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The impact of a humanitarian crisis on the magnitude of malaria in Tigray, Northern Ethiopia from 2014 to 2024

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Abstract

Background Though Ethiopia has made a remarkable effort towards malaria prevention and control activities, malaria is occurring at epidemic levels in different regions. In Tigray, the health system including the surveillance system was damaged due to the war that erupted in November 2020, which requested to assess the burden of malaria in the region. A noticeable lack of malaria is due to the humanitarian crisis (war). Therefore, this study aimed to describe the malaria situation in the Tigray region of Ethiopia from 2014 to 2024.

Methods A descriptive cross-sectional study design was conducted in January 2025 retrospectively data sourced from 2014 to 2024 in Tigray. Data was collected from the public health emergency management and health management information system database using a data abstraction tool. Data was cleaned and analysed through Microsoft Excel 2019 and ArcGIS 10.7. The analysed findings were presented using narratives, tables and graphs.

Results Among 7,195,545 suspected cases, 2,185,318 (30.37%) were confirmed malaria cases, yielding an average incidence rate of 35.37 per 1,000 people (95% CI 24.80–45.94) and a case fatality rate of 27 per 100,000. *Plasmodium falciparum* (65.3%) was the predominant species, followed by *Plasmodium vivax* (34.7%). The highest transmission was recorded in 2024 (382,955 cases), while the lowest was in 2021 (19,110 cases). During the conflict, report completeness decreased by 83%. Malaria cases peaked in autumn, with an average incidence rate of males and females at 50.19 and 25.31 per 1000, population, respectively, and individuals over 15 years old were 43.16 per 1000. Incidence was highest in the western zone (85/1,000) and lowest in the Eastern and Mekelle zones (7/1,000).

Conclusions The magnitude of malaria was low during the crisis due to a very low notification rate, but the disease flared up and still became a major public health problem during the post-war period due to improved data access. Therefore, scaling-up vector control measures during high malaria transmission periods and geographical priorities for controlling and eliminating malaria to achieve the country's elimination strategies.

Keywords Malaria, Trend analysis, Incidence rate of malaria, Tigray war, Ethiopia

Background

Malaria is caused by the *Plasmodium* species with the bite of female *Anopheles* mosquitoes. *Plasmodium falciparum* and *Plasmodium vivax* are the most common species, while *P. falciparum* is responsible for most of the severe forms [1, 2]. Even though malaria is preventable and curable, it still continues to exert a detrimental effect on global health and livelihoods [3].

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In the World Health Organization (WHO) African Region, 233 million (93.6%) cases and 580,000 (95.4%) deaths were reported in 2022; children under the age of five accounted for 78.1% of all deaths in the region [4–7]. According to the Ethiopian National Malaria Strategic Plan (NMSP), 102.8 million people lived in Ethiopia in 2020. Roughly 52% of this population resides in malaria zones, areas of strong transmission below 1000 m are often those with the highest malaria burden, and they are mostly found in Gambela, Benishangul-Gumuz, Western Oromia, Amhara, several zones of South Nations, Nationalities and Peoples (SNNP) and Tigray [3].

In Ethiopia, malaria is highly seasonal and unstable with epidemic-prone transmission patterns in many parts of the country [3, 8, 9]. *Plasmodium falciparum* (65 percent) and *P. vivax* (35 percent) are the major malaria parasites [3]. Although it has decreased significantly over the last 20 years, malaria remains the major socio-economic and public health concern in Ethiopia. The number of malaria cases decreased from 3.8 million in 2010 to about 1.2 million in 2021 and that 132 fewer people died from malaria in 2021 than in 2010 [3].

As part of the nation, malaria is a major cause of morbidity and mortality in the Tigray region. Seventy percent of the population resides in areas where malaria is endemic, and the main malaria transmission season in the region runs from September to December [9, 10]. The COVID-19 epidemic and the conflict in 2020, which disrupted malaria services, have contributed to the region's increased malaria load [11].

In 2019, the insecticide residual spraying (IRS) coverage was 93% and more than 95% long-lasting insecticidal nets (LLINs) coverage in all high-risk malaria districts in 2020. Following the eruption of the humanitarian crisis in November 2020, IRS and LLINs was not sprayed and distributed in 2021 and 2022. However, in 2023 the IRS was sprayed for 20 districts (86%) and six districts in the 2024 (83%); and in 2024, LLINs was distributed for 10 districts (87.4%) [12].

Despite the trend of malaria identified from 2012 to 2018 in the region [13], the magnitude of malaria following the eruption of the conflict had limited with having favourable conditions for malaria transmission due to interruption of the health care system due to the war. Therefore, this study aims to describe the magnitude of malaria from 2014 to 2024 and to show the impact of the humanitarian crisis (war) on the burden of malaria.

Methods

Study settings

This study is conducted in Tigray, one of the low land malarious regions of Ethiopia. Tigray is found in the northern part of Ethiopia with the capital of Mekelle 783 km far away from Addis Ababa, the capital city of Ethiopia. It is bordered by Eritrea to the North, Sudan to the West, the Afar Region to the East, and the Amhara Region to the south and southwest. According to the 2007 Central Statics Agency of Ethiopia (CSA), the estimated total population of the region in 2024 was 6,194,878 of whom 3,054,075 (49.3%) were male [14]. The region's total area is about 54,569.25 km^2 and administratively divided into seven zones including one special Zone, Mekelle. More than 80% of the population in Tigray lives in malarious area and the region have 93 Woredas with three major geographical zones, highlands or "Dega" (Above 2300 m sea level), semi-highlands or "Woyna Dega" (1500 to 2300 m above sea level), and lowlands "Kolla" or hot climatic zones (below 1500 m above sea level) accounting 12%, 49%, and 39% respectively. The annual regional rainfall ranges from 450 to 980 mm. The region has 2 specialized hospitals, 15 general hospitals, 22 primary hospitals, 223 health centres (HCs), and 740 health posts (HPs), while 89% of the facilities were partially and fully damaged [15]. In addition, there are more than 500 private health facilities including hospitals, higher clinics, pharmacies, and rural drug vendors.

Study design and period

A descriptive cross-sectional study design was conducted retrospectively in January 2025 data sourced from 2014 to 2024.

Population

All individuals seeking healthcare services for malaria at all health facilities of Tigray region reported to the regional health bureau from January 2014 to December 2024 were the study population. All the data in the PHEM database in the study period were used, but only HMIS data from 2016 to 2020 were used to describe the cases by personal characteristics.

Study variables

Total RDT/microscopy testing, total malaria cases, inpatients, outpatients, malaria species, and deaths, reporting years, weeks, months of the report, places, age, and sex were the study variables.

Operational definition

Suspected case any person with fever or fever with a headache, back pain, chills, rigor, sweating, muscle pain, nausea, and vomiting was considered a suspected case of malaria [16].

Confirmed case suspected case confirmed by rapid diagnostic test (RDT) or microscopy for *Plasmodium* species [16].

Population at risk population living in a geographical area in which locally acquired malaria cases occurred in the current and/or previous years.

Tigray War Was an armed conflict that lasted from November 4, 2020, to November 4, 2022 [15].

Data collection tools, procedures and quality

Data was collected through self-prepared data abstraction tools. The data were collected from PHEM database from 2014 to 2024 weekly malaria cases and from HMIS unit, DHIS software (Source data from 2016 to 2020). Only five years data were collected from HIMS to characterize the demographic variables of the malaria cases while the data after the eruption of war and before 2015 were missed from the system and excluded from the study. The data was extracted through the prepared tools by the investigators. Total confirmed cases were checked for their completeness.

Data processing and analysis

Data was entered, processed, and analyzed through Microsoft Office Excel 2019 and ArcGIS 10.7. For mapping the spatial distribution of cases. A descriptive analysis was done by person, place, and time to describe the malaria cases. Incidence rate, case fatality rate, and positivity rate were measured to describe the magnitude of the malaria cases. Narrations, tables, graphs, and maps were used to present the findings.

Results

Magnitude of malaria

A total of 7,195,545 population were tested for malaria by both microscopic and rapid diagnostic tests from 2014 to 2024. A total of 2,185,318 (30.37%) were confirmed for malaria with 597 deaths (CFR = 27/100,000). Annually, an average of 198,665 cases (19,110 in 2021 to 382,955 in 2024) malaria reported with average annual incidence rate of 35.37 cases/1000 population (95% CI 24.80–45.94) ranges from 3.28/1000 in 2021 to 61.82/1000 in 2024 (Fig. 1).

The proportion of malaria admissions (inpatient malaria cases) ranged from 0.51% in 2014 to 0.49% in 2024 and the malaria fatality rate ranged from 0.16% to 0.01% in 2022 and 2023 respectively (Table 1).

Distribution of malaria cases by personal characteristics

A total of 1,034,067 cases reported from the HMIS data (2016–2020), 680,981 (66%) of them were male and 353,086 (34%) females with average IR of 50.19 and 25.31 per 1000 population respectively. The proportion of malaria cases between 15 years and above were 65% and the rest 23% and 12% were between five to 14 years and less than five years. The average IR of malaria cases among 15 years and older was 43.16 per 1000 population followed by individuals aged less than 5 years and five to 14 years with an average IR of 31.62 and 29.75 per 1000 population respectively. Among the age of 15 and above, 70% of them were males and only 44% accounted for those aged below 5 years (Fig. 2).

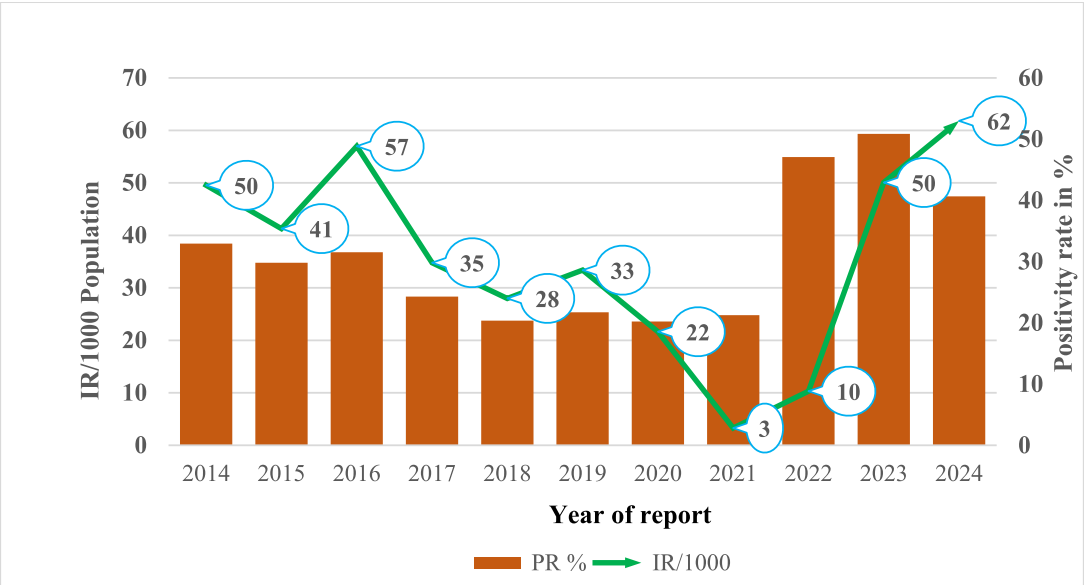

Fig. 1 Annual malaria incidence rate/1,000 population and positivity rate of malaria in Tigray region from 2014 to 2024

Table 1 Annual malaria incidence rate/1000 per year populations and the CFR of Tigray region, Ethiopia, from 2014 to 2024

Years	Population	Cases	IR/1000	IPD rate	Deaths	CFR %
2014	5072461	251294	49.54	1275 (0.51%)	89	0.04
2015	5180386	213902	41.29	1395 (0.63%)	65	0.03
2016	5288310	301405	56.99	1891 (0.69%)	77	0.03
2017	5396235	187720	34.79	1296 (0.53%)	52	0.03
2018	5504160	154072	27.99	812 (0.38%)	48	0.03
2019	5612084	187266	33.37	715 (0.29%)	31	0.02
2020	5720009	123793	21.64	355 (0.19%)	24	0.02
2021	5827934	19110	3.28	37 (0.24%)	11	0.06
2022	5935859	61,196	10.31	147 (0.24%)	98	0.16
2023	6043783	302605	50.07	756 (0.25%)	26	0.01
2024	6194878	382955	61.82	1874 (0.49%)	76	0.02
Average	**5616009**	**198655**	35.37	**10,553 (0.48%)**	**597**	**0.027**

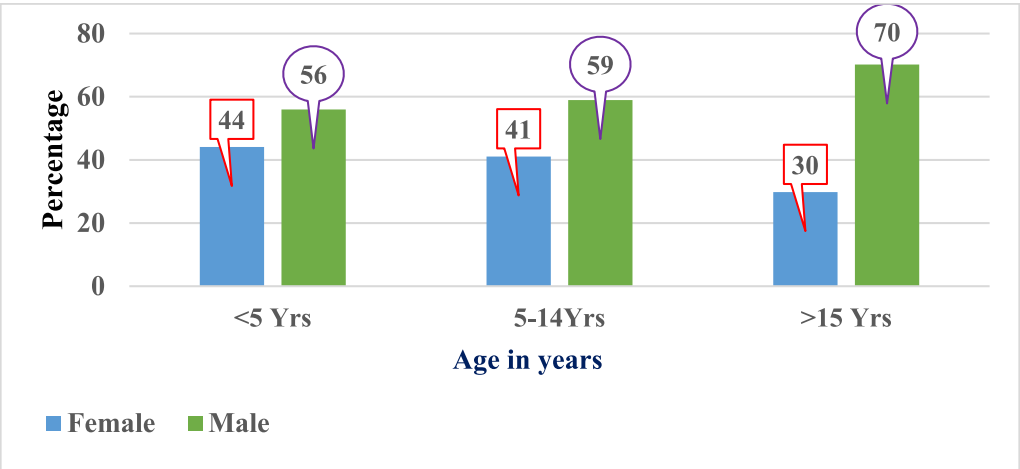

Fig. 2 Proportion of malaria cases by age and sex in Tigray region (HMIS data 2016–2020)

Distribution of malaria cases by place

The distribution of malaria incidence varies geographically in the different zones of the region. High average incidence rate (above 46 cases per 1000 population) was reported in Western and northwestern before the war, and northwester and central zones after the war. Conversely, the average incidence of malaria in eastern and southern zone in each period was less than 15 cases per 1000 population. The incidence of malaria during the war period (2021–2022) was below 15 cases per 1000 population with the 12% of notification rate of the data (Fig. 3).

Seasonal distribution of malaria cases

The malaria cases peaked in between September to November seasons ranges from 129,501 to 152,657 from the five-year data (HMIS data of 2016–2020), while low malaria cases were noted between March and May in the study period (Fig. 4).

Distribution of *Plasmodium* species

From the total of 2,185,318 cases, 1,426,907 (65.3%) *were P. falciparum* and 758,411 (34.7*%) P. vivax* malaria. *Plasmodium falciparum* ranged from 228,493 cases in 2024 to 11,967 in 2021 and *P. vivax* cases ranged from 154,462 to 5225 in the same year, while *P. falciparum* cases increased from 2021 to 2024 (Fig. 5).

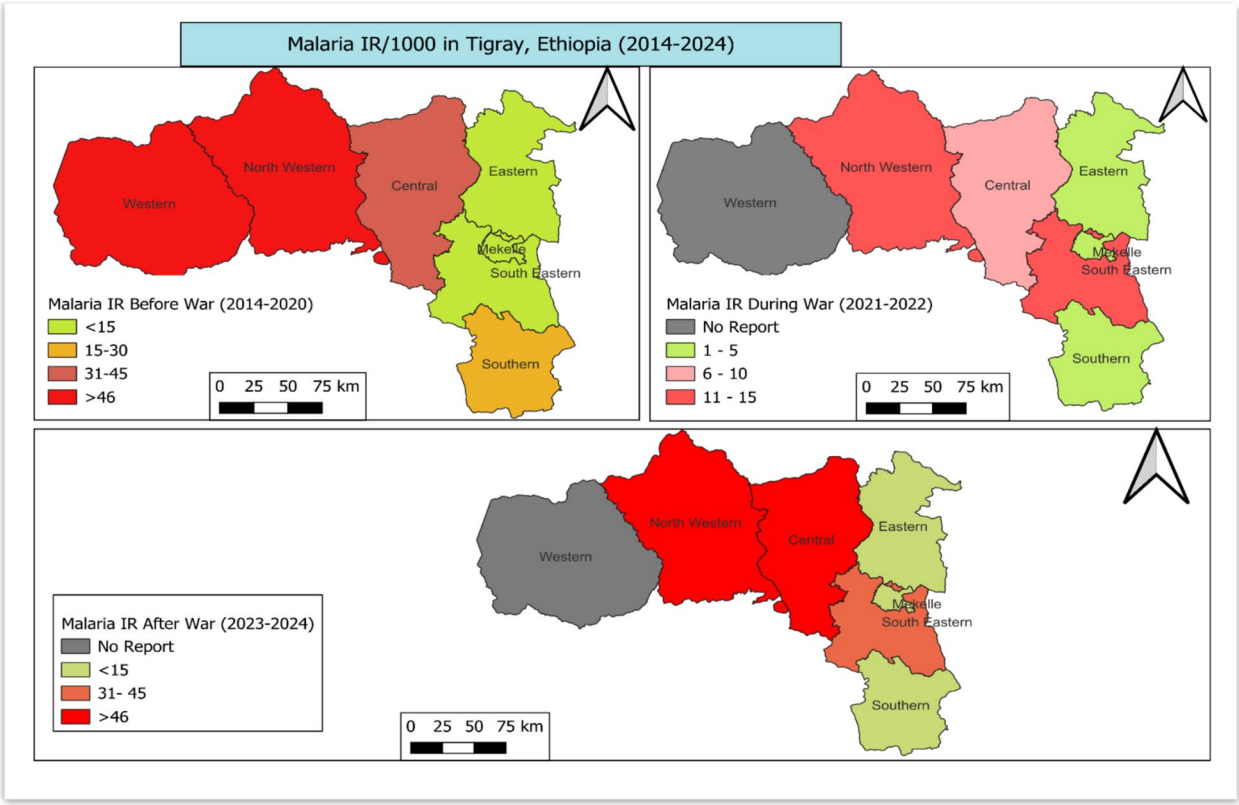

Fig. 3 Incidence rate of malaria distribution by zones pre-, during, and postwar in Tigray Region ranging from 2014 to 2024

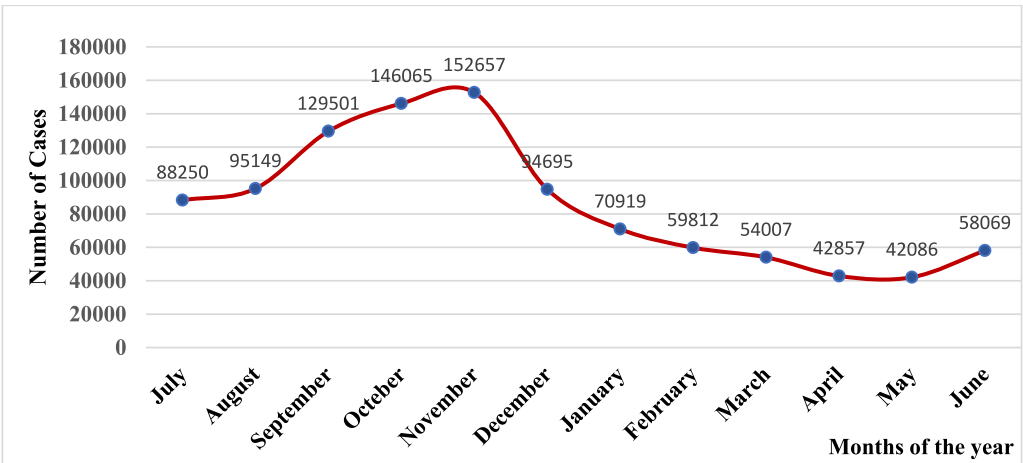

Fig. 4 Monthly incidence of malaria cases in the Tigray region from (HMIS data 2016–2020)

The effect of humanitarian crisis (War) on malaria prevalence

The incidence rate of malaria ranged from 56.99/1000 in 2016 to 21.64/1000 in 2020, while the incidence after the eruption of the crisis sharply increased from 3.28/1000 in 2021 to 61.82/1000 in 2024 post crisis. During the two-year war period (November 2020-November 2022), the health system collapsed and few health facilities and MHNTs were reporting units and only 19,110 malaria cases were reported in 2021. The malaria report completeness of the region

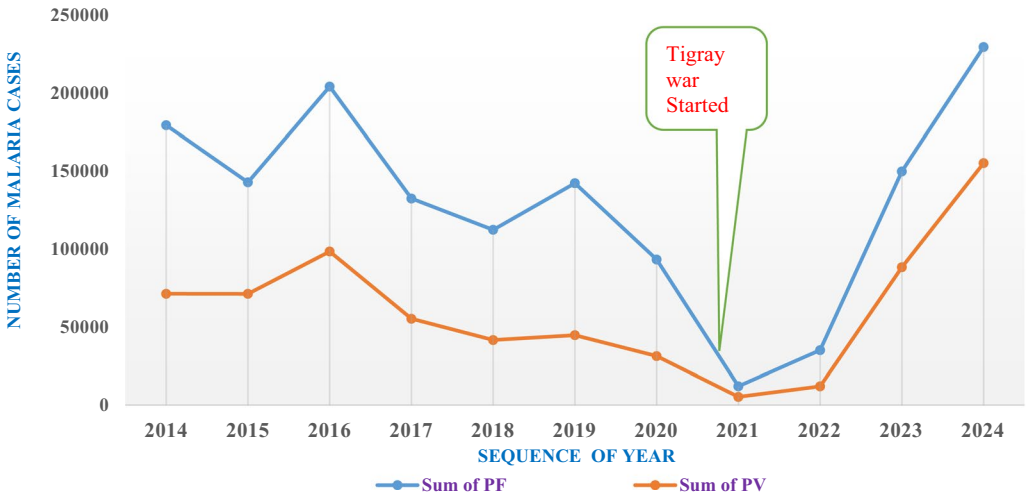

Fig. 5 Ten years of malaria incidence cases by species in the Tigray region from 2014 to 2024

in pre-, during, and post-war was 95%, 12%, and 77%, respectively. Following the crisis, malaria IR increased in most of the zones with the highest in the Northwest (123/1000), while the report from the Western zone was absent.

Discussion

In this study, 2,185,318 (30.37%) were confirmed for malaria with 597 deaths. The average annual incidence rate and CFR were 35.37/1000 and 27/100,000 respectively. The incidence rate radically decreased from 49.54/1000 in 2014 to 21.64/1000 in 2020 and reversed following the eruption of the crisis from 3.28/1000 in 2021 to 61.82/1000 in 2024. This finding is higher than the retrospective study done in Boricha district; southern Ethiopia (12.2) [17] and malaria incidence rate in Ethiopia in 2018 (18.6) [10]. This may be due to the collapse of public health infrastructures during the crisis leading to an increase in the burden of malaria [18]. The implementation of high-impact interventions, such as the expansion of ACT, ITN and the use of RDTs may decrease the incidence of malaria cases [19].

In this study the malaria incidence rate between 2020 and 2022 is 3.28-10.31/1000, which is lower that the study conducted in Amhara region among children [20]. This is because of low-report notification rate due the crisis and communication blackout in the region, where the health facilities (89%) where fully and partial non-functional including the disease surveillance system [15, 21]. This is supported by the report completeness of the region in pre, during and post-war were 95%, 12%, and 77% respectively [12]. The reported cases during the aforementioned period was obtained from some functional facilities and mobile health and nutrition teams (MHNT) of different non-governmental organizations. Similarly, the incidence of malaria in the region was flared-up during the post-crisis period (50.07 and 61.82/1000 in 2023 and 2024 respectively). The data was supported by the annual report of WHO Ethiopia [22, 23]. This is happened due to different factors such as political instability, population movement, and infrastructural destructions. This condition is supported by studies conducted on impact of conflict and population movement on malaria [24–27]

In this study, the positivity rate of confirmed malaria cases was 30.37%. This finding is higher than the retrospective studies conducted in the north Shewa zone of Amhara region (11%) [28] and west Wallaga zone of Oromia region (13.4%) [29]. This could be explained by variations in height, microclimate, the growth of development projects like irrigation systems or dams, community knowledge about the spread and prevention of malaria, and intervention strategies for malaria [30].

The most common species of *Plasmodium* was *P. falciparum,* which accounts for 65.3%. In a study conducted in the Ethiopia's lowland areas with hot climate conditions, the predominant *Plasmodium* species was *P. falciparum* (80.1%) [31]. In addition, in a five-year surveillance analysis in the north Shewa zone [28] and the East Shewa zone, 56.4% and 61%, respectively, were due to *P. falciparum* [32]. This is due to the hot humidity which means annual temperature of 25.4 °C and means annual rainfall of 935 mm. [31, 33].

In this study, individuals 15 years old and above were highly affected (65% with IR 43.16 per 1000) followed by < 5 years of children 31.62 per 1000. This finding is in line with the studies conducted in Shewarobit, Amhara, Ethiopia (64.6%) was greater than or equal to 15 years of age [16] and East Shewa, Ethiopia five-year trend

analyses (60%) [34]. Another investigation conducted in Adama revealed that people over the age of 15 accounted for 60% of all malaria cases, with those ages between 5 and 14 accounting for 28% and children under the 5 were the least impacted [35]. This may be due to adults commonly being responsible for outdoor activities, especially in the evening and the mosquito bites at outdoors activities [28].

Males were more highly affected than females with 66% and 34% respectively. This is in line with the studies done in Shewarobit, Ethiopia (65.3%) [16], study done in Tigray (69%) [36]. This is explained as males are usually involved in irrigation activities, agricultural activities, and day labor, which might be suitable environments for mosquito breeding sites; alternatively, males are usually engaged in outdoor activities at dusks and dawns, which may coincide 16 h after peak biting [16].

In this study, western and northwestern zones reported the highest incidence rate (85/1000) and (65/1000) respectively and lower in Mekelle (7/1000) and Eastern zones (7/1000). This may be due to the geographical variations of the region [37]. In addition, the incidence after the war was higher in the northwestern and central Tigray regions, this may be due to various factors such as geographic variation, population movements for traditional mineral mining, scale of infrastructure destructions, and decline of malaria prevention measures (12). No reports were compiled from western Tigray from 2021 to 2024 due to inaccessibility [21].

In this study malaria cases were higher reported in the autumn season (September to November) with the peak month in November which was the same with retrospective studies conducted in the Shewarobit, Amhara, North Central, Ethiopia [16], north Shewa zone of Amhara region [28], Oromia regional state, and western Ethiopia [38]. This is due to the climatic and environmental conditions and favorability of mosquito breeding sites in this season after the cessation of rainfall in the study area [31].

Limitations of the study

As this study uses secondary data/surveillance data from the PHEM department, the eleven years of data lacks some essential variables like age, gender, other sociodemographic variables, and associated factors. There were no HMIS/DHIS reporting systems during and after the war (from November 2020–December 2023) for about 3 years. There was no reporting unit from the part of southern and western zones of Tigray from 2021 to 2024. Moreover, advanced statistical analysis was not applied due to the structure of the data available in the PHEM department.

Conclusions

In the region, the magnitude of malaria cases was declined from 2014 to2020 and recorded with low magnitude during the crisis due to very low notification rate, but the disease is flared-up and still became a major public health problem during the post-war period due to improved data access and service utilizations. The dominant species of malaria parasites was *P. falciparum* and mostly malaria transmission typically begins at the end of September and extends through December, disproportionately affecting individuals aged 15 and above years, male population and the low-land area of the region. Therefore, it is imperative to implement the national malaria control and elimination strategy to reduce the malaria burden especially to the adult and under five children and low-land areas during the post-crisis period.

Abbreviations

DHIS2	District Health Information Software 2
HMIS	Health management information system
IR	Incidence rate
NMSP	National Malaria Strategic Plan
PHEM	Public health emergency management
RDT	Rapid diagnostic test
WHO	World Health Organization

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Declaration of generative AI in scientific writing

None of the documents are generated by AI/chat GPT.

Author contributions

GGH—Conception, design, acquisition, analysis, interpretation of data, and draft and revision of the manuscript; ATN—Design, analysis, interpretation of data, and draft and revision of the manuscript; MHA—acquisition, data collection, interpretation of data, and draft and revision of the manuscript. All authors have read and approved the manuscript.

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Availability of data and materials

All the data is available from the corresponding author upon reasonable request.

Declarations

Ethical approval and consent to participate

Ethical clearance was obtained from Mekelle University, College of Health Science institutional review board (CHS-IRB 3004/2024) and the department of Epidemiology issued a supportive letter to the Tigray Regional Health Bureau. Every effort was made to ensure the confidentiality and security of the data, by not using anything other than this study purpose.

Competing interests

The authors declare no competing interests.

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