Burden and seasonal distribution of malaria in Ziquala district, Northeast Ethiopia: a 5-year multi-centre retrospective study

Habtu Debash 1, 1 Habtye Bisetegn, 1 Hussen Ebrahim, 1 Mihret Tilahun 1, 1 Zelalem Dejazmach 2, 2 Nigatu Getu, 3 Daniel Getacher Feleke 4

ABSTRACT

Objective This study was aimed to determine the 5-year trend of malaria positivity rate in Ziquala district, Northeast Ethiopia.

Methods Review of blood film reports from health institutions’ laboratory record books using predefined checklists was done as part of an institution-based retrospective study to assess the 5-year (2016/2017–2020/2021) trend of malaria. To display data and analyse patterns in the trend of malaria over the course of years, months and seasons, descriptive statistics were used. The results of the data analysis were displayed in tables and figures using SPSS V.26.0. P values under 0.05 were considered as statistically significant for all comparisons.

Results A total of 46 365 blood films from malaria suspected individuals were diagnosed using microscopy over the last 5 years. Of the diagnosed individuals, 14 429 (31.1%) were confirmed positive for Plasmodium infection. Plasmodium falciparum (59.7%) and Plasmodium vivax (37.0%) were the dominant species. The positivity rate of mixed infection (P. falciparum and P. vivax) was 3.3%. The maximum (3598; 29.6%) and minimum (2085; 29.1%) number of cases were reported in 2019/2020 and 2020/2021, respectively. Of the total cases, 9206 (63.8%) were in males. Moreover, the highest malaria positivity rate was observed in the age group of 15–45 (4040; 28.0%). Among the six health facilities, Ziquala district hospital had the highest malaria positivity rate (35.8%), followed by Tsitsika health centre (27.3%) and Mishra health centre (14.2%).

Conclusion With P. falciparum being the most common species, malaria remains a severe public health threat in the district. Therefore, the district health office and other concerned bodies should strengthen and implement evidence-based malaria prevention and control measures.

INTRODUCTION

Malaria is one of the major serious public health and life-threatening parasitic disease caused by the Plasmodium species. 1 It is the greatest cause of death in developing countries for children under the age of five and pregnant women. 2, 3 Children with severe malaria may experience cerebral malaria, severe anaemia, and respiratory distress and also lead multi-organ failure in adults. 4 Between 2000 and 2019, global malaria prevention and control were ramped up, and the WHO African Region achieved significant success in reducing its malaria burden, particularly in sub-Saharan Africa. 5

According to WHO, in 2020 the WHO African Region account for 95% of all malaria cases (228 million) and 96% of all malaria deaths (602 000). Moreover, the report showed that 80% of all malaria deaths in WHO African Region were among children under the age of five. Malaria services were disrupted during the COVID-19 pandemic in 2020, adding to the region’s malaria burden. 6 About 75% of Ethiopia’s landmass estimated to be malarious and 68% of the population is at danger of contracting the disease. Plasmodium falciparum is responsible for 60%–70%
of malaria cases in Ethiopia, with *P. vivax* causing the remainder.\(^7\)

In order to inform national malaria control interventions, the Global Technical Strategy for Malaria 2016–2030 report recommends that National Malaria Control Programmes analyse past malaria incidence data, risk factors related to the human host, parasites, vectors, and the environment.\(^8\) Spatial and temporal analysis of malaria data can be used as a decision-making tool to better understand the heterogeneity of malaria transmission in a nation, direct malaria control programmes and improve intervention efficiency.\(^9\)–\(^11\) Malaria cases spread more widely during normal monsoon years than during drought years, which can be attributed to a more conducive environment for mosquito breeding. The greatest link between seasonal and annual precipitation and malaria case burden was found in China and India.\(^12\)\(^\text{13}^\) Malaria transmission is seasonal in the Sahelian nations, with the exception of Algeria and Cabo Verde, which are year-round.\(^3\) Conducive environment, such as rainfall, high temperatures and humidity, is needed for malaria transmission between the mosquito vectors and its human host.\(^14\)\(^\text{15}\) Altitude and rainfall have an impact on the erratic and seasonal transmission pattern of malaria.\(^16\) Peak transmission in the majority of Ethiopian regions takes place from September to December, following the primary wet season (June to August), and the second minor transmission takes place from April to June, following a brief rainy season (February to March). However, its transmission tends to be highly heterogeneous within or between years, and from area to area.\(^17\)\(^\text{18}\)\(^\text{19}\) Most malaria cases are among working adults in rural areas, and malaria transmission typically corresponds with the planting and harvesting seasons. As a result, Ethiopia faces a significant economic burden.\(^7\)\(^\text{20}\) The indicators of malaria seasonality could allow for more accurate forecasting in malaria interventions and supply planning throughout the year.

To reduce the prevalence of malaria in the research area, various intervention actions have been carried out, such as the distribution of insecticide-treated nets (ITN), indoor residual spray and health information. However, the disease continues to be a serious public health issue and one of the main causes of morbidity.\(^20\) Ethiopia is currently implementing a malaria prevention and control programme with the goal of eliminating the disease by 2030.\(^21\)\(^\text{22}\) For the purpose of developing context-specific evidence-based interventions, making wise decisions and monitoring the effectiveness of malaria control programmes, researchers must look into trends of malaria in diverse settings. Hence, studies have demonstrated that both the frequency of malaria cases and the *Plasmodium* species composition change with time. It was proposed that this fluctuation was caused by climatic, environmental and behavioural risk factors in those years.\(^23\)\(^\text{24}\)

Even though there are retrospective malaria trend studies in Ethiopia, they reviewed routine clinical data at a single health institution. Therefore, lacks contextual information, is limited in scope, and does not present enough information to support the conclusions drawn. The present study assessed malaria prevalence in six health facilities of Ziquala district to overcome the above mentioned limitations. According to the Ziquala district health department office report, the district is one of the areas in the region where malaria is most prevalent, and it is one of the top 10 causes of morbidity there.

In order to comprehend the dynamics of disease transmission and assess the efficacy of malaria interventions for reducing the disease burden in a specific area, it is important to assess the pattern of malaria morbidity in endemic areas. It is essential to understand the current malaria prevalence in healthcare institutions in order to scale up and plan effective intervention programmes. Eventhough malaria is the most common reason for health institutions visit and hospitalisation in the study area, no studies have been conducted. Therefore, this study aimed to assess the trend of malaria from 2016/2017 to 2020/2021 in the health institutions of Ziquala district, Northeast Ethiopia.

**METHODS**

**Study area and period**

The study was conducted at the health facilities (Ziquala hospital, Tsitsika, Mishra, Arshewa, Kidamit and Hamusit health centres) of Ziquala district, Amhara region, Northeast Ethiopia. The overall population of the district is 55 708. Malaria is endemic in the area, however it varies seasonally. Malaria transmission peaks from September to December, following the rainy summer months, and from March to May. The district’s climatic circumstances are a favourable factor for malaria transmission. Some of the methods have been described in a previous paper\(^24\) (figure 1). The 5-year data (2016/2017–2020/2021) was reviewed from 1 December 2021 to 30 January 2022.

**Study population and eligibility criteria**

From 1 September 2016 to 30 August 2021, all malaria-suspected persons who visited Ziquala district health institutions and underwent blood film tests were included in the study. Malaria cases diagnosed throughout months and years, *Plasmodium* species detected, and sociodemographic data were all included in the analysis. Data that did not meet any of the inclusion criteria were excluded from the analysis.

**Study design, sampling method and data collection**

By examining blood film reports from laboratory logbooks, a retrospective study was carried out to evaluate the 5-year (2016/2017–2020/2021) trend of malaria at Ziquala district health facilities. In Ziquala district, there are five health centres and one district hospital. In this study, data was collected from all those health facilities. A total of 46 407 febrile patients were diagnosed from 1 September 2016 to 30 August 2021. Of these, 46 365 individuals screened for malaria were included in the study (figure 2).
However, 42 patients with incomplete data like sociodemographic and malarial variables were excluded from the study. In the study health facilities, only blood film examination using microscopy was done. As recommended by the WHO, these healthcare facilities used well-prepared and well-stained blood films to confirm the presence of malaria parasites. Trained laboratory technologists gathered the entire set of microscopically verified positive

Figure 1  Map of the study area. Maps were generated by authors using the ArcGIS V.10.8 software. The shape files of Ethiopia’s administrative regions, zones and woredas were freely downloaded from a link (https://africaopendata.org/dataset/ethiopia-shapefiles).

Figure 2  Sampling procedure for a study conducted on malaria among febrile patients in Ziquala district, Northeast Ethiopia from September 2016 to August 2021.
and negative results. Data collection checklist was used to gather information about the patient’s age, sex, date, month, and year of the examination, blood film result, and Plasmodium species found. The positivity rate of malaria infections per hospital, month, year, age, sex and residence was calculated.

**Data quality control**
Before collecting data, the completeness of the malaria diagnostic data was reviewed to verify data quality. Data were examined for completeness of all variables in the Ziquala district’s health institutions from 2016/2017 to 2020/2021. Then, a data-collection format sheet was created using Microsoft Excel and used for data recording. The data collector has been trained for 2 days prior to data extraction. The lead investigator monitored the whole data extraction procedure, and before analysis, the data were reviewed for accuracy, completeness and consistency. The analysis did not include any data that were incompletely documented.

**Statistical analysis**
Using Microsoft Excel, data were retrieved from laboratory registration logbooks and summarised. The SPSS V.26 software package was then used to input and analyse the data. To present the data and analyse malaria trends over years, months and seasons, descriptive statistics were used. The relationship between the prevalence of malaria and other factors, including sex, age, month, year and parasite type, was examined using a χ² test. Figures and tables were used to depict the number of malaria cases over the last 5 years (2016/2017–2020/2021). P values less than 0.05 were deemed statistically significant for all comparisons at a 95% confidence level.

**RESULTS**

**Overall positivity rate and annual trend of malaria at Ziquala district**
A total of 46 365 patients who were clinically suspected of malaria were screened for malaria parasites throughout the last 5 years, from September 2016 to August 2021. The overall positivity rate of malaria was 31.1% (14 429/46 365). When the proportion was taken into account, the prevalence decreased from 35.8% (3420/9556) in 2016/2017 to 27.3% (2071/7590) in 2018/2019, but it gradually rose to 29.6% (3598/12163) in 2019/2020 (figure 3), and the difference was statistically significant (p<0.0001).

The number of malaria suspected cases progressively increased from 2016/2017 to 2017/2018, sharply grew during 2018/2019 to 2019/2020, and then it declined in 2020/2021. On average 9273 febrile and 2886 malaria-confirmed cases visited the health facilities in each year. Of the Plasmodium species identified, *P. falciparum* was the most predominant species accounting for 8612 (59.7%), followed by *P. vivax* 5338 (37.0%) and mixed infection accounted for 479 (3.3%) from the confirmed malaria cases (table 1).

Over the last 5 years, there has been a shifting pattern in malaria cases, with the greatest number of cases (3598) in 2019/2020, followed by 3420 in 2016/2017. The malaria trend was decreased from 2016/2017 to 2018/2019 but there was a sharp increase in malaria prevalence from 2018/2019 to 2019/2020 and then decline from 2019/2020 to 2020/2021. The number of malaria cases...
P. falciparum showed a decreasing pattern from 1744 in 2016/2017 to 1228 in 2018/2019 then sharply increases from 1228 in 2018/2019 to 2371 in 2019/2020, before declining in 2020/2021. The trend of P. vivax showed a similar trend, with the exception that the highest number was recorded in 2016/2017, while the highest number of P. falciparum was recorded in 2019/2020. Moreover, the highest number of mixed infections was observed in 2019/2020 (figure 4).

Malaria positivity rate, species distribution and trends among health institutions

The positivity rate and distribution of Plasmodium species from 2016/2017 to 2020/2021 also varied among health institutions. Ziquala district hospital had the highest malaria positivity rate (33.6%), followed by Tsitsika health centre (33.4%) and Mishra health centre (29.2%). The lowest malaria cases were reported from the Hamusit health centre (24.5%). Regarding the species distribution, P. falciparum was the most prevalent species in all health facilities. A higher percentage was found in Hamusit health centre 63.9% (586/917) followed by Arshewa health centre 62.0% (1003/1618) and Ziquala hospital 60.6% (3133/5169). On the contrary, the positivity rate of P. vivax was significantly higher in Kidamit, Mishra and Tsitsika health centres accounting 42.5%, 40.4% and 37.5%, respectively (table 2).

According to the record review, a fluctuating trend of malaria cases was reported among health institutions in the last 5 years. The trend of malaria cases showed an increment in Ziquala hospital from 2016/2017 to 2019/2020. On the contrary, in Tsitsika and Mishra health centres malaria cases decrease from the year 2016/2017 to 2018/2019 and then increase in 2019/2020. Furthermore, Arshewa, Kidamit and Hamusit health centres showed a declined malaria trend from 2016/2017 to 2020/2021. In all health facilities, the number of malaria cases was decreased in 2020/2021 (figure 5).

Overall monthly and seasonal variation of malaria cases between 2016/2017 and 2020/2021

Almost every month and season of the year had malaria cases, despite the study area’s apparent fluctuations in malaria trends. In the present study, the maximum numbers of malaria cases were reported in September, October,

![Figure 4](image_url)
November and December accounting as 1777, 1747, 1462 and 1299, respectively. This period is considered as the peak malaria transmission period in Ethiopia after the heavy rain in July and August. Following the heavy rains in July and August, this time frame is regarded as the malaria transmission peak in Ethiopia. In contrast, the lowest number of malaria cases were observed in February (766) and March (882) months. In general, the mean monthly malaria-confirmed case was 240.48 over the last 5 years (figure 6).

The highest peak of malaria cases was observed during autumn (September to November) and the minimum malaria cases were observed during spring (March to May) seasons. In terms of cases per species, the maximum numbers of *P. falciparum* and *P. vivax* cases were observed in autumn and summer (June to August). Additionally, spring was the season with the minimum malaria cases in both species (figure 7).

Table 2 Malaria distribution by different health institutions in Ziquala district, Northeast Ethiopia from September 2016 to August 2021

<table>
<thead>
<tr>
<th>Health institution</th>
<th>Blood films examined number (%)</th>
<th>Confirmed cases number (%)</th>
<th>Plasmodium species</th>
<th>P. falciparum number (%)</th>
<th>P. vivax number (%)</th>
<th>Mixed number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ziquala hospital</td>
<td>15 397 (33.2)</td>
<td>5169 (33.6)</td>
<td>3133 (60.6)</td>
<td>1845 (35.7)</td>
<td>191 (3.7)</td>
<td></td>
</tr>
<tr>
<td>Tsitsika health centre</td>
<td>11 775 (25.4)</td>
<td>3936 (33.4)</td>
<td>2338 (59.4)</td>
<td>1475 (37.5)</td>
<td>123 (3.1)</td>
<td></td>
</tr>
<tr>
<td>Mishra health centre</td>
<td>7026 (15.2)</td>
<td>2051 (29.2)</td>
<td>1154 (56.3)</td>
<td>829 (40.4)</td>
<td>68 (3.3)</td>
<td></td>
</tr>
<tr>
<td>Arshewa health centre</td>
<td>5683 (12.6)</td>
<td>1618 (28.5)</td>
<td>1003 (62.0)</td>
<td>579 (35.8)</td>
<td>36 (2.2)</td>
<td></td>
</tr>
<tr>
<td>Kidamit health centre</td>
<td>2746 (5.9)</td>
<td>738 (26.9)</td>
<td>398 (54.0)</td>
<td>314 (42.5)</td>
<td>26 (3.5)</td>
<td></td>
</tr>
<tr>
<td>Hamusit health centre</td>
<td>3738 (8.1)</td>
<td>917 (24.5)</td>
<td>586 (63.9)</td>
<td>296 (32.3)</td>
<td>35 (3.8)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>46 365 (100)</td>
<td>14 429 (31.1)</td>
<td>8612 (59.7)</td>
<td>5338 (37.0)</td>
<td>479 (3.3)</td>
<td></td>
</tr>
</tbody>
</table>

The positivity rate of malaria varies between age, sex and place of residence. Regarding morbidity of malaria by age group, the majority of the cases (6709, 46.5%) were reported among 15–45 years followed by 4040 (28.0%) cases in the 5–14 years of age group. There was no statistically significant difference (p=0.364) between age groups in χ² analysis (figure 8).

In terms of sex, from the total of 14 429 malaria cases recorded in 5 years, 9206 (63.8%) and 5223 (36.2%) were reported in males and females, respectively. The difference was statistically significant (p<0.001). Moreover, in the Ziquala district, those who live in rural areas of the district are more likely to contract malaria than those who reside in urban areas. Rural residents had infection rates of 69.3%, while urban residents had infection rates.

Figure 5 The trend of malaria positivity rate among each health institutions in Ziquala district, Northeast Ethiopia from September 2016 to August 2021.
of 30.7%. Moreover, there was a significant difference between rural and urban residents (p=0.038) (table 3).

**DISCUSSION**

In the present study, a total of 14,429 confirmed malaria cases were detected from September 2016 to August 2021 in Ziquala district. The overall positivity rate of malaria in this study was 31.1%. This shows that the prevalence of malaria in the research area necessitates coordinated efforts for the implementation of efficient malaria preventive and control measures. The current study malaria positivity rate was comparable to those conducted at the Arjo-Didessa sugar development site 33.4%, Walga health centre 33.8%, Wolaita Zone, Southern Ethiopia 33.27%, and Nakfa hospital, Eritrea 33.0%. However, this result was lower than similar studies conducted in Kola Diba health centre 39.6%, Mankush health centre, Western Ethiopia 51.04% and Bale zone, Southeast Ethiopia 66.7%. On the other hand, this finding was higher than studies conducted in Ataye, North Shoa, Ethiopia 8.4%, Woreta health centre, Northwest Ethiopia 5.4% and Dembecha health centre, Northwest Ethiopia 16.34% and the pool prevalence of malaria among adults in Ethiopia 13.6%. This variation might be due to differences in the implementation of the prevention and control of malaria.

![Figure 6](bmjopen.bmj.com) The trend of malaria cases by months at Ziquala district, Northeast Ethiopia from September 2016 to August 2021.

![Figure 7](bmjopen.bmj.com) The distribution of confirmed malaria cases by seasons at Ziquala district, Northeast Ethiopia from September 2016 to August 2021.

<table>
<thead>
<tr>
<th>Season</th>
<th>Number of malaria cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter</td>
<td>1803</td>
</tr>
<tr>
<td>Spring</td>
<td>1697</td>
</tr>
<tr>
<td>Summer</td>
<td>2074</td>
</tr>
<tr>
<td>Autumn</td>
<td>3038</td>
</tr>
<tr>
<td>P. falciparum</td>
<td>3038</td>
</tr>
<tr>
<td>P. vivax</td>
<td>1753</td>
</tr>
<tr>
<td>Mixed</td>
<td>195</td>
</tr>
<tr>
<td>Total</td>
<td>4986</td>
</tr>
</tbody>
</table>

malaria, population vulnerability, and community awareness of the disease’s transmission and prevention. In addition, the study area’s high positivity rate of malaria might potentially be a result of the local climate. The district is classified as a hot and warm submoist lowland located at an elevation of 1450 m above sea level, with an annual temperature of 22°C and rainfall of 225 mm. The Anopheles mosquito and the Plasmodium species both have high survival and development rates under these environmental circumstances. The frequency with which adult female mosquitoes bite would rise due to the higher temperature, thereby increasing the risk of malaria transmission to uninfected human hosts.

The result of this study showed that the positivity rate of *P. falciparum*, *P. vivax* and mixed infections was 59.7%, 37.0% and 3.3%, respectively. This was in agreement with studies conducted in Kombolcha health centre which reported the positivity rate of *P. falciparum* 60.2%, *P. vivax* 35.5% and mixed infections accounted for 4.3%, in Woreta health centre, which reported the positivity rate of *P. falciparum* 69.7%, *P. vivax* 26.5% and 3.8% mixed infection. It was also comparable to the national malaria parasite distribution pattern, *P. falciparum* (60%), and *P. vivax* (40%) in Ethiopia. The study area has lowland climatic conditions, where *P. falciparum* is a widespread species in the lowlands, as well as the possibility of development of resistance to currently used medications or *P. falciparum*’s recrudescence features, may explain why *P. falciparum* dominates *P. vivax*.

The 5-year retrospective data analysis demonstrated that the overall positive rate of malaria was dropping, with the exception of a peak spike in 2019/2020. This study confirmed that malaria infection reduced from 2016/2017 (3420, 35.8%) to 2018/2019 (2071, 27.3%). This could be because malaria control techniques are being implemented properly in these years. The highest number of malaria infections was recorded in 2019/2020 (3598, 29.6%) might be due to the occurrence of malaria epidemics in the study area as the information obtained from the district health office indicated. It might also be due to the community and responsible bodies had given less attention on the prevention and control measures of malaria in this year. In general, although the health system data showed a continual decline of malaria positivity rate

![Figure 8](http://bmjopen.bmj.com/)

**Figure 8** Malaria cases distribution by age groups at Ziquala district, Northeast Ethiopia from September 2016 to August 2021.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Blood films number (%)</th>
<th>Slide positive number (%)</th>
<th><em>P. falciparum</em> number (%)</th>
<th><em>P. vivax</em> number (%)</th>
<th>Mixed number (%)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>27 077 (58.4)</td>
<td>9206 (63.8)</td>
<td>5598 (60.8)</td>
<td>3303 (35.9)</td>
<td>305 (3.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Female</td>
<td>19 288 (41.6)</td>
<td>5223 (36.2)</td>
<td>3014 (57.7)</td>
<td>2035 (39.0)</td>
<td>174 (3.4)</td>
<td></td>
</tr>
<tr>
<td>Residence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>36 106 (77.9)</td>
<td>11 831 (82.0)</td>
<td>7607 (64.3)</td>
<td>3888 (32.9)</td>
<td>336 (2.8)</td>
<td>0.038</td>
</tr>
<tr>
<td>Urban</td>
<td>10 259 (22.1)</td>
<td>2598 (18.0)</td>
<td>1005 (38.7)</td>
<td>1450 (55.8)</td>
<td>143 (5.5)</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Distribution of confirmed malaria cases by sex and residence at Ziquala district, Northeast Ethiopia from September 2016 to August 2021.
in the study area proves that the efforts that have been made by the district, as well as the regional health office and other concerned bodies to control malaria in the study area, were not sufficient.

The number of malaria cases in recent year has shown decreased in the study area. This could be attributed to the efficacy of national malaria control and preventive measures. The overall trend of malaria positivity rate in the district was variable. This was in agreement with the study conducted in Kombolcha health centre, Adi Arkay health centre and Bichena primary hospital. This emphasises the importance of ongoing and joint efforts to manage, prevent and possibly eliminate malaria. The positivity rate of *P. falciparum* showed a steady increased from 2016/2017 to 2020/2021 in the study area. This was in contrast to a study conducted at Wolktie health centre where *P. vivax* was dominated over *P. falciparum* throughout a study period. Because of its clinical consequences and the danger of medication resistance, stakeholders have focused their efforts on combating *P. falciparum*.

The highest rate of malaria infection was at Ziquala hospital, followed by Tsitsika and Mishra health centres. *P. falciparum* was the predominant species found in all health facilities. This variation in malaria positivity rates among different areas is consistent with studies conducted in Wolktie, Southern Ethiopia, Tanzania and Iran. This could be related to regional disparities in malaria prevention and control efforts. These variances could also be attributable to altitude differences and climate diversity, which are directly related to Anopheles species reproduction.

The trend of malaria cases showed a decline in all health facilities with exception of Ziquala hospital and Mishra health centre. According to the Ziquala district health department, an extremely violent outbreak was noticed in the catchment areas of Ziquala hospital and Mishra health centre in 2019/2020. Early diagnostic and treatment protocols were followed at health facility and community levels, as well as thorough management of severe malaria at higher health services, and the outbreak was brought under control in a few months. ITN were distributed at every household unit in the Ziquala district to reduce man–mosquito contact. Activities to raise community awareness have also been conducted through the promotion of information, education and communication.

Environmental, climatic and seasonal factors play a major role in determining the prevalence and extent of malaria transmission. In this study, the highest number of cases was found in September (1777) while the lowest number of cases was found in February (766). This is related to temperature, rainfall and relative humidity which are all factors that affect malaria transmission at different periods of the year. Furthermore, in the research area, seasonal fluctuations in malaria positivity rate have been found. Autumn (September to November) has the highest prevalence of malaria cases, followed by summer (June to August).

The findings of this study were consistent with studies conducted in Wolktie health centre, Guba district and a national report which found that the peak malaria transmission season is from September to December, following the rainiest season from June to September. It might be related to the formation of breeding sites during and after the heavy rain season, favourable temperature and high vegetation density for mosquito breeding. Seasonal fluctuations in rainfall and temperature influence the availability of mosquito vector breeding habitats, the length of mosquito larvae development and the rate of multiplication of malaria parasites inside the vector. The transmission coincides with the primary harvesting and ploughing seasons in the study area and rural Ethiopia in general. This might have a deleterious socioeconomic effect on productivity and development of the district and the country as a whole.

In the current study, malaria cases were observed in both gender and all age groups of the population throughout the study period. In terms of the distribution of malaria positivity rate by age group, the majority of reported cases were between the ages of 15 and 45. Since, this productive age group might involve in agricultural activities and need to travel exposing places. This was consistent with a study conducted in Kola Diba and Kombolcha health centres. Malaria was found to be less common in people over the age of 45, as well as in children under the age of five. This could be because they are less likely to be bitten by mosquitoes and slumber under bed nets. This study also showed that males had a greater rate of malaria positivity (58.1%) than females (41.9%). This finding is consistent with other research conducted in other parts of Ethiopia. Males are thought to have a greater malaria positivity rate because they are more likely to engage in outdoor activities that expose them to the disease, little chance of sleeping under bed nets and travel to endemic areas for labour work. Malaria was more widespread in the rural population than in the urban population throughout the reviewed period. This was in disagreement with a study done in Kombolcha health centre. As a result, rural people are more likely to engage in outside activities such as keeping domestic animals and other agricultural products, making them more vulnerable to Anopheles mosquito bites. There was a statistically significant association between Plasmodium infection and residence in this investigation. Because Plasmodium infection varies by geographical context and population, the control strategy must be according to the local epidemiology of each place. As a result, the national malaria control programme should improve high-risk populations’ access to malaria prevention and stratification-based prioritisation of high-risk locations.

**Strengths and limitations of the study**

The use of 5 years of pooled data provided more power to assess the trends of malaria morbidity in the study area, which gives essential information to strengthen malaria control interventions. To overcome the limitations of...
research conducted on a single health facility, the current study assessed malaria prevalence in six health facilities in the Ziquala district. On the other hand, the present study had some limitations. This research also did not include the case fatality rate and the determinants of malaria infection. The datasets were collected solely from health facilities, which may have underestimated the real burden of malaria in the study area’s population. Another limitation of the research was poor data management: 42 patients were excluded from the study, and only 5-year data were available at the time of data collection preventing us from conducting more than a 5-year retrospective analysis.

Conclusion

Although the results indicate a fluctuating yet declining trend, malaria infection remains a serious health problem in the Ziquala district. *P. falciparum* is the dominant species in the study area, indicating a shift from *P. vivax* to *P. falciparum* malaria, which poses a challenge to the ongoing malaria elimination programme’s effectiveness. The reproductive age group and males were more affected by the infection, which was more prevalent during the cultivation season, affecting public health and economic growth in the district and throughout the nation. As a result, malaria control and elimination programmes should be strengthened in order to further reduce the burden of malaria, especially among the most vulnerable groups. There is also a need to strengthen *P. falciparum* prevention and control measures.

Acknowledgements

The authors thank Wollo University for its ethical approval. The authors also thank Ziquala district health department, health facilities administrators and data collectors.

Contributors

HD and HB were involved in design of the study, supervised the data collection, and performed the data analysis and interpretation. HE, MT, ZD, NG and DGF assisted in designing the study, data collection, data analysis and interpretation. HD wrote the manuscript. HB and DGF critically reviewed the final version of the manuscript. HD is responsible for the overall content as the guarantor. All authors agreed to bear responsibility for all parts of the research work and approved the final version of the manuscript.

Funding

The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Map disclaimer

The inclusion of any map (including the depiction of any boundaries therein), or of any geographic or locational reference, does not imply the expression of any opinion whatsoever on the part of BMJ concerning the legal status of any country, territory, jurisdiction or area or of its authorities. Any such expression remains solely that of the relevant source and is not endorsed by BMJ. Maps are provided without any warranty of any kind, either express or implied.

Competing interests

None declared.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication

Not applicable.

Provenance and peer review

Not commissioned; externally peer reviewed.

Data availability statement

All data relevant to the study are included in the article or uploaded as supplementary information.

Open access

This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/.

REFERENCES


