RESEARCH PAPER

Epidemiology and Species Distribution of Malaria in Chandrapur District, Central India: A Retrospective Record-Based Study

Dr Priyanka Mategadikar[1], Dr. Sagnik Poddar[2], Dr. Dilip Gedam[3], Dr. Gopal Agrawal[4]

[1]Senior Resident, Department of Microbiology, IGGMC Nagpur, India.
[2]Senior resident, Department of microbiology, IGGMC Nagpur, India.
[3]Associate Professor, Department of Microbiology, IGGMC Nagpur, India.
[4]Professor and Head, Departm,ent of Microbiology, IGGMC Nagpur, India.

Corresponding author addresses: E-mail id/ Social Media Link

Dr. Dilip Gedam, Associate Professor Department of Microbiology, IGGMC Nagpur, India.

Email: gedam_dilip74@rediffmail.com

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ABSTRACT

Background: Malaria continues to pose a major public health concern in India, particularly in forested and tribal regions where transmission persists despite ongoing control and elimination initiatives. Central India's ecological and climatic conditions support sustained malaria transmission, with *Plasmodium falciparum* remaining the leading cause of severe malaria. Chandrapur district in Maharashtra represents one such endemic area, highlighting the need for continuous epidemiological monitoring.

Aim: To assess the prevalence of malaria in Chandrapur district, Central India, and examine its epidemiological profile, species distribution, surveillance indicators, and treatment outcomes. **Materials and Methods:** A retrospective record-based study was carried out using malaria surveillance records from Chandrapur district covering the period from 2019 to April 2026. Data on laboratory-confirmed malaria cases, *Plasmodium* species, surveillance indicators, mortality, and treatment outcomes were extracted and analyzed. Descriptive statistical methods, including mean, standard deviation, median, and range, were used to summarize the findings, while temporal trends in disease burden and surveillance indicators were evaluated across the study period. **Results:** During the study period, 1,514 confirmed malaria cases were documented. *Plasmodium falciparum* was the predominant species, accounting for 1,209 (79.9%) cases, followed by *Plasmodium vivax* with 265 (17.5%) cases. The highest annual case count was reported in 2024 (561 cases), whereas the lowest was observed in 2019 (53 cases). The mean annual malaria burden was 214 ± 171 cases. Annual Parasite Incidence increased from 0.02 in 2019 to 0.25 in 2024 before declining to 0.12 in 2025. Treatment outcomes were favorable throughout the study period, with recovery rates consistently exceeding 96% and an overall case fatality rate of 1.4%. **Conclusion:** Malaria in Chandrapur district remains largely driven by *P. falciparum* and demonstrates notable year-to-year fluctuations in disease occurrence. Although a reduction in malaria transmission was observed after 2024, maintaining robust surveillance systems, ensuring early diagnosis and prompt treatment, and strengthening targeted vector control interventions will be essential for sustaining progress toward malaria elimination and reducing the risk of future outbreaks.

Keywords: Malaria, *Plasmodium falciparum*, *Plasmodium vivax*, prevalence, Chandrapur, Central India, epidemiology, surveillance.

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.INTRODUCTION

Malaria remains one of the world's most important vector-borne parasitic diseases and continues to be a major cause of morbidity and mortality in tropical and subtropical regions. It is caused by protozoan parasites of the genus *Plasmodium* and transmitted through the bite of infected female *Anopheles* mosquitoes. Despite considerable advances in vector control, rapid diagnosis, and effective antimalarial therapy, malaria continues to impose a substantial public health burden. According to the **World Malaria Report 2025**, an estimated 282 million malaria cases and approximately 610,000 malaria-related deaths occurred worldwide, with the highest burden occurring in low- and middle-income countries [(1)].

India has achieved remarkable progress in reducing malaria over the past decade through implementation of the National Framework for Malaria Elimination and the National Strategic Plan for Malaria Elimination. Strengthened surveillance, universal access to rapid diagnostic tests, prompt treatment with artemisinin-based combination therapy, distribution of long-lasting insecticidal nets, and indoor residual spraying have contributed to a substantial decline in malaria incidence and mortality [(2–4)]. India is currently committed to achieving malaria elimination by 2030; however, transmission remains unevenly distributed across the country.

Residual malaria transmission is largely concentrated in tribal, forested, and difficult-to-

access regions of central, eastern, and northeastern India, where environmental and socioeconomic conditions favor continued transmission (5,6). Dense forest cover, suitable mosquito breeding habitats, inadequate housing, limited healthcare access, occupational exposure, and seasonal migration collectively contribute to sustained malaria transmission in these endemic areas [5].

Among the five *Plasmodium* species known to infect humans, *Plasmodium falciparum* and *Plasmodium vivax* account for the vast majority of malaria cases in India. Although *P. vivax* is widely distributed, *P. falciparum* is associated with severe disease, complications, and malaria-related mortality [6]. Previous studies from endemic regions have consistently reported the predominance of *P. falciparum*, particularly among tribal populations. For example, surveillance studies from northeastern India demonstrated that *P. falciparum* constituted nearly 90% of confirmed malaria cases, while similar observations have been reported from central Indian states with extensive forest cover [7,8].

Central India remains one of the country's principal malaria-endemic regions because of its favorable ecological conditions for vector breeding and transmission. Tribal communities living in forested areas experience a disproportionately higher malaria burden owing to increased exposure to mosquito vectors, delayed healthcare seeking, inadequate preventive measures, and limited access to diagnostic and treatment facilities [5,8]. Agricultural activities, mining, and seasonal migration further increase the risk of infection among economically active populations [9].

Maharashtra has made significant progress in malaria control; however, transmission continues to persist in several rural and forested districts. Chandrapur district, located in eastern Maharashtra, possesses extensive forest cover, tribal settlements, mining industries, abundant water bodies, and climatic conditions that facilitate mosquito breeding throughout much of the year. Owing to its ecological similarity to neighboring endemic districts such as Gadchiroli, Chandrapur continues to remain vulnerable to malaria transmission.

Malaria transmission demonstrates pronounced seasonal variation, with the highest incidence occurring during and immediately after the monsoon season when vector density increases substantially. Previous studies have shown that adult males, migrant workers, and socioeconomically disadvantaged populations are disproportionately affected because of occupational and environmental exposure [9,10]. In addition, climate variability, asymptomatic infections, insecticide resistance, and population mobility continue to pose challenges to malaria elimination efforts [10,11].

Although Chandrapur has historically been recognized as a malaria-endemic district, recent comprehensive data describing malaria prevalence, *Plasmodium* species distribution, surveillance indicators, and treatment outcomes remain limited. Such information is essential for evaluating ongoing malaria control programmes, identifying high-risk populations, and supporting evidence-based interventions aimed at achieving malaria elimination.

Therefore, the present study was undertaken to determine the prevalence of malaria in Chandrapur district, Central India, and to analyze its epidemiological characteristics, *Plasmodium* species distribution, surveillance indicators, and treatment outcomes using routine surveillance data collected between 2019 and April 2026. The findings are expected to contribute to regional malaria surveillance and provide evidence to strengthen public health strategies for malaria elimination.

MATERIALS AND METHODS

A retrospective record-based study was conducted using malaria surveillance data obtained from the District Malaria Office, Chandrapur, Maharashtra, under the National Vector Borne Disease Control Programme (NVBDCP)/National Centre for Vector Borne Diseases Control (NCVBDC). Since the Department of Microbiology, Indira Gandhi Government Medical College (IGGMC), Nagpur, is not a designated NVBDCP/NCVBDC malaria diagnostic center, data were collected from the district malaria surveillance records. Surveillance data covering the period from January 2019 to April 2026 (7 years and 4 months) were reviewed. Information on laboratory-confirmed malaria cases, *Plasmodium* species (*P. falciparum*, *P. vivax*, and mixed infections, where applicable), Annual Parasite Incidence (API), treatment outcomes, and malaria-related deaths was extracted. Malaria diagnosis was based on microscopic examination of Giemsa-stained peripheral blood smears performed according to NVBDCP/NCVBDC guidelines. The collected data were entered into Microsoft Excel and analyzed using descriptive statistics, including frequencies, percentages, mean, standard deviation, median, and range, to assess temporal trends in malaria prevalence, species distribution, surveillance indicators, and treatment outcomes. The study was approved by the Institutional Ethics Committee of Indira Gandhi Government Medical College (IGGMC), and only anonymized secondary surveillance data were analyzed.

RESULTS

A total of **1,514 confirmed malaria cases** were reported in Chandrapur district during the study period from 2019 to April 2026. The annual number of malaria cases showed considerable variation over the study period, ranging from 53

cases in 2019 to a peak of 561 cases in 2024. Overall, a substantial increase in malaria incidence was observed between 2023 and 2024, followed by a decline in 2025 and the early months of 2026.

Table 1: Year-wise malaria burden in Chandrapur district

Year	Population	*P. vivax*	*P. falciparum*	Total Cases	Deaths	Recovered
2019	2,470,279	9	44	53	1	52
2020	2,248,599	17	179	196	3	193
2021	2,248,598	32	119	151	5	146
2022	2,248,598	26	95	121	4	117
2023	2,249,151	29	130	159	4	155
2024	2,246,032	78	443	561	2	559
2025	2,224,950	65	192	257	2	255
Jan–Apr 2026	2,227,823	9	7	16	0	16

Total malaria cases: 1,514
***P. falciparum* cases:** 1,209 (79.9%)
***P. vivax* cases:** 265 (17.5%)
Mixed/Unspecified: 40 (2.6%)

Table 1 summarizes the annual malaria burden, species distribution, mortality, and recovery outcomes. The total number of malaria cases increased from 53 cases in 2019 to 196 cases in 2020, followed by a gradual decline during 2021–2023. However, a marked surge was observed in 2024, when 561 cases were reported, representing the highest annual burden during the study period. Subsequently, malaria cases decreased to 257 in 2025. During January–April 2026, only 16 cases were reported.

The majority of cases throughout the study period were caused by *Plasmodium falciparum*. The proportion of falciparum malaria ranged from 75% to 91% of all reported cases, indicating the predominance of this species in the district. Recovery rates remained consistently high (>96%) throughout the study period, while mortality remained low.

Table 2: Species distribution of malaria cases

Species	Number	Percentage (%)
P. falciparum	1,209	79.9
P. vivax	265	17.5
Other/Mixed	40	2.6
Total	**1,514**	**100**

Statistical observation:

P. falciparum infections were significantly more common than *P. vivax* infections (χ^2 test, $p < 0.001$).

Analysis of species distribution revealed that *Plasmodium falciparum* was the predominant malaria parasite in Chandrapur district. Of the 1,514 confirmed malaria cases, **1,209 (79.9%)** were caused by *P. falciparum*, while **265 (17.5%)** were caused by *P. vivax*. Mixed infections and other species constituted a very small proportion of cases.

Statistical analysis demonstrated a significantly higher prevalence of *P. falciparum* infection compared to *P. vivax* infection (χ^2 test, $p < 0.001$). These findings indicate that falciparum malaria remains the principal contributor to malaria transmission and disease burden in the district.

Table 3: Descriptive statistics of annual malaria cases (2019–2025)

Variable	Mean ± SD	Median	Range (Min–Max)
Total malaria cases	214 ± 171	177.5	53–561
P. falciparum cases	173 ± 131	161	44–443
P. vivax cases	38 ± 25	29	9–78
Deaths	2.6 ± 1.7	2.5	1–5
Recovered cases	187 ± 168	174.5	52–559

The distribution of annual malaria cases showed considerable variability, as reflected by a coefficient of variation of approximately 80%, indicating unstable malaria transmission during the study period. The predominance of *P. falciparum* was statistically significant when compared with *P. vivax* infections (χ^2 test, $p < 0.001$).

The descriptive statistical analysis of malaria cases reported in Chandrapur district during the study period demonstrated considerable interannual variation in malaria transmission. The mean annual malaria burden was **214 ± 171 cases**, with a median of **177.5 cases** and a range of **53–561 cases**. The large standard deviation and wide range indicate substantial fluctuations in malaria incidence during the study period, primarily due to the marked increase in cases observed in 2024.

The mean annual number of *Plasmodium falciparum* infections was **173 ± 131 cases**, with a median of **161 cases** and a range of **44–443 cases**. In comparison, *Plasmodium vivax* infections accounted for a mean of **38 ± 25 cases annually**, with a median of **29 cases** and a range of **9–78 cases**. These findings confirm the predominance of

P. falciparum malaria in Chandrapur district throughout the study period.

Malaria-related mortality remained low, with a mean annual mortality of **2.6 ± 1.7 deaths**, a median of **2.5 deaths**, and a range of **1–5 deaths**. Conversely, treatment outcomes were favorable, with an average of **187 ± 168 recovered cases per year**, a median of **174.5 recoveries**, and a range of **52–559 recoveries**.

Overall, the descriptive statistics indicate that malaria transmission in Chandrapur district was characterized by significant temporal variability, with a pronounced increase in disease burden during 2024. Despite fluctuations in case numbers, *P. falciparum* remained the predominant infecting species, and clinical outcomes were favorable, as evidenced by high recovery rates and low mortality throughout the study period.

Table 4: Malaria Surveillance Indicators in Chandrapur District (2019–2026)

Year	Population	Total Malaria Cases	API*	ABER† (%)	SPR‡ (%)	SFR§ (%)	Pf% ¶
2019	2,470,279	53	0.02	29.56	0.01	0.01	83
2020	2,248,599	196	0.09	24.25	0.04	0.03	91
2021	2,248,598	151	0.07	21.93	0.03	0.02	79
2022	2,248,598	121	0.05	26.54	0.020	0.02	79
2023	2,249,151	159	0.07	30.47	0.020	0.02	82
2024	2,246,032	561	0.25	31.61	0.079	0.068	86
2025	2,224,950	257	0.12	38.33	0.03	0.02	75
Jan–Apr 2026	2,227,823	16	0.01	11.67	0.01	0.003	44

API (Annual Parasite Incidence) = Number of confirmed malaria cases per 1,000 population per year.

ABER (Annual Blood Examination Rate) = Percentage of population examined for malaria annually.

SPR (Slide Positivity Rate) = Percentage of examined blood smears found positive for malaria.

SFR (Slide Falciparum Rate) = Percentage of examined blood smears positive for *P. falciparum*.

Pf% = Percentage of malaria cases caused by *P. falciparum*.

Malaria surveillance indicators demonstrated notable variation over time. Annual Parasite Incidence (API) increased from **0.02 per 1,000 population in 2019** to **0.25 per 1,000 population in 2024**, representing the highest transmission intensity observed during the study period. API subsequently declined to 0.12 in 2025.

The Annual Blood Examination Rate (ABER) showed a gradual increase from 21.93% in 2021 to 38.33% in 2025, indicating improved surveillance coverage and enhanced malaria screening activities. Increased ABER reflects strengthening of malaria surveillance systems and active case detection efforts within the district.

Slide Positivity Rate (SPR) and Slide Falciparum Rate (SFR) followed a pattern similar to API. The highest SPR (0.079%) and SFR (0.068%) were recorded in 2024, corresponding to the year with the highest malaria burden. The predominance of falciparum malaria was further reflected in the high proportion of *P. falciparum* cases among all confirmed infections.

Table 5. Outcome of Malaria Cases During the Study Period

Year	Total Cases	Recovered	Deaths	Recovery Rate (%)	Case Fatality Rate (%)
2019	53	52	1	98.1	1.9
2020	196	193	3	98.5	1.5
2021	151	146	5	96.7	3.3
2022	121	117	4	96.7	3.3
2023	159	155	4	97.5	2.5
2024	561	559	2	99.6	0.4
2025	257	255	2	99.2	0.8
Jan–Apr 2026	16	16	0	100	0

Table 5 presents the clinical outcomes of malaria cases reported during the study period. Recovery rates remained consistently high, ranging from 96.7% to 100%. The highest recovery rate was observed during January–April 2026, when all reported cases recovered successfully.

A total of 21 malaria-related deaths were recorded during the study period. Annual mortality ranged from zero to five deaths. The highest number of deaths was reported in 2021 (n=5), despite a relatively lower number of malaria cases compared with 2024. The overall case fatality rate for the study period was approximately **1.4%**, indicating

favorable treatment outcomes and effective case management.

DISCUSSION

The present retrospective study describes the epidemiological pattern of malaria in Chandrapur district, Maharashtra, over a seven-year period (2019–April 2026). A total of 1,514 laboratory-confirmed malaria cases were reported, with marked year-to-year variation in disease burden and a clear predominance of *Plasmodium falciparum*. These findings highlight the continued endemicity of malaria in this forested district despite ongoing malaria control and elimination efforts.

The annual malaria burden fluctuated considerably during the study period, with the lowest number of cases reported in 2019 and a marked increase in 2024. Such temporal variation is characteristic of malaria-endemic regions and is influenced by climatic conditions, rainfall, vector density, human migration, and the effectiveness of surveillance and vector control activities. Similar fluctuations in malaria transmission have been reported from central and northeastern India, where seasonal and ecological factors substantially influence malaria incidence [7,8]. The decline in cases observed after 2024 may reflect the combined impact of strengthened surveillance, early diagnosis, prompt treatment, and intensified vector control measures implemented under India's malaria elimination programme [1,4].

A major finding of the present study was the predominance of *P. falciparum*, which accounted for nearly 80% of all confirmed malaria cases and was significantly more common than *P. vivax* ($p < 0.001$). This observation is consistent with previous studies from forested and tribal regions of central India, where *P. falciparum* remains the dominant malaria parasite because of favorable ecological conditions for efficient *Anopheles* vectors [5,8,12]. Similar species distribution has also been reported from northeastern India, where *P. falciparum* constitutes the majority of laboratory-confirmed malaria cases [7]. Since *P. falciparum* is associated with severe malaria and higher mortality, its predominance underscores the importance of continued species-specific surveillance and timely initiation of effective antimalarial therapy.

The descriptive statistical analysis demonstrated substantial interannual variability in malaria transmission, reflected by a high coefficient of variation and a wide range in annual case numbers. These findings suggest that malaria transmission in Chandrapur remains unstable and susceptible to periodic increases in incidence. Such variability has been documented in other malaria-endemic districts of India and emphasizes the need for continuous surveillance to detect outbreaks at an early stage [8,10].

Surveillance indicators further supported the observed epidemiological trends. Annual Parasite Incidence (API), Slide Positivity Rate (SPR), and Slide Falciparum Rate (SFR) all reached their highest values in 2024, indicating increased malaria transmission during that year. In contrast, the Annual Blood Examination Rate (ABER) remained consistently above the recommended surveillance threshold and increased progressively over the study period, suggesting improved case detection and strengthened surveillance activities. Similar improvements in surveillance indicators have been reported following implementation of India's National Framework for Malaria Elimination, which emphasizes active case detection, universal parasitological diagnosis, and prompt treatment [2,4,11].

Clinical outcomes in the present study were favorable, with recovery rates exceeding 96% throughout the study period and an overall case fatality rate of approximately 1.4%. The observed highest case fatality rate of 3.3% in year 2021 and 2022 could be explained by the substantial diversion of healthcare infrastructure, manpower and resources towards the COVID 19 pandemic response, which may have adversely impacted routine disease surveillance and patient management. Although the highest number of malaria cases occurred in 2024, mortality remained low, indicating effective case management and access to appropriate antimalarial treatment. These findings are consistent with national reports showing substantial reductions in malaria-related mortality following expanded use of rapid diagnostic tests, artemisinin-based combination therapy, and strengthened referral services[1,2]. Nevertheless, the occurrence of malaria-related deaths indicates that severe malaria continues to occur, particularly in vulnerable populations, highlighting the importance of early diagnosis and timely treatment.

The findings of this study have important public health implications. Chandrapur shares ecological characteristics with neighbouring malaria-endemic districts, including dense forest cover, tribal settlements, mining activities, and favourable breeding habitats for *Anopheles* mosquitoes. Sustained surveillance, targeted vector control, community awareness, and uninterrupted availability of diagnostic and treatment services remain essential to prevent resurgence and support malaria elimination efforts.

The present study has certain limitations. It was based on retrospective secondary surveillance data and lacked individual-level information on demographic characteristics, seasonal distribution, clinical severity, entomological factors, and potential risk determinants. Molecular confirmation of *Plasmodium* species and information on antimalarial drug resistance were also unavailable.

Despite these limitations, the study provides comprehensive long-term surveillance data from an important malaria-endemic district and contributes valuable evidence for strengthening malaria control programmes in central India.

CONCLUSION

This retrospective study demonstrates that malaria remains an important public health concern in Chandrapur district, Central India, despite ongoing control efforts. During the study period (2019–April 2026), *Plasmodium falciparum* was the predominant species, accounting for 79.9% of all confirmed malaria cases, with marked temporal variation in disease burden and a peak in transmission during 2024. Surveillance indicators showed improved malaria monitoring, while the subsequent decline in Annual Parasite Incidence, Slide Positivity Rate, and Slide Falciparum Rate suggests progress in malaria control. High recovery rates and low mortality reflect effective case management and access to timely treatment. Continued strengthening of surveillance, early diagnosis, prompt treatment, targeted vector control, and focused interventions in high-risk tribal and forested areas will be essential to sustain these gains and support India's goal of malaria elimination by 2030.

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