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Dry-season malaria transmission and associated risk factors among urban residents of Jabi Tehnan District, northwest Ethiopia

Solomon Yeshanew
solarm12@yahoo.com

Bahir Dar University
Fasil Adugna Kendie
Bahir Dar University
Getnet Atenafu
Debre Markos University
Endalkachew Nibret
Bahir Dar University

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Abstract

Background

Dry-season malaria transmission is a growing public health challenge in urban areas of Ethiopia. However, concrete evidence on its magnitude and associated factors remains scarce. The present study, therefore, assessed the extent of malaria transmission and identified factors associated with malaria among urban residents of Jabi Tehnan District during the dry season.

Methods

A community-based cross-sectional study was conducted in March 2026 among 335 residents of Finote Selam, Mankusa, and Jiga towns. One eligible adult from each selected household was tested for malaria using a CareStart™ Malaria Pf/Pv Ag Combo rapid diagnostic test (RDT). Sociodemographic and malaria-related data were collected using a pretested structured questionnaire. Associations were assessed using multivariable logistic regression and reported as adjusted odds ratios (AORs) with 95% confidence intervals (CIs). Statistical significance was considered at $p < 0.05$.

Results

Malaria prevalence was 17.6% (59/335), with cases detected in all urban centers of the district. *Plasmodium falciparum* was the predominant parasite identified (59.3%), while mixed *P. falciparum/P. vivax* infections accounted for 6.8% of cases. Individuals engaged in farming activities (AOR=3.575; 95% CI: 1.218-8.858), houses with eave openings (AOR=9.635; 95% CI: 2.718-34.155), and inadequate knowledge about malaria preventive measures (AOR=2.218; 95% CI: 1.011-5.301) appeared as significant explanatory risk factors associated with increased odds of malaria. In contrast, insecticide-treated nets (ITNs) utilization was associated with reduced odds of infection (AOR=0.076; 95% CI: 0.011-0.525).

Conclusion

Dry-season malaria transmission persists among urban residents of Jabi Tehnan District. Strengthening personal protection during farming activities and ITNs utilization at home, improving housing conditions, and promoting malaria-related health education should be prioritized alongside targeted surveillance and vector-control interventions.

Introduction

Urban malaria has become an important public health concern in many malaria-endemic countries [1,2,3]. Although malaria transmission has traditionally been associated with rural settings, rapid and often poorly planned urban and peri-urban expansion creates heterogeneous ecological conditions that support *Anopheles* mosquito breeding, thereby creating opportunities for continued transmission [4,5,6]. Inadequate drainage, construction activities, urban agriculture, and domestic water storage may generate temporary or permanent aquatic habitats suitable for vector development [3,7]. For example, a study conducted in three residential areas of Jimma town, Ethiopia, documented three *Anopheles* mosquito species: *Anopheles gambiae* s.l, *An. pharoensis* and *An. coustani complex* [8]. Moreover, increased human mobility, together with frequent human-vector contact and the introduction of malaria parasites through population movement, can facilitate local transmission where competent vectors are present, thus complicating malaria prevention and control efforts in urban settings [3,7].

Globally, remarkable progress has been achieved in reducing malaria morbidity and mortality through the widespread implementation of ITNs, indoor residual spraying (IRS), prompt diagnosis, and effective artemisinin-based combination therapy (ACT) [9,10]. Despite these achievements, residual malaria transmission is emerging as a major obstacle to malaria elimination in many endemic countries. Because transmission continues even where conventional vector control interventions have achieved high coverage [9,11]. Residual transmission is maintained through a combination of persistent vector breeding habitats, adaptive mosquito behaviors, and human activities that increase exposure to infective mosquito bites. Consequently, identifying and eliminating these remaining transmission foci has become a central component of global malaria elimination strategies [12,13].

In Ethiopia, malaria transmission is unstable and highly seasonal, with considerable spatial and temporal variation mainly determined by altitude, rainfall, temperature, and local ecological conditions [14]. However, rapid urban expansion has altered traditional malaria epidemiology by creating diverse natural and human-made breeding habitats within and around urban settlements. Rivers, ponds, irrigation schemes, drainage canals, construction sites, and other permanent or semi-permanent water bodies provide favorable environments for *Anopheles* mosquitoes throughout the year, allowing vector populations and low-level parasite circulation to persist

beyond the major transmission season [2,3]. As a result, malaria transmission may continue during the dry season, as well as creating residual parasite reservoirs that can re-establish transmission when environmental conditions become favorable [15].

The persistence of urban malaria is driven by a complex interaction of environmental, household, behavioral, and socioeconomic factors. Living near mosquito breeding sites, poor housing construction that facilitates mosquito entry, inadequate environmental sanitation, inconsistent utilization of ITNs, limited access to vector control interventions, occupational and recreational outdoor activities during peak mosquito biting hours, and increasing human mobility all contribute to sustained malaria transmission [10,16]. These risk factors frequently coexist in rapidly expanding urban settings where infrastructure development fails to keep pace with population growth. As a result, malaria transmission in urban areas is often spatially heterogeneous, with infections clustering in localized ecological hotspots rather than being uniformly distributed across communities [2,3,4,6].

Evidence from several urban and peri-urban settings in Ethiopia, such as Jimma, Adama, Metehara, Awash Sebat Kilo, and southwestern Ethiopia, indicates that malaria transmission persists despite routine prevention and control interventions. These studies demonstrated that infections are frequently concentrated in localized areas where favorable breeding habitats coincide with increased human exposure. Such persistent transmission hotspots present a significant challenge to Ethiopia's malaria elimination strategy because they maintain low-level parasite circulation, contribute to dry-season transmission, and serve as potential sources of infection during subsequent transmission seasons [17,18,19,20]. Understanding the epidemiology and determinants of these residual malaria transmissions is therefore essential for strengthening surveillance systems and implementing targeted, evidence-based control interventions.

Jabi Tehnan District, located in the West Gojjam Zone of northwestern Ethiopia, has entomological, ecological, and demographic characteristics that may favor persistent malaria transmission in urban settings. The ongoing expansion of residential and commercial areas together with rivers crossing the towns, small-scale urban agricultural activities, and poorly managed permanent and/or semi-permanent water storage sites may create suitable habitats for malaria vectors and contribute to year-round transmission [21,22]. Although routine health facility reports in the district indicate that malaria cases continue to occur among urban residents during the dry season, empirical evidence regarding the magnitude of transmission and its associated determinants remains limited (Unpublished data). Furthermore, most malaria studies have focused on rural populations, peak transmission periods, or vector ecology, leaving an important knowledge gap regarding whether there is sustained dry-season malaria transmission in urban communities. Addressing this gap is essential for identifying residual transmission hotspots and informing targeted surveillance and integrated vector management strategies in support of the malaria elimination agenda [4,21]. Therefore, this study aimed to assess the prevalence of dry-season malaria and identify associated factors among urban residents of Jabi Tehnan District, northwest Ethiopia.

Materials and Methods

Study design, period, and setting

A community-based cross-sectional study was conducted in March 2026 among residents of the three urban centers of Jabi Tehnan District (Finote Selam, Mankusa, and Jiga towns), West Gojjam Zone, Amhara National Regional State, northwest Ethiopia. Jabi Tehnan is a malaria-endemic district that lies approximately between 10° 50' 0" N, 37° 10' 0" E (10.833333, 37.166667) (Fig. 1). The district is bordered to the southeast by Dembecha, to the west by Bure, to the northwest by Sekela, to the north by Kuarit, and to the east by Dega Damot districts [23]. According to the 2023 Ethiopian Statistical Service (ESS) population projection, the district has an estimated population of 230,992 (114,970 male and 116,022 female), and nearly 40% of the population are residents of the urban centers [24]. The district lies at an altitude ranging from 1,345 to 2,572 m above sea level, is predominantly characterized by the "*Woina Dega*" agro-ecological zone, receives an average annual rainfall of approximately 1,250 mm, and has mean annual temperatures ranging from 14°C to 32°C [22]. Preliminary assessments indicate that the district, including the urban centers, contains various water sources, such as rivers, dams, swampy areas, and ponds, which serve multiple purposes; however, many of these water bodies are poorly managed, creating potential breeding habitats for mosquitoes and contributing to the persistence of malaria transmission during the dry season. According to the Jabi Tehnan District Health Office, malaria accounted for 21.7% of outpatient visits during the 2024/25 reporting year. Malaria diagnosis and treatment are provided free of charge through public health facilities under Ethiopia's National Malaria Elimination Programme. Long-lasting insecticidal nets (LLINs) are periodically distributed to at-risk populations, and additional malaria prevention, diagnosis, and treatment services are provided through private facilities and non-governmental organizations (NGOs) (District health office report; unpublished data).

Study site selection

The three urban centers of Jabi Tehnan District (Finote Selam, Mankusa, and Jiga towns) were selected because they represent the district's urban population. They also possess entomological, ecological, and epidemiological characteristics conducive to dry-season urban malaria transmission, including potential mosquito breeding habitats, a history of malaria transmission, and previous implementation of conventional vector control interventions [21,22]. These characteristics make the sites suitable for assessing urban malaria transmission and associated factors during the dry season.

Source and target population

The source population comprised all permanent household residents living in the selected urban communities of Jabi Tehnan District during the study period. The target population included all permanent residents of the urban centers of Jabi Tehnan District who met the study eligibility criteria.

Eligibility criteria

Permanent household residents who had lived in the study area for at least six months before the survey and were present during the data collection period were eligible for inclusion. Individuals who declined to provide informed consent, were seriously ill, or were unable to provide a capillary blood sample from their fingers at the time of data collection were excluded from the study.

Sampling unit and study participant

The household was the primary sampling unit. In each selected household, one eligible adult household member, preferably the household head or another responsible adult, was selected from all permanent household residents to participate in the study and provide a capillary blood sample for malaria testing.

Sample size determination

The sample size was determined using the single population proportion formula. Considering a dry-season malaria prevalence of 16.4% reported in Jawi District, northwest Ethiopia [25], the sample size was calculated using the formula: $n = \frac{(Z\alpha/_2)^2 x\, p\, (1-p)}{d^2}$, where *n* is the required sample size, *p* is the estimated malaria prevalence (16.4%), *Z* is the standard normal value at a 95% confidence interval (1.96), and *d* is the margin of error (5%) [26]. The calculated initial sample size was 211 households. After adding a 10% allowance for non-response or incomplete data, the sample size was increased to 232 households. Considering the multistage sampling approach, a design effect of 1.5 was applied, resulting in a final planned sample size of 348 households. Data collection was conducted in March 2026. Of the 348 selected households, 11 were excluded due to predefined exclusion criteria or incomplete information. Consequently, 335 participants from 335 households were included in the final analysis.

Sampling procedure

A multistage sampling technique was employed to select the study households. First, Jabi Tehnan District was purposively selected because of its malaria-endemic urban settings and diverse ecological and sociodemographic characteristics. Second, all three urban centers of the district (Finote Selam, Mankusa, and Jiga) were included in the study. The calculated sample size of 348 households was proportionally allocated to the three urban centers, with 194 households assigned to Finote Selam and 77 households each to Mankusa and Jiga. Third, two of the four kebeles in Finote Selam and one of the two kebeles in both Mankusa and Jiga were selected using simple random sampling (Fig. 2). Within the selected kebeles, households were selected using systematic random sampling. Based on an estimated total of 2,100 households in the selected kebeles, the sampling interval (k) was calculated as 2,100/348 ≈ 6. A random starting household was identified in each selected kebele, after which every sixth household was included until the required sample size was achieved. In each selected household, the questionnaire was administered to an eligible adult household member to collect household-level information on sociodemographic characteristics, housing conditions, malaria prevention practices, and potential risk factors. The same respondent subsequently provided a capillary blood sample for malaria testing. Household questionnaire data and malaria test results were linked using a unique household identification code assigned to each participating household. If the randomly selected household member was unavailable during the initial visit, a repeat visit was conducted. When participation remained impossible after the repeat visit, the household was replaced by the next eligible household in the sampling sequence.

Methods of data collection and quality assurance

Sociodemographic data collection

Household-level data were collected through face-to-face interviews with an eligible adult household member, using a pretested structured questionnaire. The questionnaire collected information on household sociodemographic characteristics, including the respondent's age, sex, marital status, educational level, occupation, household size, monthly household income, and household sleeping arrangements. Information on malaria-related risk factors, including previous malaria incidents among household members, ownership and utilization of ITNs, IRS, proximity of the household to potential mosquito breeding sites, and the presence of openings between walls and roofs, was also collected. Each interview was completed within approximately 20 minutes.

Blood sample collection and malaria diagnosis

Capillary blood samples were collected by finger-prick from the responding individual in each household using a sterile, disposable lancet by trained medical laboratory technologists. Approximately 5 µL of capillary blood was tested using the CareStart™ Malaria Pf/Pv (HRP2/pLDH) Ag Combo RDT according to the manufacturer's instructions. Test results were read 20 minutes after sample application and interpreted following the manufacturer's guidelines based on the presence or absence of visible coloured lines in the control (C) and parasite-specific test regions. A test was considered negative when only the control line was visible. A *P. falciparum*-positive result was indicated by the presence of both the control line and the *P. falciparum*-specific test line, whereas a *P. vivax*-positive result was indicated by the control line and the corresponding pLDH test line. The presence of the control line together with both parasite-specific test lines was interpreted as a mixed *P. falciparum/P. vivax* infection. A test was considered invalid when the control line was absent, regardless of the presence of test lines, and was repeated using a new RDT kit.

Data quality assurance

Standard operating procedures (SOPs) were strictly followed throughout blood sample collection, RDT testing, and result interpretation. The performance, storage conditions, and expiry dates of the kits were verified before use. The questionnaire was developed in English, translated into Amharic (the local language of the study community), and then back-translated into English to ensure conceptual equivalence. Before the main survey, the questionnaire was pretested on 5% of the target population from a non-study area (Dembecha Town, northwest Ethiopia) to assess content validity, clarity, and internal consistency. The questionnaire demonstrated acceptable reliability, with a Cronbach's alpha of 0.77. Medical laboratory technologists and health extension workers who participated in the study were selected from the respective town public health facilities. Before fieldwork, they received one day of training on the study objectives, data collection procedures, ethical considerations, and their specific roles, including blood sample collection and RDT procedures for laboratory personnel and interview techniques for health extension workers. Completed questionnaires and RDT records were reviewed daily by the principal investigator to ensure completeness, consistency, and accuracy.

Operational definitions

Adequate knowledge of malaria: *participants who answered ≥ 50% of questions assessing general knowledge of malaria, including its causes, mode of transmission, symptoms, treatment, and prevention.*

Inadequate knowledge of malaria: *participants who were unable to answer questions assessing general knowledge of malaria above the cut-off point (<50%).*

Adequate knowledge of malaria prevention: *participants who answered ≥ 50% of questions assessing knowledge of malaria preventive measures such as ITNs use, IRS, environmental management, etc.*

Inadequate knowledge of malaria prevention: *participants who were unable to answer questions assessing knowledge of malaria preventive measures above to the cut-off point (<50%).*

Statistical analysis

Data were checked for completeness, accuracy, and consistency before being entered into Microsoft Excel and exported to IBM SPSS Statistics version 23 (IBM Corp., Armonk, NY, USA) for analysis. Descriptive statistics were used to summarize household and individual-level characteristics, malaria-related variables, and malaria prevention practices. Malaria prevalence was calculated as the proportion of selected household respondents who tested positive by RDT. Household-level variables obtained from the respondents, together with individual-level characteristics, were evaluated as potential predictors of malaria. Associations between independent variables and malaria were initially assessed using bivariable logistic regression. Variables with $p<0.25$ in the bivariable analysis were entered into a multivariable logistic regression model using the purposeful variable selection approach described by Bursac et al. [27]. The strength of associations was expressed as crude odds ratios (CORs) and AORs with 95% CIs. Variables with $p<0.05$ were considered significantly associated with malaria.

Results

Sociodemographic and housing characteristics

A total of 335 urban residents were included in the analysis, with a response rate of 96.3% (335/348). Finote Selam accounted for 55.5% (n=186) of participants, while females comprised 62.7% (n=210). The largest proportion of participants were aged between 26 and 35 years (38.8%, n=130). The majority were married (57.4%, n=192), and self-employment was the predominant occupation (39.1%, n=131). Regarding educational attainment, 26.3% (n=88) had no formal education, whereas 52.0% (n=174) had completed secondary or higher education. Households with 1 to 3 members constituted 56.1% (n=188) of the study participants, and 52.6% (n=176) reported a monthly household income of less than 5,000 Ethiopian Birr. Regarding housing characteristics, 24.2% (n=81) of participants slept on the floor, while wall and eave openings were reported in 20.6% (n=69) and 34.6% (n=116) of households, respectively. Most houses had corrugated iron roofs (85.4%, n=286) and mud-plastered walls (92.8%, n=311) (Table 1).

Malaria-related awareness and preventive practices

Most urban residents received information about malaria (96.7%, n=324), with health workers being the main source of information (76.1%, n=255). Adequate knowledge of malaria transmission was reported by 73.4% (n=246) of participants, while 70.1% (n=235) identified two or more malaria prevention measures. At the household level, ITNs were available in 92.5% (n=310) and utilized in 80.9% (n=271) of households. However, potential outdoor exposure remained common: 38.8% (n=130) reported that a household member slept outdoors and 45.4% (n=152) reported outdoor activities during the evening. IRS coverage during the preceding six months was low: 3.6% (n=12), while 61.5% (n=206) of households were located within 1 km of a potential mosquito breeding site. Previous experience of malaria was reported by 40.9% (n=137) of the participants (Table 2).

Malaria prevalence among study participants and distribution across study sites

The overall prevalence of malaria among urban residents of Jabi Tehnan District was 17.6% (59/335) during the dry-season study period (Fig. 3). Malaria cases were detected across all three study sites, with variation in both the absolute number and site-specific prevalence. Finote Selam accounted for the largest share (27 cases, 45.8%), followed by Jiga (18 cases, 30.5%). However, site-specific prevalence was highest in Jiga (23.7%, 18/76), followed by Mankusa (19.2%, 14/73) and Finote Selam (14.5%, 27/186) (Fig. 4).

Potential explanatory factors associated with malaria

Seven factors were significantly ($p<0.05$) associated with malaria among urban residents of Jabi Tehnan District in the final multivariable logistic regression model (Table 3). Participants engaged in farming (AOR=3.575; 95% CI: 1.218-8.858; p=0.011) had higher odds of malaria than housewives. Those who slept on the floor were nearly five-fold more likely to have malaria than those who slept on a bed (AOR=4.979; 95% CI: 1.606-15.438; p=0.005). Participants living in houses with eave openings had substantially higher odds of malaria than those living in houses without eave openings (AOR=9.635; 95% CI: 2.718-34.155; p=0.001). ITN use was also significantly associated with malaria; participants who used ITNs had lower odds of malaria than those who did not use ITNs (AOR=0.076; 95% CI: 0.011-0.525; p=0.009). In addition, participants who were unaware of malaria transmission modes were two times more likely to have malaria than individuals who had adequate knowledge (AOR=2.235; 95% CI: 1.863-4.867; p=0.030). Similarly, participants who had inadequate knowledge of malaria prevention measures had approximately twice the odds of malaria compared with those who had adequate knowledge (AOR=2.218; 95% CI: 1.011-5.301; p=0.037). Furthermore, participants with a previous history of malaria had approximately twice the odds of current malaria compared with those without a previous history of malaria (AOR=2.136; 95% CI: 1.541-4.453; p=0.001).

Discussion

Malaria remains an important public health problem in Ethiopia. It has traditionally been considered a rural disease, with transmission occurring mainly after the main rainy season [2,3]. However, in recent years, few reports have shown that transmission persists during the dry season, particularly in urban settings where suitable mosquito breeding habitats and continued human-vector contact are present [3,7]. This persistence underlines the increasing recognition of dry-season urban malaria despite the ongoing conventional control efforts. On the other hand, plausible evidence on the magnitude and determinants of dry-season malaria transmission among urban populations is scarce. Therefore, this study assessed the extent of malaria transmission and associated risk factors among urban residents of Jabi Tehnan District during the dry season.

The present study found a malaria prevalence of 17.6% among urban residents of Jabi Tehnan District. The finding highlights the persistence of malaria beyond the main transmission period and the continuing public health importance of the disease in urban settings.

The observed prevalence was comparable to the 16.4% reported during the dry season in Jawi District, northwest Ethiopia [25]. Similarly, a prevalence of 17.1% was reported in Batu town, central Ethiopia [28]. In contrast, lower prevalence was reported in Damboya town (5.0%) [29], Adama City (3.7%) [19], and Dire Dawa city (3.5%) [30], whereas a substantially higher prevalence was reported in Dilla town (29.6%) [31].

The variation across studies could be attributed to multiple factors. Local ecological and climatic conditions, vector composition, population characteristics, timing of data collection, and the coverage and use of malaria prevention and control measures may influence transmission intensity. Differences in study populations and diagnostic methods may also partly explain the observed variation, as some previous studies were conducted among febrile patients or schoolchildren, whereas the present study was community-based. The relatively high prevalence observed in the present study may also be influenced by broader contextual factors, including armed conflict in suburban and/or peri-urban areas in the study sites, leading to population displacement, which disrupts malaria prevention and control activities such as on-time provision of ITNs, IRS, and prompt diagnosis and ACT, potentially increasing vulnerability to malaria transmission [32,33,34,35,36,37]. Overall, these findings add to the growing evidence that malaria transmission during the dry season in Ethiopia, including in urban areas, underlines the need for continued surveillance and sustained malaria prevention and control interventions beyond the peak transmission season.

Plasmodium falciparum and *P. vivax* were the two species detected in the present study, comprising 59.3% and 33.9% of confirmed cases, respectively. Mixed *P. falciparum* and *P. vivax* infections accounted for 6.8%. The predominance of *P. falciparum* is consistent with recent national trends in malaria species distribution in Ethiopia. According to the World Health Organization, Ethiopia was estimated to have 12.4 million malaria cases in 2025, including 4.5 million confirmed cases, with *P. falciparum* and *P. vivax* accounting for 65.05% and 34.88% of infections, respectively [38]. Similarly, a study from Dire Dawa reported a comparable predominance of *P. falciparum* (59.0%), which is identical to the proportion observed in the present study [30]. However, this species distribution contrasts with findings from several previous studies conducted in urban and low-transmission settings. In Batu town, *P. vivax* predominated, accounting for 50.8% of infections compared with 45.6% for *P. falciparum* [28]. Similarly, *P. vivax* was predominant in Adama City (66.0%) and Damboya town (61.9%), compared with 20.5% and 33.3% for *P. falciparum*, respectively [19,29]. A study from southern Ethiopia also reported a predominance of *P. vivax* (64.5%) over *P. falciparum* [31]. However, the proportions of mixed-species infections were comparable across the studies [19,28,29,30,31].

The predominance of *P. falciparum* in the present study may reflect differences in local ecological and climatic conditions, and vector composition. Population mobility may also have contributed to the observed species distribution, particularly during the period of armed conflict, when displacement from rural and lowland malaria-endemic areas to urban and higher altitude communities may facilitate the introduction of the parasite into areas receiving displaced populations. This is relevant in northwestern Ethiopia, where conflict-related population displacement and movement have occurred across areas with different malaria transmission profiles. As a result, individuals originating from lowland areas where *P. falciparum* transmission is predominant moved into the study areas and could have contributed to the predominance of *P. falciparum* [38,39]. In addition, the use of an HRP2-based RDT may have influenced the observed species distribution, as HRP2 antigen can persist after parasite clearance following treatment and may also result in prolonged test positivity [40]. Future studies should therefore combine RDT with microscopy or other more sensitive methods to improve species identification and detection. Similarly, longitudinal studies across transmission seasons are also needed to better characterize the factors influencing malaria species distribution in urban settings.

Several occupational, behavioral, and housing-related factors were independently associated with *Plasmodium* infection in the present study. Participants engaged in farming activities had significantly higher odds of infection than those engaged in other occupations (AOR=3.575; 95% CI: 1.218-8.858). This finding is consistent with a study in Siraro District of southern Ethiopia, where farmers had approximately six-fold higher odds of malaria than merchants (AOR=6.05; 95% CI: 1.38-26.49) [41]. The increased risk among farmers may be attributed to the prolonged exposure to mosquito bites during outdoor activities. In addition, agricultural activities also bring individuals into proximity to mosquito breeding habitats such as irrigation areas, streams, and other water bodies. Similarly, some farmers may also spend nights in temporary shelters at agricultural sites with limited personal protection from mosquito bites, further increasing the risk of malaria. Therefore, targeted health education should prioritize farmers and promote the appropriate use of personal protective measures during agricultural activities.

The presence of eave openings was an important housing-related determinant in the present study. Participants living in houses with eave openings had higher odds of malaria than those living in houses without eave openings (AOR=9.635; 95% CI: 2.718-34.155). This association is consistent with evidence from northwestern Ethiopia, Debre Elias District, where individuals living in houses with eaves had more than three-fold higher odds of malaria (AOR=3.35; 95% CI: 1.02-10.93) [42]. Similarly, a study of residual malaria transmission in Ethiopia reported higher odds of infection among individuals living in houses with eaves (AOR=2.28; 95% CI: 1.14-4.55) [43]. A study from

Jawi District in northwestern Ethiopia also reported a comparable association, with individuals living in houses with eaves having more than four-fold higher odds of malaria (AOR=4.23; 95% CI: 1.07-16.80) [25]. The consistently elevated odds observed across studies suggest that open eaves may provide entry access for mosquitoes into houses, thereby increasing indoor human-vector contact and the risk of malaria transmission. These findings highlight the need to promote simple housing improvements, particularly the closure or screening of open eaves to reduce mosquito entry.

Inadequate knowledge of malaria transmission and preventive measures was also significantly associated with malaria in the present study. Participants with inadequate knowledge had higher odds of infection (AOR=2.235; 95% CI: 1.863-4.867, p=0.030). A similar association was reported among febrile adults in Siraro District, where participants with inadequate knowledge of malaria transmission had nearly three-fold higher odds of malaria than those with adequate knowledge (AOR=2.95; 95% CI: 1.48-5.88) [41]. Recent reports from Jawi and Dejen districts also support the present findings, where limited awareness of malaria transmission and preventive measures were determinants of higher odds of malaria [35,36]. The findings, therefore, emphasize the importance of health education in increasing awareness and promoting the appropriate use of preventive measures.

Proper utilization of ITNs was significantly associated with lower odds of malaria in the present study. Participants who reported proper ITN utilization had an approximately 92.4% (AOR=0.076; 95% CI: 0.011-0.525, p=0.009) reduction in the odds of infection. A similar study from Kola Diba, northwestern Ethiopia, also reported significantly lower odds of malaria among ITN users (AOR=0.35; 95% CI: 0.21-0.60) [44]. However, a systematic review and meta-analysis of malaria among the general population in Ethiopia found that non-utilization of ITNs was associated with higher odds of malaria (AOR=4.80; 95% CI: 3.41-6.78) [45]. Similarly, a meta-analysis of asymptomatic malaria in Ethiopia reported that individuals who did not use ITNs had more than six-fold higher odds of infection than ITN users (AOR=6.36; 95% CI: 4.01-10.09) [46]. The consistency of these reports across different settings supports the protective role of ITN utilization against malaria. Therefore, promoting and sustaining correct and consistent use of ITNs should remain a key component of malaria preventive measures, particularly in urban communities where residual transmission may persist during the dry season.

Limitation of the study

This study has several limitations that should be considered when interpreting the findings. First, the cross-sectional design limits the ability to establish temporal or causal relationships between the associated factors and malaria cases. Second, information on malaria-related knowledge, ITN utilization, and behavioral practices was collected through self-reported responses and may therefore be subject to recall bias. Third, malaria was assessed using RDT kits, which may have limited sensitivity for detecting low-density infections and may not provide the same diagnostic accuracy as microscopy or molecular methods. In addition, the HRP2-based RDT used for *P. falciparum* detection may have missed infections caused by parasites carrying deletions of the *pfhrp2* and *pfhrp3* genes, potentially resulting in false-negative results and underestimating the prevalence of *P. falciparum*. This limitation is relevant because previous studies have documented *pfhrp2* and *pfhrp3* gene deletions in the study area and their association with RDT diagnostic failure [47,48]. Finally, the study was conducted during a single dry-season period; therefore, temporal variations in malaria transmission and associated risk factors could not be assessed.

Conclusion

Dry-season malaria transmission remains a public health concern among urban residents of Jabi Tehnan District, with a prevalence of 17.6%. Malaria was detected across all three urban centers. Farming activities, sleeping on the floor, and open house eaves were associated with increased risk of malaria. However, consistent use of ITNs was associated with reduced odds of infection. These findings revealed that both household and behavioral factors contribute to continued dry-season malaria transmission in the study area. Strengthening ITNs utilization and improving housing conditions should be prioritized alongside existing malaria control measures.

Abbreviations

ACT: Artemisinin combination therapy; AOR: Adjusted odd ratio; APHI: Amhara public health institute; CI: Confident interval; COR: Crude odd ratio; ESS: Ethiopian statistical services; HRP: Histidine-rich protein; IRERC: Institutional research ethical review committee; IRS: Indoor residual spray; ITNs: Insecticide-treated nets; LLINs: Long lasting insecticide nets; NGOs: Non-governmental organizations; pLDH: Parasite lactate dehydrogenase; RDT: Raped diagnostic test; SOP: Standard operating procedures

Declarations

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Author contributions

SY, EN, and GA conceived and designed the study. SY and FAK performed the statistical analyses. All authors contributed to data interpretation and critically revised the manuscript for important intellectual content.

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Data availability

All data analyzed during this study are included in this manuscript.

Ethical approval and consent to participate

Before data collection began, ethical approval was obtained from the Institutional Research Ethical Review Committee (IRERC) of the College of Science, Bahir Dar University (Reference number: IRERC08/2026). A letter of permission was also obtained from the Amhara Public Health Institute (APHI), which facilitated authorization from the relevant governmental and public institutions to conduct the study.

Consent to participate

The study objectives, procedures, potential risks, and expected benefits were explained to all selected participants, and written informed consent was obtained. Participation was entirely voluntary, and participants were informed of their right to decline or withdraw from the study at any time without any consequences. Confidentiality and anonymity were maintained throughout the study by using unique identification codes. Participants who tested positive for malaria were referred to the nearest health facility for appropriate case management. All study procedures were conducted in accordance with the ethical principles of the Declaration of Helsinki [49].

Competing interests

The authors declared that they have no competing interests.

Consent to publication

All authors have approved the submission of the final copy for publication.

Disclaimer

During the preparation of this manuscript, the authors used OpenAI's ChatGPT and Grammarly tools solely to improve the English language, grammar, clarity, and readability of the manuscript.

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Tables

Table 1: Socio-demographic and housing characteristics of study participants among urban residents of Jabi Tehnan District, northwest Ethiopia, March 2026.

Variables	Category	Frequency (n)	Percentage (%)
Residence	Finote Selam	186	55.5
	Jiga	76	22.7
	Mankusa	73	21.8
Gender	Male	125	37.3
	Female	210	62.7
Age (years)	19-25	67	20
	26-35	130	38.8
	36-45	69	20.6
	>45	69	20.6
Marital status	Single	49	14.6
	Married	192	57.4
	Widowed	42	12.5
	Divorced	52	15.5
Occupation	Student	10	3.0
	Self-employee	131	39.1
	Daily-labor	41	12.2
	Farmer	25	7.5
	Gov.'s-employee	74	22.1
	House-wife	54	16.1
Educational status	No formal education	88	26.3
	Primary school	73	21.7
	Secondary school	87	26.0
	Higher education	87	26.0
Family size	1-3	188	56.1
	4-6	144	43.0
	>6	3	0.9
Sleeping space	Floor	81	24.2
	Bed	254	75.8
Number of sleeping rooms	One	187	55.8
	Two	130	38.8
	≥3	18	5.4
Monthly income/Eth birr	<5,000	176	52.6
	5,000-10,000	113	33.7
	10,000-20,000	41	12.2
	>20,000	5	1.5
Roof type	Corrugated iron	286	85.4
	Thatched	49	14.6

Wall type	Brick wall	24	7.2
	Mud plastered	311	92.8
Wall openings	Yes	69	20.6
	No	266	79.4
Eave openings	Yes	116	34.6
	No	219	65.4

Table 2: Malaria-related knowledge, awareness, and preventive practices among urban residents of Jabi Tehnan District, northwest Ethiopia, March 2026.

Variables	Category	Frequency (n)	Percentage (%)
Information about malaria	Yes	324	96.7
	No	11	3.3
Knowledge about malaria	Yes	322	96.1
	No idea	13	3.9
Information sources	Family	14	4.2
	Friends	12	3.6
	Health workers	255	76.1
	Media	54	16.1
Knowledge of the causes of malaria	Yes	175	52.2
	No	160	47.8
Knowledge of malaria transmission	Yes	246	73.4
	No	89	26.6
Knowledge of malaria prevention	No idea	2	0.6
	Using net	75	22.4
	IRS	12	3.6
	Water drainage	4	1.2
	Smoking	7	2.1
	Two or more methods	235	70.1
Knowledge of the causative agents	Parasite	93	27.8
	Fungi	9	2.7
	Bacteria	66	19.7
	No idea	167	49.8
Knowledge of malaria in the community	Yes	306	91.3
	No	17	5.1
	No idea	12	3.6
Knowledge of the types of malaria	One type	56	16.7
	Two type	133	39.7
	>Two types	114	34.0
	No idea	32	9.6
Knowledge of malaria treatability	Yes	323	96.4
	No idea	12	3.6
ITNs availability	Yes	310	92.5
	No	25	7.5
ITNs utilization	Yes	271	80.9
	No	64	19.1
Who used a bed net in the family	Whole family	231	69.0
	Children only	78	23.3

	Female only	11	3.3
	Parents only	4	1.1
	No one	11	3.3
Family member sleeps outdoors	Yes	130	38.8
	No	205	61.2
Outdoor activities during the evening	Yes	152	45.4
	No	183	54.6
Cattle live in the house	Yes	31	9.3
	No	304	90.7
IRS status/6 months	Yes	12	3.6
	No	323	96.4
Mosquito breeding distance	< 1 km	206	61.5
	1- 2 km	29	8.7
	> 2 km	100	29.8
Previous experience of malaria	Yes	137	40.9
	No	198	59.1

Table 3: Bivariable and multivariable logistic regression analyses of factors associated with dry-season malaria transmission among urban residents of Jabi Tehnan District, northwest Ethiopia.

Variables	Total examined n (%)	Malaria positive n (%)	COR (95% CI)	p-value	AOR (95% CI)	p-value
Residence						
Mankusa	73(21.8)	14(19.2)	1.401(0.661-2.970)	0.385	-	-
Jiga	76(22.7)	18(23.7)	1.832(0.887-3.822)	0.111	2.208(0.751-5.852)	0.130
Finote Selam	186(55.5)	27(14.5)	1	-	-	-
Gender						
Male	125(37.3)	19(15.2)	0.762(0.419-1.385)	0.372	-	-
Female	210(62.7)	40(19.1)	1	-	-	-
Age (years)						
19-25	67(20.0)	16(23.9)	1.654(0.704-3.889)	0.250	-	-
26-35	130(38.8)	18(13.8)	0.847(0.375-1.913)	0.690	-	-
36-45	69(20.6)	14(20.3)	1.342(0.561-3.209)	0.508	-	-
>45	69(20.6)	11(15.9)	1	-	-	-
Marital Status						
Married	192(57.4)	34(17.7)	0.961(0.401-2.310)	0.921	-	-
Widowed	42(12.5)	9(21.4)	1.213(0.441-3.356)	0.730	-	-
Divorced	52(15.5)	7(13.5)	0.69 (0.250-1.921)	0.482	-	-
Single	49(14.6)	9(18.4)	1	-	-	-
Occupation						
Student	10(3.0)	2(20.0)	0.537(0.101-2.836)	0.470		
Self-employee	131(39.1)	26(19.8)	0.539(0.257-1.101)	0.091	1.579(0.167-4.893)	0.690
Daily laborer	41(12.2)	9(22.0)	0.606(0.235-1.555)	0.304	-	-
Farmer	25(7.5)	1(4.0)	0.086(0.011-0.727)	0.024	3.575(1.218-8.858)	0.011*
Gov.'s employee	74(22.1)	4(5.4)	0.118(0.036-0.403)	<0.001	4.754(0.783-12.878)	0.090
House-wife	54(16.1)	17(31.5)	1	-	-	-
Educational level						
No formal	88(26.3)	24(27.3)	6.150(2.223-17.012)	<0.001	0.567(0.061-5.269)	0.618
Primary	73(21.7)	14(19.2)	3.892(1.329-11.397)	0.013	0.606(0.084-4.391)	0.620
Secondary	87(26.0)	16(18.4)	3.696(1.289-10.596)	0.015	0.362(0.054-2.441)	0.297
Higher	87(26.0)	5(5.5)	1	-	-	-
Monthly income						
<5000	176(52.6)	43(24.4)	1.293(0.141-11.885)	0.820	-	-
5000-10,000	113(33.7)	12(10.6)	0.475(0.049-4.607)	0.521	-	-
10,000-20,000	41(12.2)	3(7.3)	0.316(0.026-3.801)	0.364	-	-
> 20,000	5(1.5)	1(20.0)	1	-	-	-

Sleeping space						
Floor	81(24.2)	27(33.3)	3.469(1.918-6.272)	<0.001	4.979(1.606-15.438)	0.005*
Bed	254(75.8)	32(12.6)	1	-	-	-
Number of bedrooms						
One	187(55.8)	37(19.8)	0.493 (0.178-1.365)	0.176	1.215(0.936-1.329)	0.156
Two	130(38.8)	16(12.3)	0.280 (0.096-0.820)	0.019	0.782(0.337-1.881)	0.229
≥3	18(5.4)	6(33.3)	1	-	-	-
Roof type						
Thatched	49(14.6)	9(18.4)	1.062(0.484-2.328)	0.881	-	-
Corrugated iron	286(85.4)	50(17.5)	1	-	-	-
Wall type						
Mud plastered	311(92.8)	57(18.3)	2.47 (0.571-10.710)	0.231	0.234(0.027-2.441)	0.216
Blocks	24(7.2)	2(8.3)	1	-	-	-
Wall openings						
Yes	69(20.6)	25(36.2)	3.877(2.109-7.126)	<0.001	1.359(0.364-5.068)	0.648
No	266(79.4)	34(12.8)	1	-	-	-
Eave openings						
Yes	116(34.6)	37(31.9)	4.194(2.328-7.556)	<0.001	9.635(2.718-34.155)	0.001*
No	219(65.4)	22(10.0)	1	-	-	-
Family size						
More than three	147(43.9)	28(19.0)	1.169(0.662-2.064)	0.591	-	-
1-3	188(56.1)	31(16.5)	1	-	-	-
Information about malaria						
No	11(3.3)	5(45.5)	4.167(1.227-14.145)	0.022	0.423 (0.082-3.387)	0.257
Yes	324(96.7)	54(16.7)	1	-	-	-
Knowledge of the causes of malaria						
No	160(47.8)	41(25.5)	3.005(1.644-5.493)	<0.001	3.230(0.833-12.524)	0.090
Yes	175(52.2)	18(10.3)	1	-	-	-
Knowledge of malaria transmission						
No	89(26.6)	22(24.7)	1.855(1.023-3.363)	0.042	2.235(1.863-4.867)	0.030*
Yes	246(73.4)	37(15.0)	1	-	-	-
Knowledge of the causative agent of malaria						
No idea	167(49.8)	40(24.0)	2.348(1.140-4.837)	0.021	0.416 (0.150-1.458)	0.303
Fungi	9(2.7)	1(11.1)	0.932(0.106-8.178)	0.949	-	-

Bacteria	66(19.7)	7(10.6)	0.884(0.324-2.416)	0.811	-	-
Parasite	93(27.8)	11(11.8)	1	-	-	-
Knowledge of malaria transmission in the community						
No	17(5.1)	4(23.5)	1.437(0.449-4.596)	0.541	-	-
No idea	12(3.6)	1(8.3)	0.424(0.052-3.439)	0.424	-	-
Yes	306(91.3)	54(17.6)	1	-	-	-
Knowledge that malaria is a treatable disease						
No idea	12(3.6)	2(16.7)	0.933(0.199-4.375)	0.930	-	-
Yes	323(96.4)	57(17.6)	1	-	-	-
Knowledge of malaria prevention						
No idea	2(0.6)	1(50.0)	4.732(0.290-13.211)	0.215	2.218 (1.011-5.301)	0.037*
Using net	75(22.4)	10(13.3)	0.728(0.345-1.535)	0.404	-	-
IRS	12(3.6)	4(33.3)	2.366(0.680-8.230)	0.176	1.317(0.446-1.458)	0.551
Drainage	4(1.2)	1(25.0)	1.577(0.160-15.546)	0.696	-	-
Smoking	7(2.1)	2(28.6)	1.893(0.355-10.096)	0.455	-	-
Two or more methods	235(70.1)	41(17.4)	1	-	-	-
Previous experience of malaria						
Yes	137(40.9)	32(23.4)	0.517(0.288-0.906)	0.023	2.136(1.541-4.453)	0.001*
No	198(59.1)	27(13.6)	1	-	-	-
ITNs availability						
No	25(7.5)	2(8.0)	0.388(0.088-1.684)	0.205	3.191(0.110-5.932)	0.500
Yes	310(92.5)	57(18.4)	1	-	-	-
ITNs utilization						
No	64(19.1)	5(7.8)	0.340(0.129-0.896)	0.029	0.076(0.011-0.525)	0.009*
Yes	271(80.9)	54(19.9)	1	-	-	-
Status of IRS within six months						
No	323(96.4)	59(18.3)	NE	-	-	-
Yes	12(3.6)	0(0.00)	1	-	-	-
Who used a bed net in the family?						
No one	11(3.3)	2(18.2)	1.096(0.230-5.226)	0.908	-	-
Only children	78(23.3)	12(15.4)	0.895(0.442-1.813)	0.757	-	-
Only female	11(3.3)	6(54.4)	5.920(2.000-17.523)	<0.001	0.224(0.016-3.207)	0.270
Parents only	4(1.1)	0(0.0)	0.000	1.000	-	-
Whole family	231(69.0)	39(16.9)	1	-	-	-
A family member sleeps outdoors						
Yes	130(38.8)	24(18.5)	1.100(0.620-1.951)	0.745	-	-

No	205(61.2)	35(17.1)	1	-	-	-
Outdoor activities during the evening						
Yes	152(45.4)	32(21.1)	1.541(0.876-2.710)	0.134	1.148(0.391-3.370)	0.802
No	183(54.6)	27(14.8)	1	-	-	-
Cattle live in the house						
Yes	31(9.3)	3(9.7)	0.478(0.139-1.641)	0.242	0.896(0.139-5.784)	0.908
No	304(90.7)	56(18.4)	1	-	-	-
Mosquito breeding distance from home						
< 1 km	206(61.5)	41(19.9)	1.408(0.737-2.688)	0.300	-	-
1-2km	29(8.7)	3(10.3)	0.654(0.176-2.436)	0.527	-	-
> 2 km	100(29.8)	15(15.0)	1	-	-	-

Note: *NE: Not estimable*

Figures

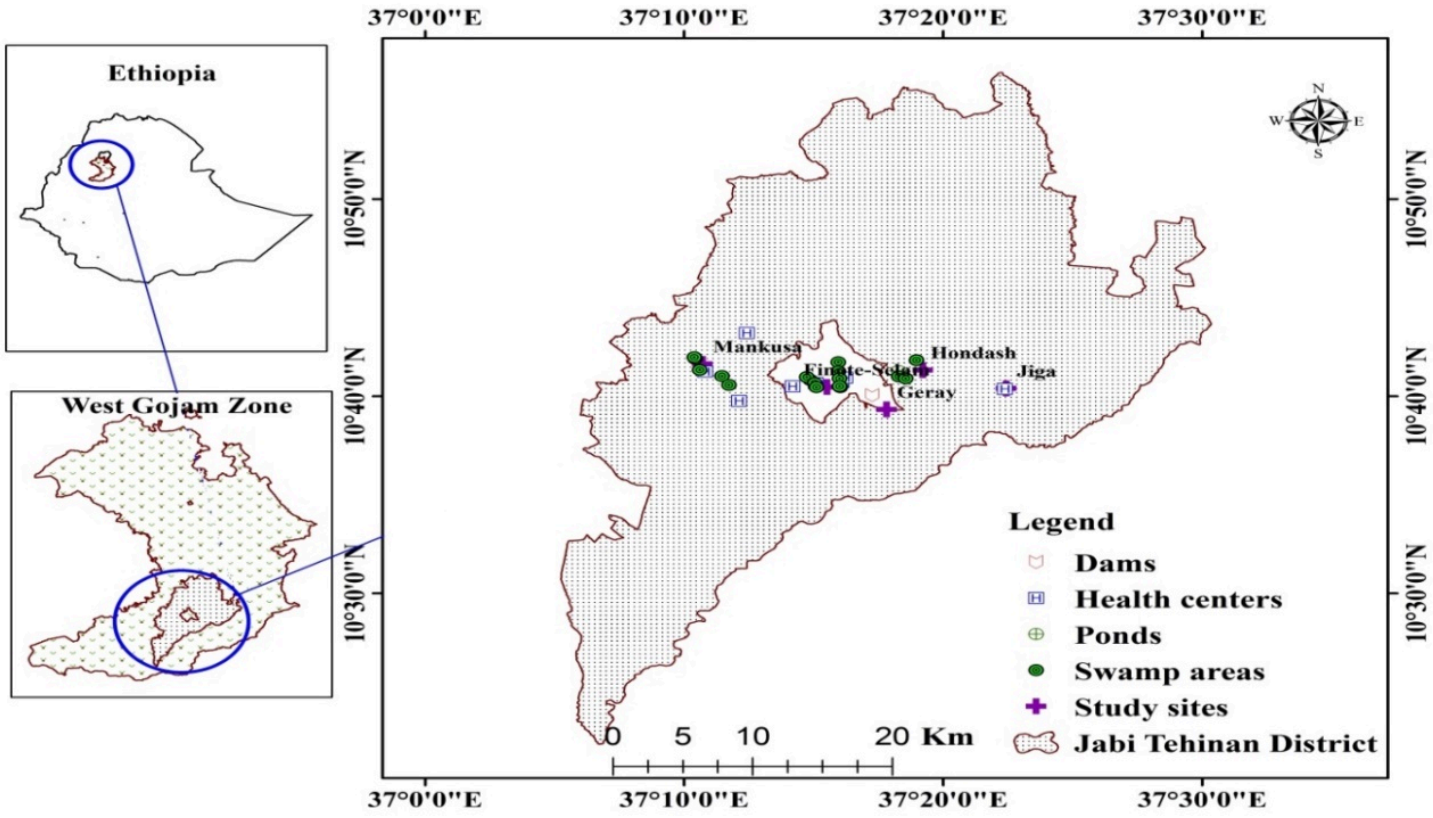


Figure 1

Geographical location of the study areas

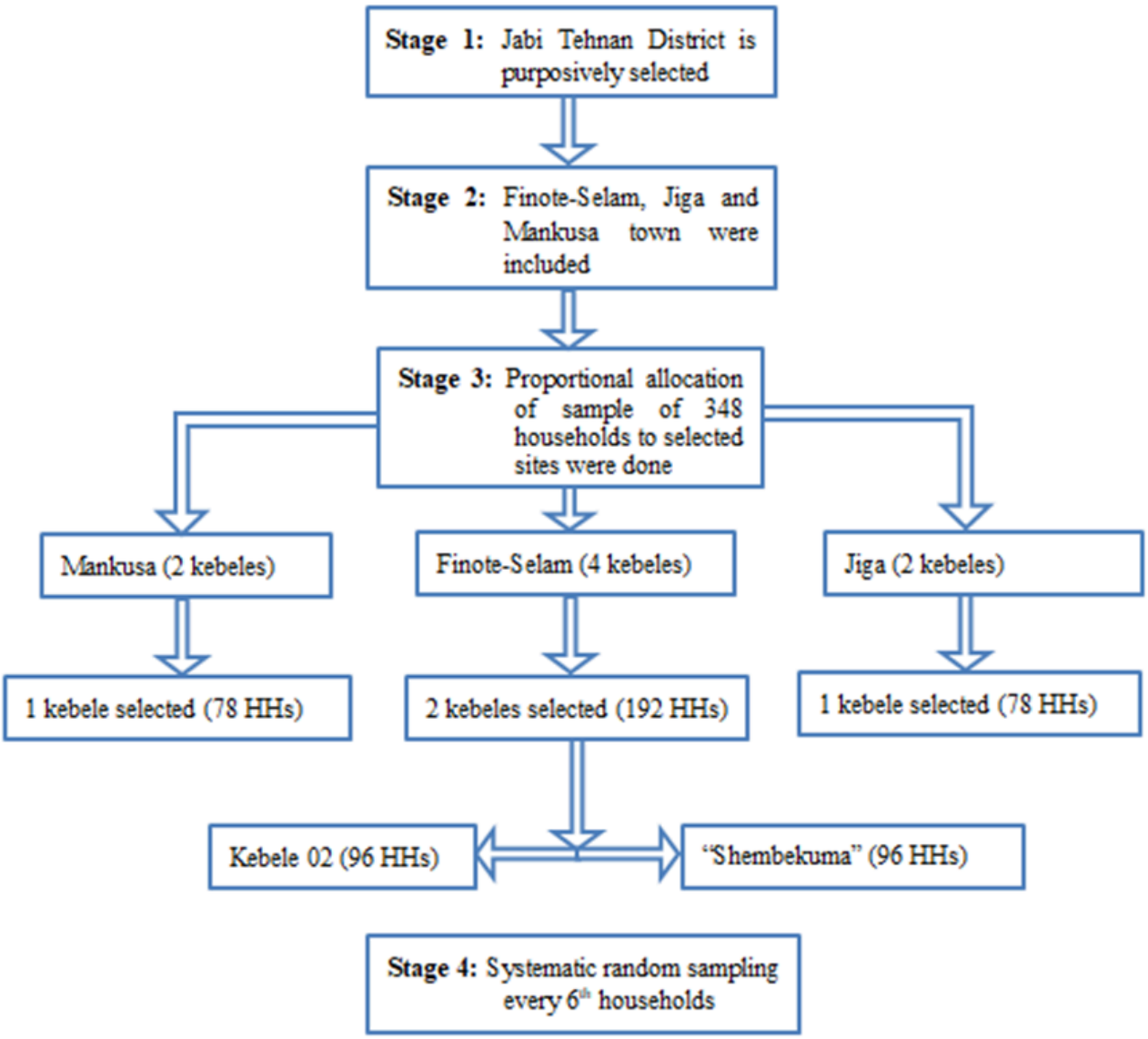


Figure 2

Graphical presentation of sampling technique

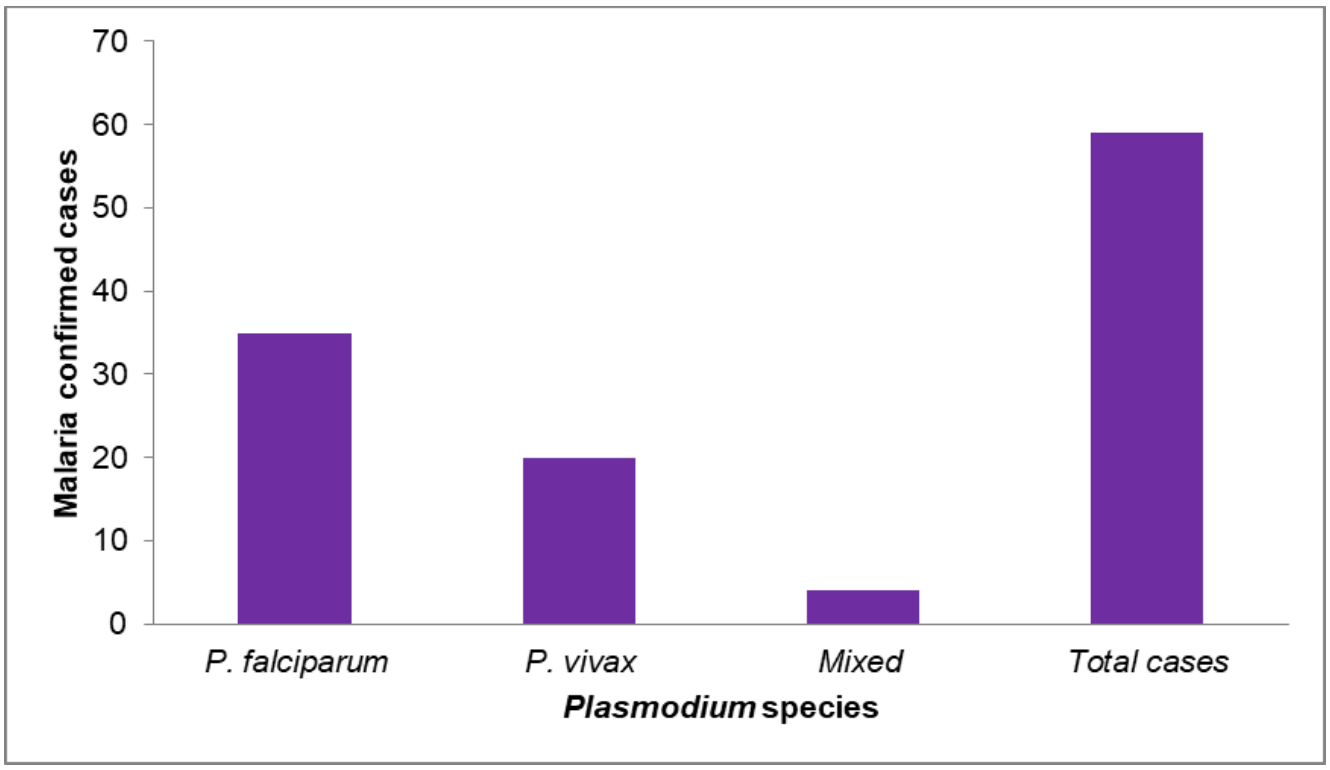


Figure 3

Confirmed malaria cases among urban residents of Jabi Tehnan District, northwest Ethiopia, during the dry season.

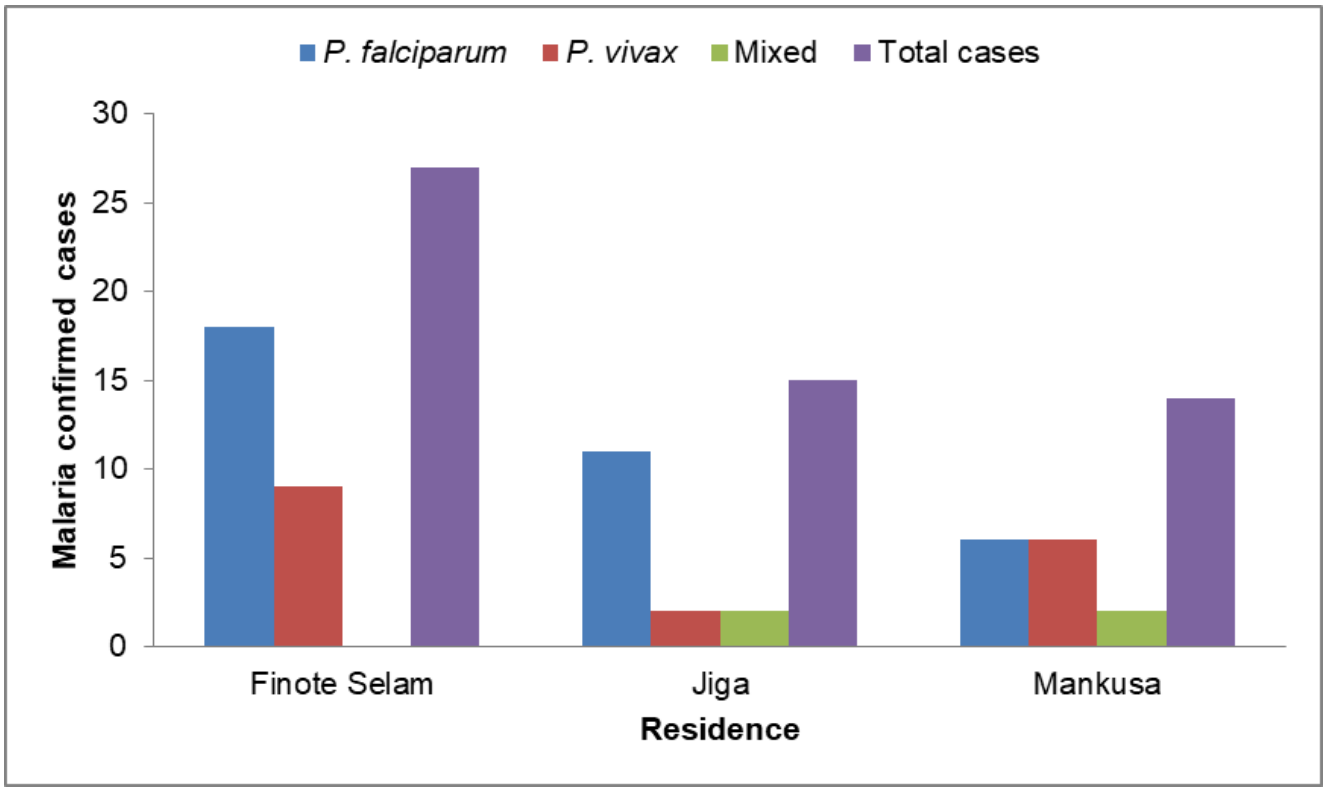


Figure 4

Distribution of confirmed malaria cases across study sites among urban residents of Jabi Tehnan District, northwest Ethiopia, during the dry season.