

Decreasing Trend of *Plasmodium Falciparum* and *Vivax* Transmission in Mojo Health Center, East Shoa Oromia Region, Ethiopia: a Retrospective Study

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Research

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Abstract

Introduction: Malaria continues to strike hardest against the public health and economic development in Ethiopia. Its transmission tends to be highly heterogeneous within or between years, and from area to area which need understanding of the contextual diversity of malaria prevalence within each site to deliver optimal intervention according to the site specific situation of the disease. Thus, this study was aimed to determine the trend prevalence of malaria in Mojo health center, East Shoa Zone, Ethiopia.

Methods: A retrospective study was conducted in Mojo health center, East Shoa zone, Ethiopia from February to March, 2021. Malaria cases and related data reported 2016-2020 were carefully reviewed from laboratory registration logbooks. The collected data was analyzed using SPSS 25 software.

Results: A total of 19, 106 blood films were examined from malaria suspected patients. The overall microscopically confirmed prevalence of malaria was 4.2%. *P. vivax* was the predominant species accounting 76.2% of positive samples. Malaria cases declined from 259 in 2016 to 77 in 2020. The proportion of malaria was higher among males (64.8%) than females (35.2%) in all five years. Higher malaria cases was observed from the age group 15-24 years old followed by the age group of 25-34. Malaria cases were at a peak level from September-November and lowest from December-February.

Conclusion: Although the declining trend of malaria prevalence was observed, malaria still remains a public health burden in the area. The high burden of malaria among reproductive age group, males, and during cultivation season reflects its impact on health and economic development. Shifting of *P. falciparum* to *P.vivax* related malaria should get an attention during prevention and control strategies for the successful progress of malaria elimination programme.

Introduction

Despite being preventable and treatable, malaria continues to be one of the global deadly diseases contributing a significant impact on public health and economic development. There are four different human malaria causing species (*P. falciparum*, *P. vivax*, *P. malariae* and *P. ovale*), of which *P. falciparum* and *P. vivax* are the most prevalent and *P. falciparum* is the most dangerous [1]. An estimated 229 million cases and 409 000 deaths were reported in 2019. The disease remains as a substantial health burden particularly in African countries composing 94% of the worldwide malaria cases and deaths [2].

In over a decade, remarkable achievements in malaria control were made which may have resulted from the improved coverage of interventions including vector control (destructing the breeding sites, and stopping mosquitoes from biting human beings), chemo-prevention (providing drugs that suppress infections), diagnostic testing and treatment [1] leading to overt billion of cases and million malaria deaths [2]. The global malaria case incidence (cases per 1000 population at risk) reduced by less than 2, and the mortality rate (deaths per 100 000 population at risk) from 12 in 2015 and 10 in 2019 indicating a slowing of decline on the rate of cases and deaths since 2015 [2].

Despite continuous efforts, malaria continues to strike hardest against the health of population in Ethiopia. About 60% of the population lives in malarious areas, and 68% of the country's landmass is favorable for malaria transmission associated with altitude and rainfall. The peak of malaria incidence follows the main rainfall season (July to September) each year. However, many areas in the south and west of the country have a rainfall season starting earlier in April and May or have no clearly defined rainfall season. As a result, malaria transmission tends to be highly heterogeneous within or between years, and from area to area [3–6].

There was a fluctuating trend of malaria within the last decade showing a significant reduction of malaria in 2014/15 compared to the previous 2013/2014 [7]. This declining report has been supported by the national malaria indicator survey 2015 showing the reduction of the prevalence from 1.3% in 2011 to 0.5% in 2015 [3]. Furthermore, Deribew and his colleagues have also documented the decrement of malaria new cases and deaths from 2.8 million to 621,345 cases, and 30,323.9 to 1561.7 deaths in 1990 and 2015, respectively [8]. A previous retrospective studies have also reported malaria reduction [9–11].

However, the report on decline of malaria is not conclusive that public health emergency management (PHEM) has shown an increased malaria transmission[7], and have no clearly defined situation of malaria [6]. It might be due to several factors including the resistance of the parasite to antimalarials and vectors to insecticides, and complexity of control process. In addition, the country has an interaction of variable winds, seasonal rains and ambient temperatures causing diverse micro-climates with low population immunity accelerating focal malaria transmission [7].

The fact that the prevalence of malaria is expected to shift over the years informing an understanding of the contextual diversity of malaria prevalence within each site to identify the optimal interventions, and to deliver according to the site specific situation of the disease. Therefore, determining epidemiological trends of malaria cases from specific health facility is valuable to measure progress towards malaria elimination. Thus, this study was aimed to determine the trend prevalence of malaria in Mojo health center, East Shoa Zone, Oromia region Ethiopia. As a result, results from this study will be useful in understanding and improving the interventions and in providing the information for development of new strategies for burden reduction and elimination of malaria in the country.

Methods And Materials

Study setting, and design

An institution based retrospective cross-sectional study was conducted in Mojo health center located in Mojo town from February to March, 2021. The Town is located in East Shoa zone, Oromia regional state at a distance of 70 km from Addis Ababa (capital city of Ethiopia), and 25 km from Adama town (Fig. 1). The town has an altitude range of 1730-1890m above sea level and characterized by its mean annual temperature of 16–17°C, and mean annual rainfall of 896mm. It has a latitude and longitude of 08° 37' North and 39° 07' East, respectively[12]. According to the Central statistical agency of Ethiopia' projection

carried out in 2015, the population of the town was 43,500. It has two health centers and one hospital. Among these, Mojo health center was chosen for this study since most of the town's population need to visit this health center due to its long duration of service provision than the two health institutions (Key informants). The town is malarious. Malaria is the most prevalent and seasonal disease in the area where both *P.vivax* and *P. falciparum* exist.

Study population

The study populations were all malaria suspected individuals who had visited the health center and blood film tested from January 2016 to December 2020.

Eligibility criteria

Data such as malaria cases diagnosed in months and years, types of *Plasmodium* species identified, and socio-demographic data (age and sex) were included in the analysis regardless of age, pregnancy and other infection status. Any missing data in the inclusion criteria were excluded.

Data collection and quality control

Five years malaria cases and related data were collected from Mojo health center laboratory logbooks using well developed check list. The check list consisted of year and month of visit, sex, age, blood film status (+/-), and detected *Plasmodium* species type. Data was collected by experienced medical laboratory technicians. In the health center, microscopic blood film examination was used as a golden standard to confirm the presence of *Plasmodium* parasite and identification of the species as recommended by WHO's protocol. The blood film examination for malaria parasite detection was performed according to standard operating procedure (SOP). The laboratory technologists or technicians who performed the microscopic examination were well trained in malaria microscopy. Microscopy examination was used exclusively for *Plasmodium* species detection throughout the study period (2016–2020). The data extraction process was followed up, and data were checked for completeness before analysis. Incompletely registered data were excluded from analysis.

Data processing and analysis

The collected data was coded, cleaned and entered to Epi-data and exported to SPSS 25 software for analysis. The findings were presented using frequency, tables and figures for relevant data. Descriptive statistics were performed to determine the frequencies and percentages of overall malaria prevalence, and trends of malaria transmission in terms of years, seasons, *plasmodium* species, sex and age. Chi-square test was employed to determine the association of malaria burden by sex and age groups. P-value < 0.05 was considered statistically significant in this study.

Results

Characteristics of the study population

During the study (January 2016 to December 2020), a total of 19,106 blood films from malaria suspected patients were examined to detect the presence of *Plasmodium* parasite. Lower (7.7%) number of blood films were examined in 2020. Majority of the study participants were females (54.5%). Near to thirty percent of the participants were in the age group of 15–24 years (Table 1).

Table 1
Total number of examined blood films distribution with regard to age, sex and year in Mojo health center from 2016 to 2020

Variables	Category	Frequency (%)
Sex	Male	8699(45.5)
	Female	10407(54.5)
Age	< 5	3208(16.8)
	5–14	2302(12.0)
	15–24	5747(30.1)
	25–34	4237(22.2)
	>=35	3612 (18.9)
Year	2016	3965 (20.8)
	2017	4443 (23.3)
	2018	4671 (24.4)
	2019	4550 (23.8)
	2020	1477 (7.7)

Overall prevalence and annual trend of malaria

The overall microscopically confirmed prevalence of malaria was 4.2% (793/19106). Regarding the identified *Plasmodium* species, both species of *Plasmodium* were reported in each year with *P. vivax* being the predominant species in the study area. Of the total positives, the highest prevalence of malaria was detected from *P. vivax* (76.2%) followed by *P. falciparum* (22.8%) and mixed infections (1.0%). Malaria cases had shown decrement from 259 in 2016 to 77 in 2020 (Fig. 2). When the proportion was considered, the prevalence was declined from 6.5% (259/3965) in 2016 to 2.3% (104/4550) in 2019, however it was increased to 5.2% (77/1477) in 2020, and the variation was statistically significant ($P < 0.0001$) (Fig. 3).

Malaria Distribution in relation to Age and Sex

Out of 793 malaria cases in 5 years, 514 (64.8%) and 279 (35.2%) were detected from males and females, respectively (Table 2). According to five years record of malaria cases, proportion of malaria was higher among males than females in all five years (Fig. 4). Regarding morbidity of malaria by age group, malaria was reported in all age groups and ranged from 7.4–37.3% out of recorded malaria cases within the five-year record in the study area. Relatively higher malaria cases (296 out of the total 793 malaria cases) was recorded from age group 15–24 years old followed by age group of 25–34 (211 out of 793 total malaria cases) (Table 2 & Fig. 5). The difference in the prevalence of malaria among sex and age difference was statistically significant ($P < 0.0001$).

Table 2
Recorded Malaria Distribution in relation to Age and Sex in Mojo health center from 2016 to 2020

Variables	Category	Frequency (%)
Sex	Male	514(64.8)
	Female	279(35.2)
Age	< 5	59(7.4)
	5–14	107(13.5)
	15–24	296(37.3)
	25–34	211(26.6)
	>=35	120(15.1)

Seasonal Distribution of Malaria

The seasonal distribution of malaria cases for the four seasons was analyzed. Malaria cases were reported in all months and seasons with some fluctuating trend. The peak in malaria cases occurred in July followed by November which is harvesting season during and after the main rainfall (Fig. 6). The highest cases of malaria (266 out of the total 793 cases) were observed during autumn (September–November), while the lowest cases (134 out of the total 793) were during winter (December–February). *P.vivax* infection was high in the summer and low in winter, while *P. falciparum* infection was high in the autumn and low in spring (Fig. 7).

Discussion

Malaria affects the lives of almost all people living in the area of Sub Saharan African countries where people at risk of the disease live in areas of relatively stable and seasonal malaria transmission[2]. In Ethiopia, malaria continuous as major public health problem despite relatively low prevalence compared to some African countries where malaria is endemic. Unstable malaria transmission patterns make the

country prone to epidemics [3, 13]. However, the country has planned to eliminate malaria from the whole country which needs sub-national elimination before nationwide elimination can be achieved. This is because the decrease in malaria burden is not uniform in the country [14] which is imperative to understand the contextual diversity of malaria prevalence within each site. Thus, this study determined epidemiological trends of malaria cases in specific health facility.

The current study found that the total number of microscopically confirmed malaria cases were 793 with a proportion rate of 4.2%. It was markedly lower than previous studies conducted out of Ethiopia elsewhere (25.9%-30.3%) [15, 16], and in several parts of the country such as in Dembia (21.8%) [6], Demebecha (16.34%) [17], Guba (51.04%) [11], Sibiu Sire (20.07%) [18], Arjo-Didessa sugar development site (33.4%) [19], Harari (46.9%) [20], Chalia district (7.55%) [21], Abeshge (33.8%) [22], and Bale Zone (66.7%) [23]. The overall prevalence of the current study was also relatively lower than the findings from other parts of Ethiopia like Northwest Tigray (6.96%) [4], Wereta (5.4%) [24], Kombolcha (7.52%) [9], Ataye (8.4%) [25], Halaba (9.5%) [5], Wolkite (8.56%) [26] and Arsi Negelle (11.45%) [27]. However, this study found higher prevalence of malaria relative to studies carried out abroad such as Panama (1.22%) [28] and India (1.3–3.07%) [29, 30].

These differences might be due to the fact that the quality of microscopic diagnosis is highly influenced by slide preparation and staining methodology, microscopist skill and quality of microscope [31]. The difference in time variations of the studies might also brought the difference on the overall prevalence of malaria since malaria is being declined from time to time as supported by the global [2], and national report of decreasing malaria prevalence since 2000 [14]. Moreover, the variations in malaria prevalence might also be due to geographical locations because of the fact that population awareness about malaria and application of intervention activities vary from area to area. Variation in sociodemographic status and utilization of intervention in the same locality also influence the prevalence as documented by previous studies conducted elsewhere [32–36].

In addition, the low prevalence of malaria in the current study could be due to the variation in species showing that *P. vivax* was the more predominant species in this study than *P. falciparum* in another studies listed above. This is due to the fact that the parasite density in *P. vivax* is typically lower than *P. falciparum* increasing the risk of false negative microscopy diagnosis with acute *P. vivax* malaria [31, 37, 38]. The thought was also supported by the review stated that microscopists correctly identified only 63%-86% of confirmed *P. vivax* positive blood films [37]. Another review also summarized that an average of 67% of *P. vivax* infections were reported as not detected by microscopic examination [39] masking the actual burden of *P. vivax* related malaria. This might be approved by the reporting of lower prevalence of *P. vivax* related malaria from studies done in Panama (1.22%) [28], and India (3.07%) [30] where *P. vivax* was the predominant species.

The results of the present study revealed that a sharply declined fashion of malaria cases was observed during the last five years. This finding was consistent with the worldwide decreasing malaria burden in which 1.5 billion malaria cases have been averted from 2000 to 2019 where most of the averted cases

(82%) were in the WHO African regions including Ethiopia [2]. A significant decline of malaria has been also reported in Ethiopia since 2000 [14]. The consistent reduction of malaria case in the current study was also concurred with the result of previous studies conducted in Vietnam [40], and other parts of the country such as Wolkite [26] and Jimma [41].

This might be due to the increased scaled-up of malaria control interventions by national malaria control programme of Ethiopia such as prompt diagnosis, community awareness creation, increased accessibility of long-lasting insecticide-treated nets (LLITNs) and high coverage of indoor residual spraying (IRS) [13]. This conclusion is further supported by the study indicating the reduction of malaria cases and deaths after implementing intervention [42]. This is also confirmed by the national malaria elimination roadmap proving that sustained high coverage of such interventions had reduced malaria morbidity by more than 50% between 2001 and 2011 [14]. The current progressive decline in annual malaria cases is suggestive of good national progress towards achieving of 2030 goals to reduce malaria incidence and mortality by at least 90% [14].

In contrary to the national profile of *Plasmodium* species in which *P. falciparum* is a dominant species [6, 14, 20, 23, 43], *P. vivax* accounted for 76.2% and was predominately reported in the current study. However, in line with the current study, *P. vivax* was reported as predominant species in studies done in Arsi Negelle [27] and Wolkite [26]. It could be due to the fact that malaria control programmes in the past had prioritized to focus on *P. falciparum* malaria because of its consideration as more pathogenicity, and easier to detect and treat [44, 45]. In addition, it could be due to the emergence of drug resistant [37], the parasite's ability to transmit early in the course of the disease [46], production of gametocytes transmitted more efficiently [47, 48], and a relapse from dormant liver stages [45, 49, 50]. This increment of the prevalence of *P. vivax* causing malaria with the decline of *P. falciparum* related malaria might also be supported by the fact of reporting Duffy independent invasion and genetic diversity of *P. vivax* leading to generation of new parasite strains that can translate into parasite's greater adaptability to new challenges for treatments and control measures [46].

In the present study, distribution of malaria cases was observed in both gender and all age groups of the population throughout the study period. Nevertheless, males were more affected than females which is consistent with studies conducted in other parts of Ethiopia [4–6, 11, 17, 19, 23] and out of Ethiopia in France [51] and Kuwait [16]. This gender difference in malaria prevalence could be due to the fact that males frequently bitten by mosquitoes due to the behavioral differences of males' working outdoors, little chance of sleeping under nets, travel to endemic sites for work, and dressing norms are more likely than females to expose their bodies increasing their chance of mosquitoes' bite [52]. Moreover, hormonal differences might play the role in such a way that testosterone was associated with decreased adaptive immunity against malaria [53]. Briggs and the colleagues have also thought that females cleared their infections at a faster rate than males [54] which might support the lower prevalence of malaria among females in the current study.

The present study had observed higher prevalence of malaria among age group of 15–24 years old than younger children and older adults which is in line with studies done in other parts of Ethiopia [6, 11, 25]. This might be due to the fact that productive age groups frequently engaged in outdoor activities. Surprisingly, lower prevalence of malaria was observed in children under 5 years of age which might be because of their less likely exposure to mosquito bite, and sleeping under mosquito nets.

The current study observed malaria cases in all months and seasons throughout the study period. It might indicate that malaria transmission is determined by socio-economic and biological factors such as mosquito control measures, population immunity, governmental policy and drug resistance have also contribution on malaria transmission and prevalence. In spite of that, the peak in malaria cases occurred in July followed by November which is harvesting season during and after the main rainfall. The highest cases of malaria were detected during autumn (September–November) which was in consistent with the findings of the studies carried out in Dembia [6], Demebecha [17], Northwest Tigray [4], Ataye [25], Guba [11], Jimma [41], and Harari [20]. It might be due to the heavy rains creating suitable environment for the breeding of *Anopheles* mosquitoes. In addition, it could be related to the formation of stagnant water after the heavy rain season, favorable temperature, and high vegetation density for mosquito breeding. The coinciding high prevalence of malaria with these cultivation months has a deleterious socioeconomic effect on productivity and development in the country.

Conclusion

The declining trend of the overall malaria prevalence was observed in the study area which is suggestive of good progress towards achieving of 2030 goals of malaria elimination. However malaria still remains a public health burden in the area affecting 4.2% of the population. The reproductive age group and males were more affected by the burden of malaria, and this was more common during cultivation season impacting on health and economic development. *P. vivax* is the dominant species in the study area reflecting the shift of *P. falciparum* to *P. vivax* related malaria burden challenging the success of ongoing malaria elimination programme. Therefore, malaria control and elimination programmes should be strengthened for further reduction of the burden of malaria particularly among highly affected groups. There is also a need for intensifying the prevention and control strategies on *P. vivax*.

Abbreviations

CDC: Center for Diseases Control and Prevention; EPHI: Ethiopian Public Health Institute; FMOH: Federal Ministry of Health; IRS: Indoor Residual Spraying; LLITNs: Long-Lasting Insecticide-Treated Nets; SPSS: Statistical Package for the Social Science; WHO: World Health Organization; UNDP: United Nations Development Programme; USAID: United States of America Department of State; WWARN: Worldwide Antimalarial Resistance Network

Declarations

Authors' contributions

AA and LG conceived the study. AA collected and analyzed the data, and wrote the first draft of the manuscript under supervision of LG. AA generated a map. AA and LG critically reviewed the manuscript. Both authors read and approved the final manuscript.

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Availability of data and materials

All data of findings are available from corresponding author on reasonable request. All relevant data are within the manuscript.

Ethics approval and consent to participate

Ethical clearance and support letter were obtained from Institutional review board (IRB) of Addis Ababa University, Aklilu Lemma Institute of Pathobiology, and Mojo health center to use the data for research purpose. No names or identifying information were indicated on the checklists, and confidentiality was assured throughout the study.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

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Figures

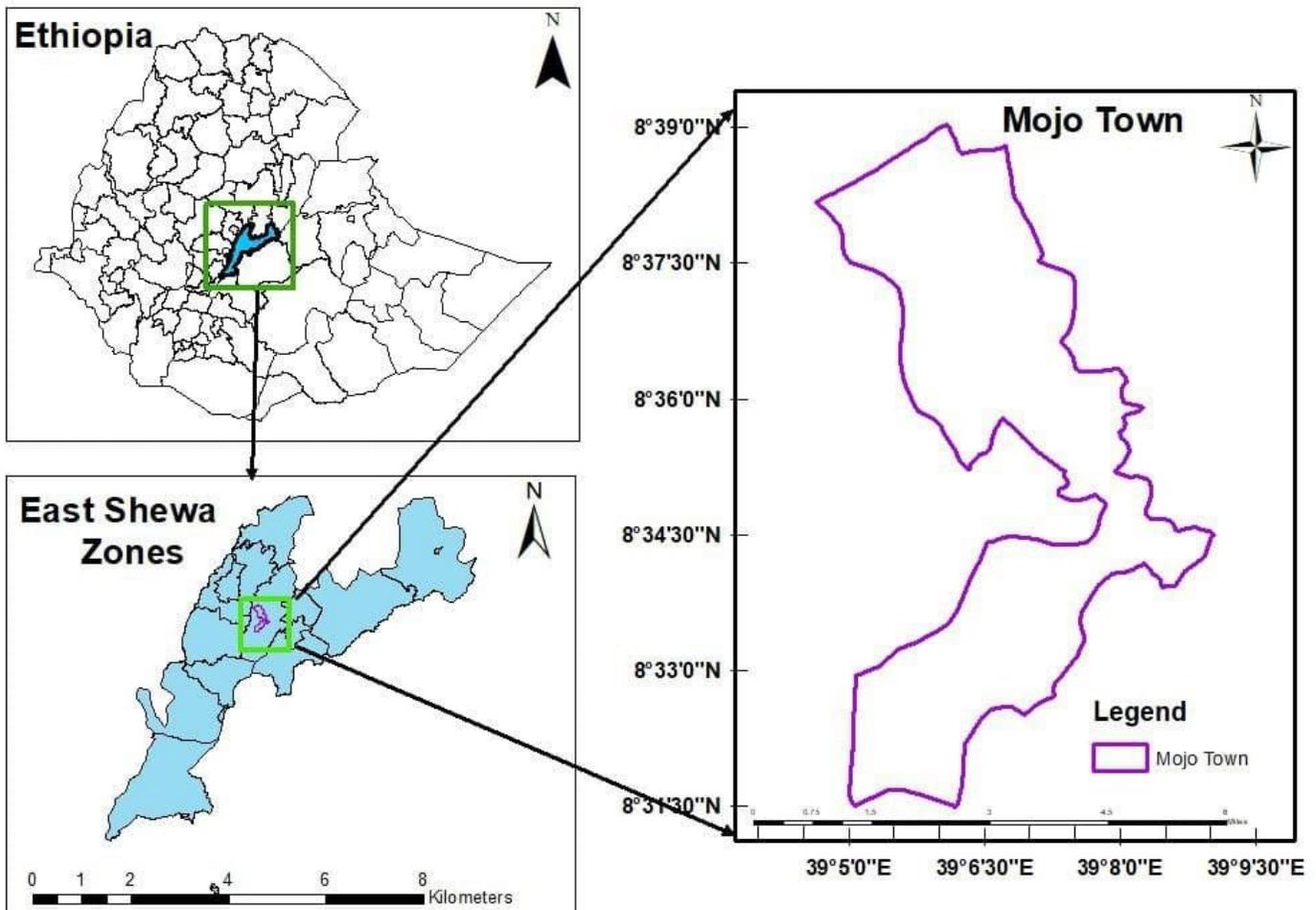


Figure 1

Physical location of Mojo town. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

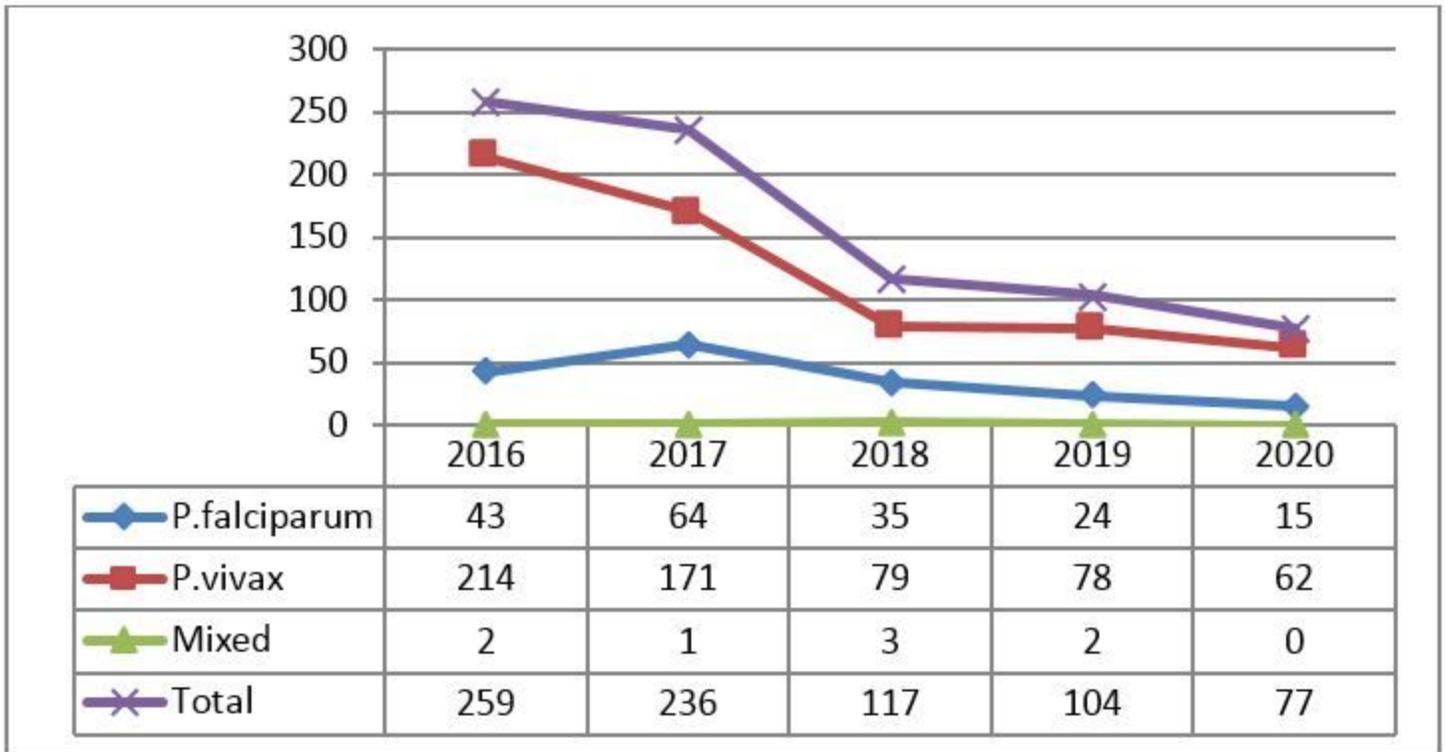


Figure 2

Annual trends of malaria cases in Mojo health center from 2016 to 2020

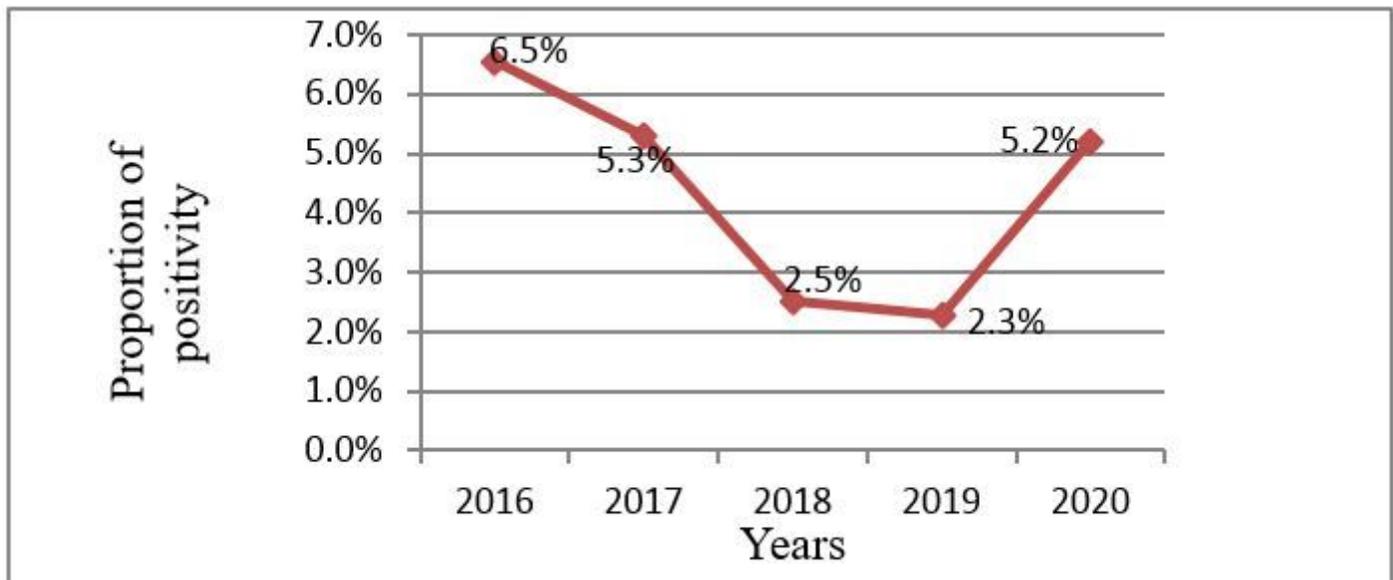


Figure 3

Annual trends of malaria prevalence in Mojo health center from 2016 to 2020

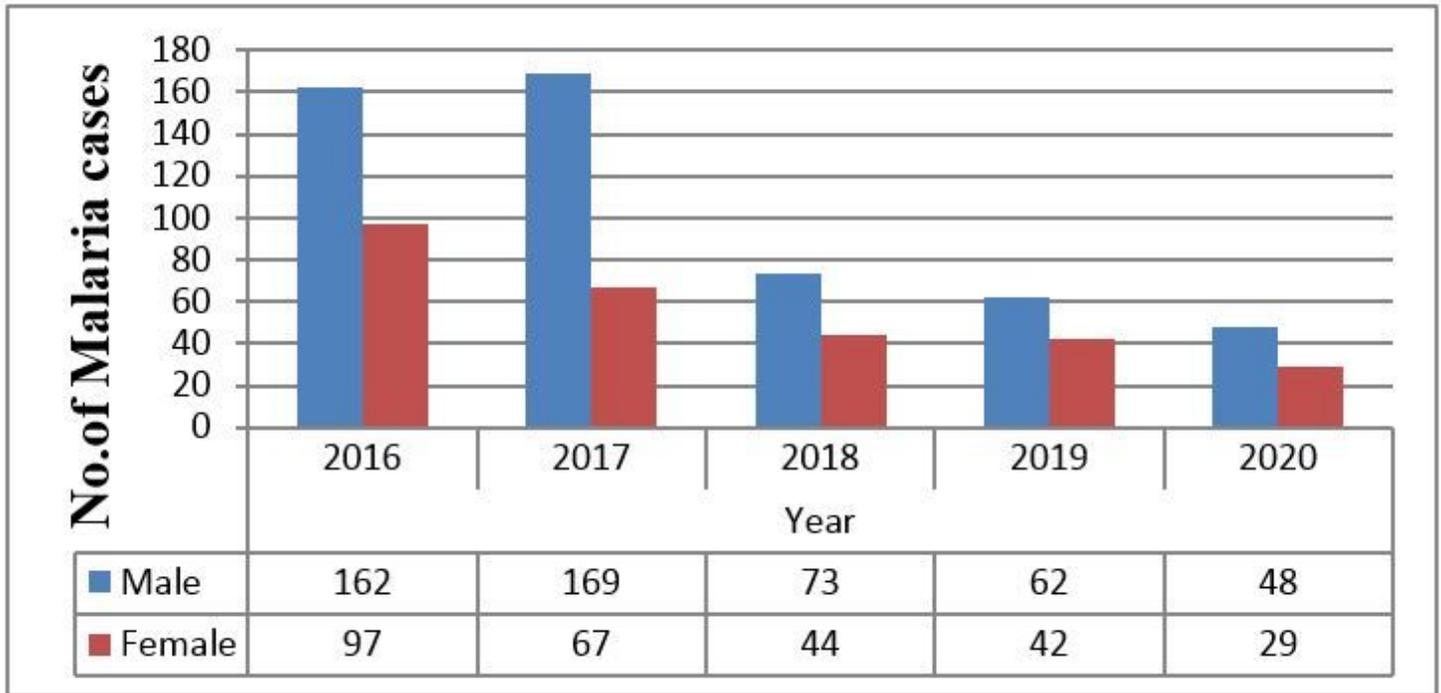


Figure 4

Annual trend of malaria cases by sex in in Mojo health center from 2016 to 2020

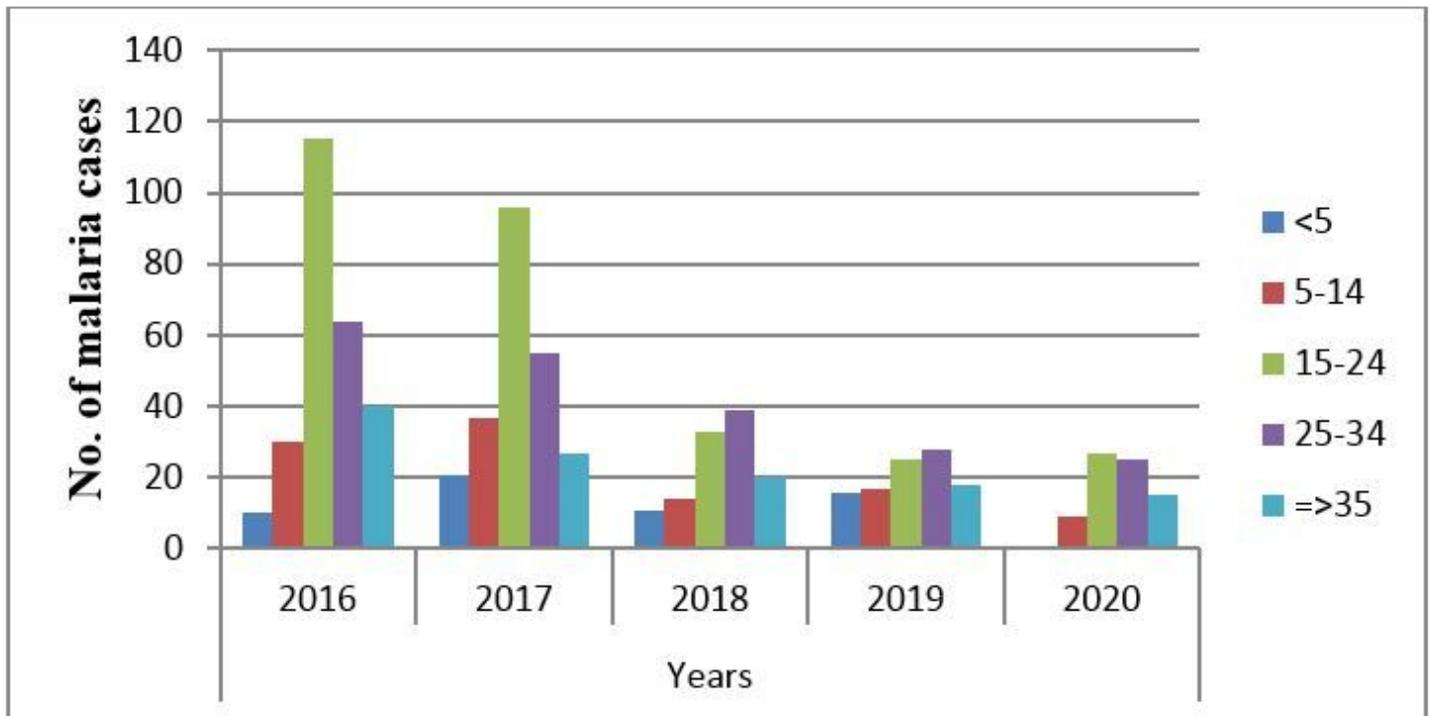


Figure 5

Annual trend of malaria cases by age in Mojo health center from 2016 to 2020

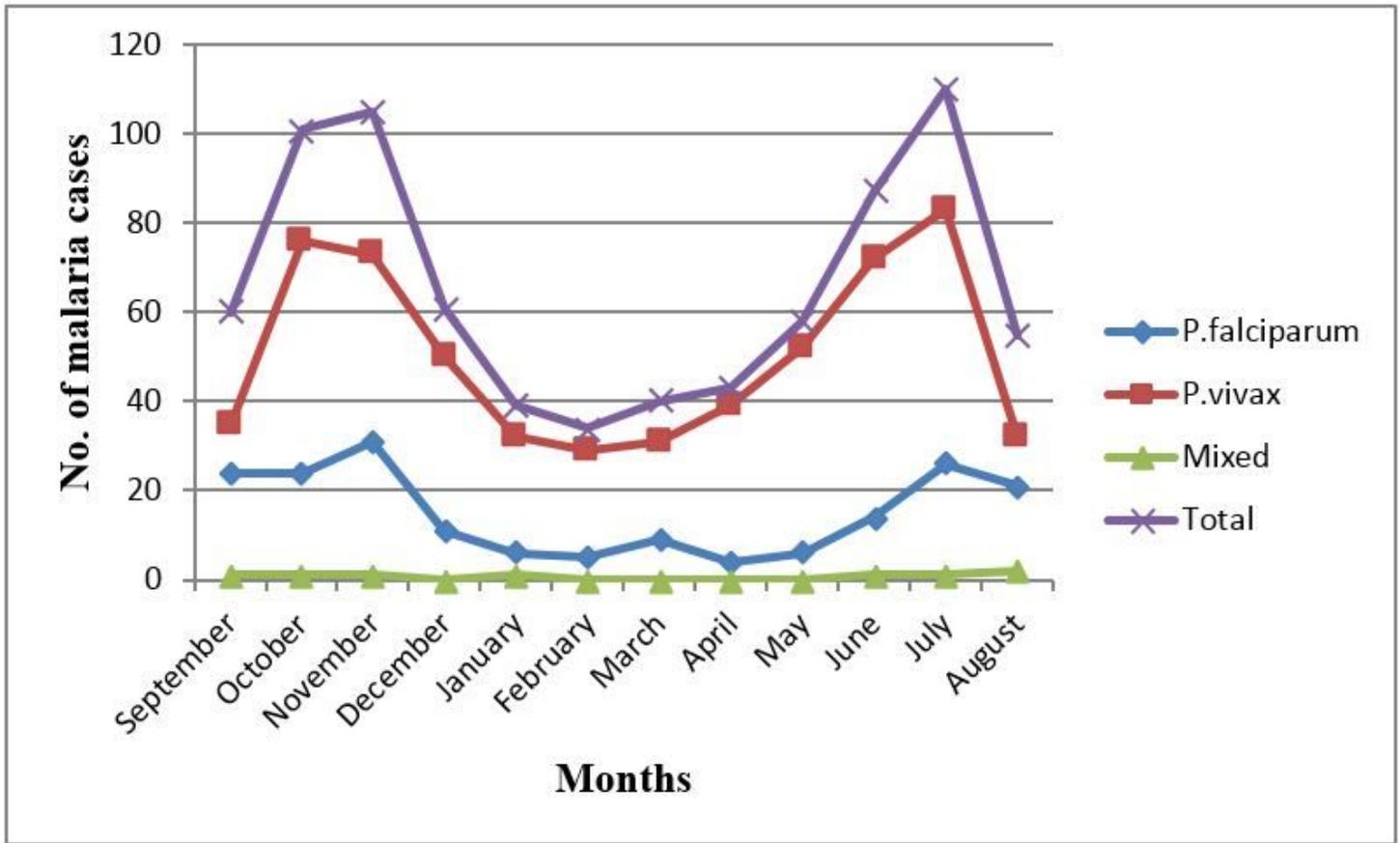


Figure 6

Trend of malaria prevalence with Plasmodium species and month in Mojo health center from 2016 to 2020

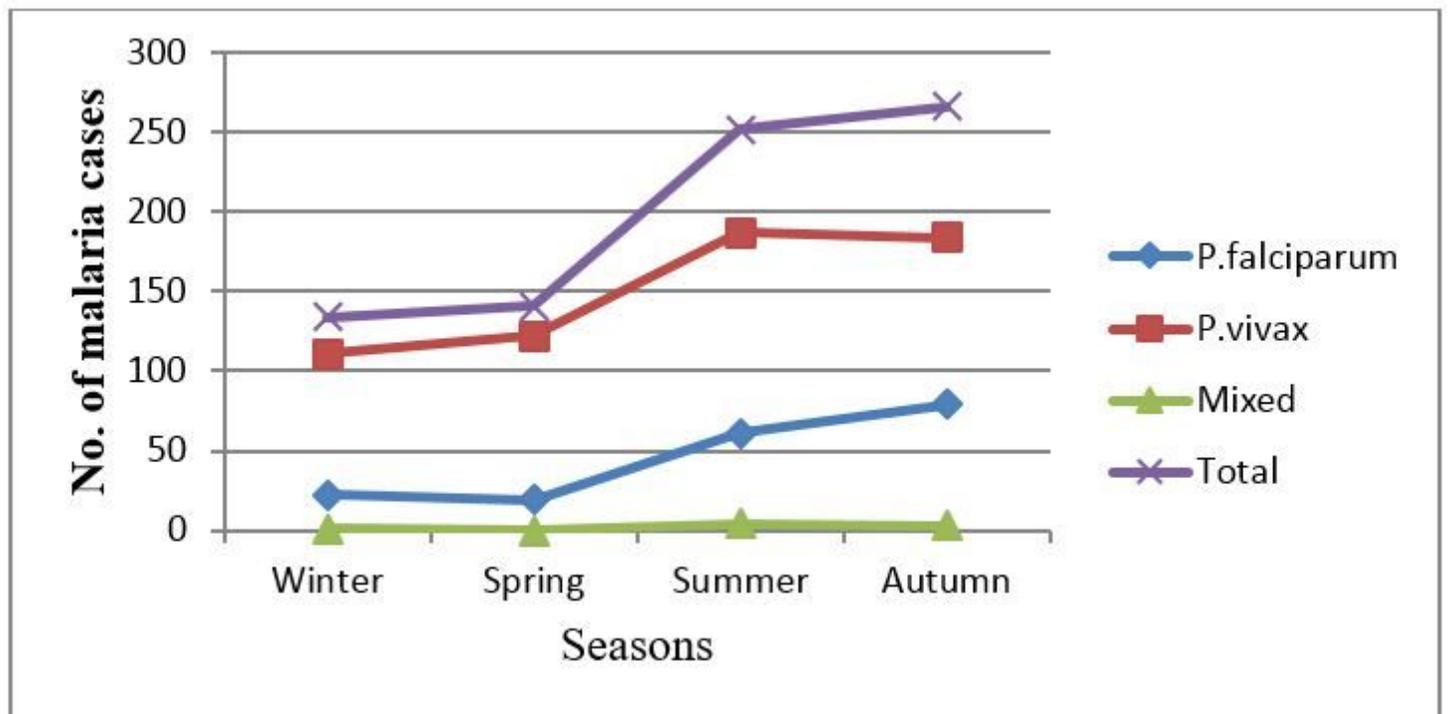


Figure 7

Seasonal profile of *P. vivax*, *P. falciparum* and mixed infections in Mojo health center from 2016 to 2020