**Spatio-temporal patterns and persistence of malaria incidence in Tete Province, Mozambique, 2016–2022, using routine public health surveillance data**

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**Abstract:**
Malaria remains a major public health problem in sub-Saharan Africa, characterized by high temporal variability and spatial heterogeneity. In Mozambique, subnational analyses based on routine surveillance data are essential to support more targeted control strategies in high-endemicity settings. **Objective:** To describe the spatio-temporal patterns of malaria incidence in Tete Province, Mozambique, from 2016 to 2022, with emphasis on temporal variability, spatial heterogeneity, and persistence of transmission at the district level. **Methods:** A descriptive study based on routine epidemiological surveillance data. Monthly cases and incidence rates were analyzed to assess temporal variability, seasonality, and interannual variation. Spatial analyses included mapping the district-level average incidence and annual ecological relative risk relative to the provincial mean. Persistence was assessed as the proportion of years in which district-level incidence exceeded the provincial median. **Results:** High temporal variability, a consistent seasonal pattern during the post-rainy-season, and marked spatial heterogeneity among districts were observed. **Conclusion:** Malaria transmission in Tete Province shows persistent spatio-temporal heterogeneity. Descriptive analyses based on routine surveillance data are strategic tools for territorial prioritization and the strengthening of malaria control actions.
**Keywords:** Malaria; Spatio-temporal analysis; Disease incidence; Spatial heterogeneity; Public health surveillance

**Padrões espaço-temporais e persistência da incidência de malária na província de Tete, Moçambique, 2016–2022, com base em dados de vigilância em saúde pública de rotina**

**Resumo:**
A malária permanece um importante problema de saúde pública na África Subsaariana, caracterizada por elevada variabilidade temporal e heterogeneidade espacial. Em Moçambique, análises subnacionais baseadas em dados de vigilância de rotina são essenciais para subsidiar estratégias de controle mais direcionadas em contextos de alta endemicidade. **Objetivo:** Descrever os padrões espaço-temporais da incidência de malária na província de Tete, Moçambique, entre 2016 e 2022, com ênfase na variabilidade temporal, na heterogeneidade espacial e na persistência da transmissão em nível distrital. **Métodos:** Estudo descritivo com base em dados de vigilância epidemiológica de rotina. Foram analisados casos mensais e suas respectivas taxas de incidência para avaliar a variabilidade temporal, a sazonalidade e a variação interanual. As análises espaciais incluíram o mapeamento da incidência média distrital e do risco relativo ecológico anual em relação à média provincial. A persistência foi avaliada pela proporção de anos com incidência distrital acima da mediana provincial. **Resultados:**

Observou-se elevada variabilidade temporal, padrão sazonal consistente no período pós-chuvoso e heterogeneidade espacial marcada entre os distritos. **Conclusão:** A malária em Tete apresenta heterogeneidade espaço-temporal persistente. Análises descritivas baseadas em dados de rotina são ferramentas estratégicas para a priorização territorial e o aprimoramento das ações de controle.
**Palavras-chave:** Malária; Análise espaço-temporal; Incidência de doenças; Heterogeneidade espacial; Vigilância em saúde pública.

**Patrones espacio-temporales y persistencia de la incidencia de malaria en la provincia de Tete, Mozambique, 2016–2022, basados en datos de vigilancia rutinaria de salud pública**

**Resumen:**
La malaria sigue siendo un importante problema de salud pública en África subsahariana, caracterizada por una elevada variabilidad temporal y heterogeneidad espacial. En Mozambique, los análisis subnacionales basados en datos de vigilancia de rutina son esenciales para respaldar estrategias de control más focalizadas en contextos de alta endemicidad. **Objetivo:** Describir los patrones espacio-temporales de la incidencia de la malaria en la provincia de Tete, Mozambique, entre 2016 y 2022, con énfasis en la variabilidad temporal, la heterogeneidad espacial y la persistencia de la transmisión a nivel distrital. **Métodos:** Estudio descriptivo basado en datos de vigilancia epidemiológica de rutina. Se analizaron los casos mensuales y las tasas de incidencia para evaluar la variabilidad temporal, la estacionalidad y la variación interanual. Los análisis espaciales incluyeron el mapeo de la incidencia media distrital y del riesgo relativo ecológico anual en relación con la media provincial. La persistencia se evaluó mediante la proporción de años con incidencia distrital superior a la mediana provincial. **Resultados:** Se observó una elevada variabilidad temporal, un patrón estacional consistente en el período posterior a la temporada de lluvias y una marcada heterogeneidad espacial entre los distritos. **Conclusión:** La malaria en Tete presenta una heterogeneidad espacio-temporal persistente. Los análisis descriptivos basados en datos de vigilancia de rutina constituyen herramientas estratégicas para la priorización territorial y el fortalecimiento de las acciones de control.
**Palabras clave:** Malaria; Análisis espacio-temporal; Incidencia de enfermedades; Heterogeneidad espacial; Vigilancia de la salud pública.

## Introduction

Malaria remains one of the major public health problems in sub-Saharan Africa, accounting for most of the global burden of the disease in terms of both morbidity and mortality (World Health Organization, 2023). Recent high-resolution global mapping indicates that malaria burden declined globally from 2005 to 2015 but that progress has stalled since then, with trends largely driven by sub-Saharan Africa, where over 90% of malaria cases and deaths occur. Importantly, these analyses show that national-level estimates are insufficient to characterise subnational patterns of risk and progress, reinforcing the need for spatially explicit approaches to guide targeted malaria control strategies (Weiss et al., 2025). Despite progress over the past two decades, sustained reductions in malaria incidence have been uneven, with increasing evidence of stagnation or resurgence in several countries in the region, particularly in settings characterised by high socio-environmental vulnerability (Lubinda, 2020; Armando et al., 2023, 2025).

The dynamics of malaria transmission are widely recognised as heterogeneous across space and time, reflecting complex interactions among climatic, environmental, demographic, behavioural, and health system-related factors (Colborn et al., 2018; Okunlola and Oyeyemi, 2019). Studies conducted in different African countries have demonstrated that national-level average patterns often mask persistent pockets of high transmission, which tend to sustain local endemicity and hinder the achievement of malaria control and elimination targets (Mogeni et al., 2017).

In this context, spatio-temporal analyses based on routine epidemiological surveillance data have gained prominence as strategic tools for the continuous monitoring of malaria, particularly in settings where population-based surveys are logistically demanding or infrequent. Routine health information systems constitute the primary source of malaria surveillance in most endemic countries, offering high temporal resolution and broad territorial coverage, and enabling the identification of trends, seasonal patterns, and spatial structures directly relevant to public health decision-making. Although such data are subject to well-known limitations, including underreporting and healthcare-seeking bias, recent methodological advances emphasise their growing relevance for subnational malaria mapping when these limitations are explicitly acknowledged (Hyde et al., 2021; Arambepola et al., 2020; Pujol et al., 2023). This renewed emphasis on surveillance is also consistent with broader assessments indicating that malaria progress has levelled off and that disruptions such as the COVID-19 pandemic exposed how weak health systems and inadequate financing can constrain malaria control, making improved surveillance a core enabling function for evidence-based decision-making (Monroe et al., 2022).

In Mozambique, a country that bears one of the highest malaria burdens in southern Africa, transmission remains highly endemic and strongly seasonal, with substantial variation across provinces and districts (Armando et al., 2025). Evidence from independent modelling studies conducted in Mozambique also supports climate-linked seasonality, showing temporal variation patterns compatible with rainfall–temperature dynamics in routine malaria time series (Ferrão et al., 2021) and environmentally structured spatial variation in incidence (Zacarias and Andersson, 2010). Against this background, the present study aims to describe in detail the temporal, spatial, and spatio-temporal patterns of malaria incidence in Tete Province, Mozambique, from 2016 to 2022, using official epidemiological surveillance data. By integrating descriptive statistics, ecological relative risk measures, and spatial persistence indicators, this study provides district-level evidence to support more targeted malaria control strategies in Tete Province (Nigussie et al., 2022; Mogeni et al., 2017).

## Methods

### Study design

This is a descriptive ecological time-series study with a spatio-temporal approach, based on aggregated secondary data from epidemiological surveillance. The study design aimed to characterize the temporal dynamics, spatial distribution, and persistence of malaria incidence at the district level, without causal inference, in accordance with the descriptive and exploratory nature of the analysis.

### Study area

The study was conducted in Tete Province, located in central-western Mozambique (Figure 1), approximately between 16°09′58″ south latitude and 33°36′00″ east longitude. The province covers an area of 100,724 km² and had an estimated population of 2,900,213 inhabitants, according to the National Institute of Statistics (INE, 2019).

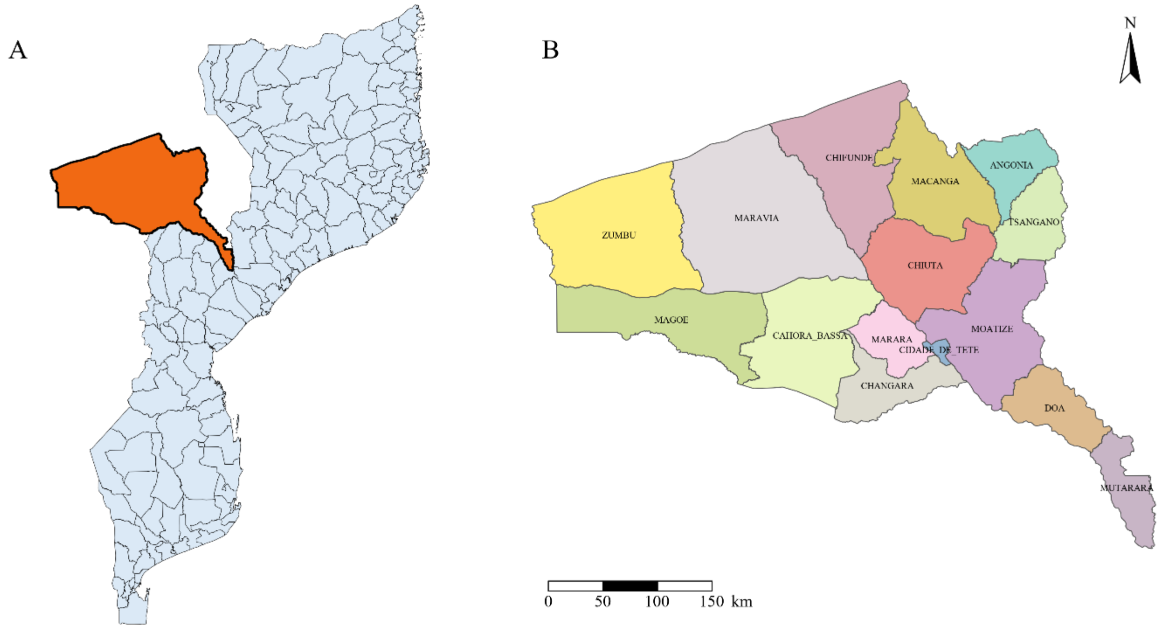


**Figure 1 -** Study area. (A) Location of Tete Province within Mozambique. (B) Administrative boundaries of districts in Tete Province. **Source:** Authors (2026).

Administratively, Tete Province comprises 15 districts, encompassing both urban and rural areas, distributed across two cities, four municipalities, 34 administrative posts, and 124 localities, which are the smallest units of local administration. This study included records from 155 health facilities distributed throughout the provincial territory, ensuring broad geographic coverage of the analyzed data.

From a climatic perspective, the province is predominantly tropical humid, with a hot, rainy season generally occurring between October and March, and a drier, milder season from April to September. This climatic regime directly influences malaria transmission dynamics, as temperature and rainfall conditions favor vector proliferation during the rainy season, which is relevant to the interpretation of the observed seasonal patterns.

The combination of geographic, administrative, climatic, and demographic characteristics makes Tete Province a particularly suitable setting for spatio-temporal analysis of malaria, allowing the exploration of differences across districts, urban and rural areas, and seasonal periods of increased transmission risk.

## Data sources and study variables

The data analyzed were obtained from the Health Information System for Monitoring and Evaluation (SISMA), the official epidemiological surveillance system that records malaria cases in Tete Province. Consolidated records covering the period from January 2016 to December 2022 were included in the analysis.

SISMA is fed by different reporting instruments operating at multiple temporal scales, including daily surveillance activity records, weekly epidemiological bulletins, and monthly reports from specific programs. Data are entered directly by health facilities responsible for healthcare delivery and epidemiological surveillance, ensuring continuous updating and wide territorial coverage.

The variables analyzed in this study were the number of reported malaria cases and the malaria incidence rate. All cases considered corresponded exclusively to laboratory-confirmed malaria cases based on positive diagnostic test results performed at health facilities in the province, according to the operational case definition adopted by SISMA during the study period.

Incidence rates were calculated using annual population projections provided by the National Institute of Statistics (INE), adopting the projected population for each year as a fixed denominator for the corresponding 12 months, a common practice when monthly population estimates are unavailable. The consolidated database contained no empty district–month records in the extracted dataset. However, as with all routine surveillance systems, the data may still be affected by underreporting and variations in healthcare access.

## Statistical and spatial analysis

Data analysis followed a descriptive and exploratory approach, oriented toward epidemiological monitoring and characterization of the spatio-temporal heterogeneity of malaria in Tete Province. Descriptive measures of central tendency and dispersion were calculated, including mean, standard deviation, minimum and maximum values, and quartiles, for both malaria cases and incidence rates.

The temporal dimension was explored by organizing monthly and annual records into discrete time series, thereby enabling the identification of seasonal patterns and interannual variation in malaria occurrence. Graphical representations, such as time-series plots and boxplots, were used to visualize variability in cases and incidence over time and across districts. Interannual variation was assessed descriptively by comparing annual distributions of monthly incidence, including changes in central tendency and dispersion across years.

The spatial dimension was analyzed by comparing incidence indicators across districts within the province. Thematic maps were produced to depict district-level average incidence over the study period and interannual variation in incidence. Additionally, annual relative risk was calculated as the ratio between district-level incidence and the provincial mean incidence for each year, enabling standardized comparison of malaria risk across districts over time. Annual relative risk (RR), as applied in this study, represents an ecological rate ratio calculated relative to the provincial mean incidence rather than an individual-level exposure contrast. This measure allows the identification of districts with incidence rates above (RR > 1) or below (RR < 1) the provincial benchmark and is widely used in descriptive subnational analyses of malaria based on routine surveillance data.

Transmission persistence was assessed by calculating the proportion of years between 2016 and 2022 in which district-level incidence remained above the provincial median, thereby identifying areas with recurrently elevated malaria risk throughout the study period.

All statistical analyses and the production of graphical and spatial outputs were conducted in the R computing environment, using packages widely employed in epidemiological studies for data analysis, visualization, and spatial data handling.

## Ethical considerations

This study was based exclusively on secondary, aggregated malaria surveillance data obtained from the Health Information System for Monitoring and Evaluation (SISMA) of Tete Province, Mozambique. The data were provided for research purposes following formal authorization from the responsible provincial health authorities in January 2023.

The dataset contained no individual-level identifiers or personal information, ensuring anonymity and confidentiality of the reported cases. As the study involved the analysis of routinely collected surveillance data in aggregated form, without direct contact with human participants, ethical review by a research ethics committee was not required according to national regulations and international guidelines for public health surveillance studies.

# Results

## Temporal variability of malaria cases and incidence

Analysis of malaria records in Tete Province from 2016 to 2022 revealed high temporal variability and spatial heterogeneity in both malaria cases and incidence rates, indicating a dynamic and irregular transmission pattern over the seven-year study period (Table 1).

**Table 1 -** Monthly summary of malaria cases and incidence in Tete Province, Mozambique (2016–2022).

| Indicator | Mean | SD | Min | 1st Q | Median | 3rd Q | Max |
|---|---|---|---|---|---|---|---|
| **Cases** | 2,296.3 | 2,023.7 | 43 | 946.8 | 1,701.5 | 2,969.3 | 17,411 |
| **Incidence** | 13.8 | 11.3 | 1 | 6 | 11 | 18 | 82 |

**Note:** Values correspond to monthly observations aggregated over the entire study period. Incidence is expressed per 1,000 inhabitants. **Source**: Authors (2026).

The mean monthly number of cases was 2,296.3, with a standard deviation of 2,023.7 and a median of 1,701.5, reflecting a right-skewed distribution driven by months with exceptionally high values. Minimum and maximum monthly case counts ranged from 43 to

17,411, highlighting sporadic episodes of intense transmission. Similarly, the mean monthly incidence was 13.8 cases per 1,000 inhabitants, with a standard deviation of 11.3 and a median of 11, reaching a maximum of 82 cases per 1,000 inhabitants, which underscores the marked monthly instability of malaria transmission in the province.

## Interannual variation and distribution of monthly values

Annual descriptive statistics (Table 2) indicate substantial variation in transmission intensity across the seven years analyzed.

**Table 2 -** Annual descriptive statistics of malaria cases and incidence in Tete Province, Mozambique (2016–2022).

| Year | Cases (mean ± SD) | Cases (min–max) | Incidence[a] (mean ± SD) | Incidence[a] (min–max) |
|---|---|---|---|---|
| 2016 | 2,138.52 ± 2,038.29 | 135 – 13,444 | 12.28 ± 9.53 | 1.46 – 55.57 |
| 2017 | 3,071.66 ± 2,752.30 | 280 – 17,411 | 19.08 ± 13.75 | 3.11 – 79.53 |
| 2018 | 2,103.83 ± 1,850.49 | 130 – 11,048 | 12.37 ± 8.30 | 1.42 – 37.75 |
| 2019 | 2,780.16 ± 2,001.36 | 130 – 11,430 | 17.25 ± 11.91 | 1.58 – 64.29 |
| 2020 | 2,865.18 ± 2,046.07 | 141 – 8,917 | 17.85 ± 14.31 | 1.71 – 81.72 |
| 2021 | 1,192.23 ± 864.28 | 43 – 4,337 | 6.90 ± 5.02 | 0.51 – 26.06 |
| 2022 | 1,922.63 ± 1,455.76 | 62 – 7,940 | 10.92 ± 7.64 | 0.75 – 39.98 |

**Note:** [a]Incidence expressed per 1,000 inhabitants. Values correspond to monthly means within each year. **Source**: Authors (2026).

The years 2017 and 2020 showed the highest mean monthly case counts and incidence rates, accompanied by large dispersion and wide ranges, characterizing periods of higher epidemiological intensity. In contrast, 2021 and 2022 exhibited lower means, standard deviations, and maximum values, suggesting a relative reduction in transmission during these years. Monthly distributions within each year, illustrated by boxplots (Figure 2), reinforce this pattern by showing pronounced intra-annual variability and recurrent outliers, particularly in years with higher disease burden.

Notably, 2017 and 2020 exhibited wider interquartile ranges and more outliers, indicating the occurrence of extreme transmission events. In subsequent years, especially 2021 and 2022, distributions became more compact, with fewer outliers, consistent with the reductions observed in annual summary statistics.

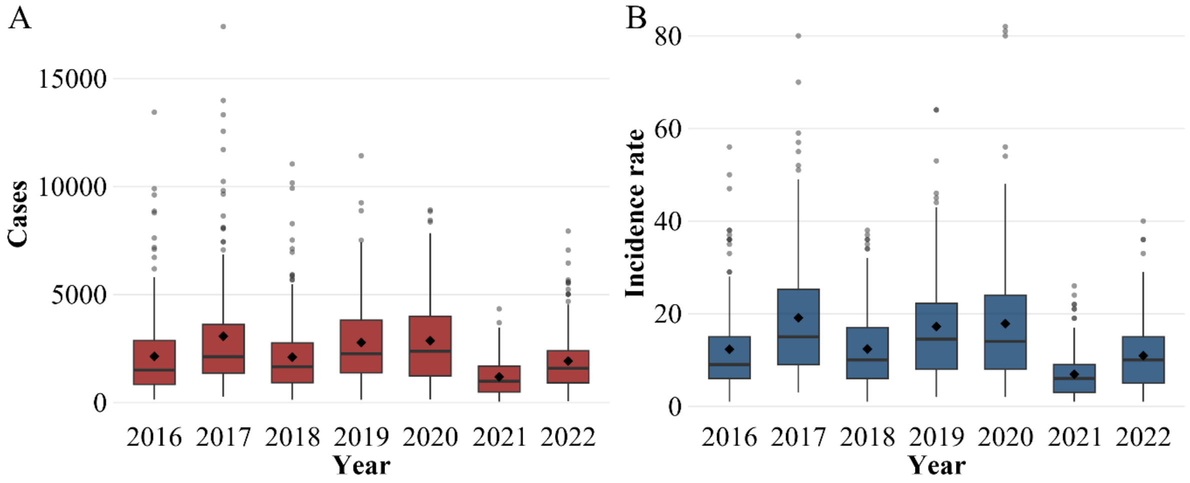


**Figure 2** – Boxplots of malaria cases (A) and incidence (B) in Tete Province, 2016-2022. **Source**: Authors (2026).

## Seasonal dynamics of malaria transmission

Monthly temporal trends in cases and mean incidence (Figure 3) reveal a consistent seasonal pattern throughout the study period. Indicators increased steadily from February to June, with recurrent peaks in March or April, followed by a gradual decline in subsequent months. The lowest values generally occurred between October and November, corresponding to the year's driest period. The recurrence of this pattern over time suggests that seasonality constitutes a structural component of malaria transmission dynamics in Tete Province.

## Spatial distribution of average malaria incidence

The spatial distribution of average annual malaria incidence by district over the period 2016-2022 shows marked territorial heterogeneity (Figure 4). Districts such as Chiuta, Macanga, and Zumbu recurrently presented high average incidence, whereas Tete City exhibited systematically lower values. This pattern indicates the coexistence of areas with higher and lower transmission intensity within the same province, suggesting the influence of territorial and structural factors on malaria risk.

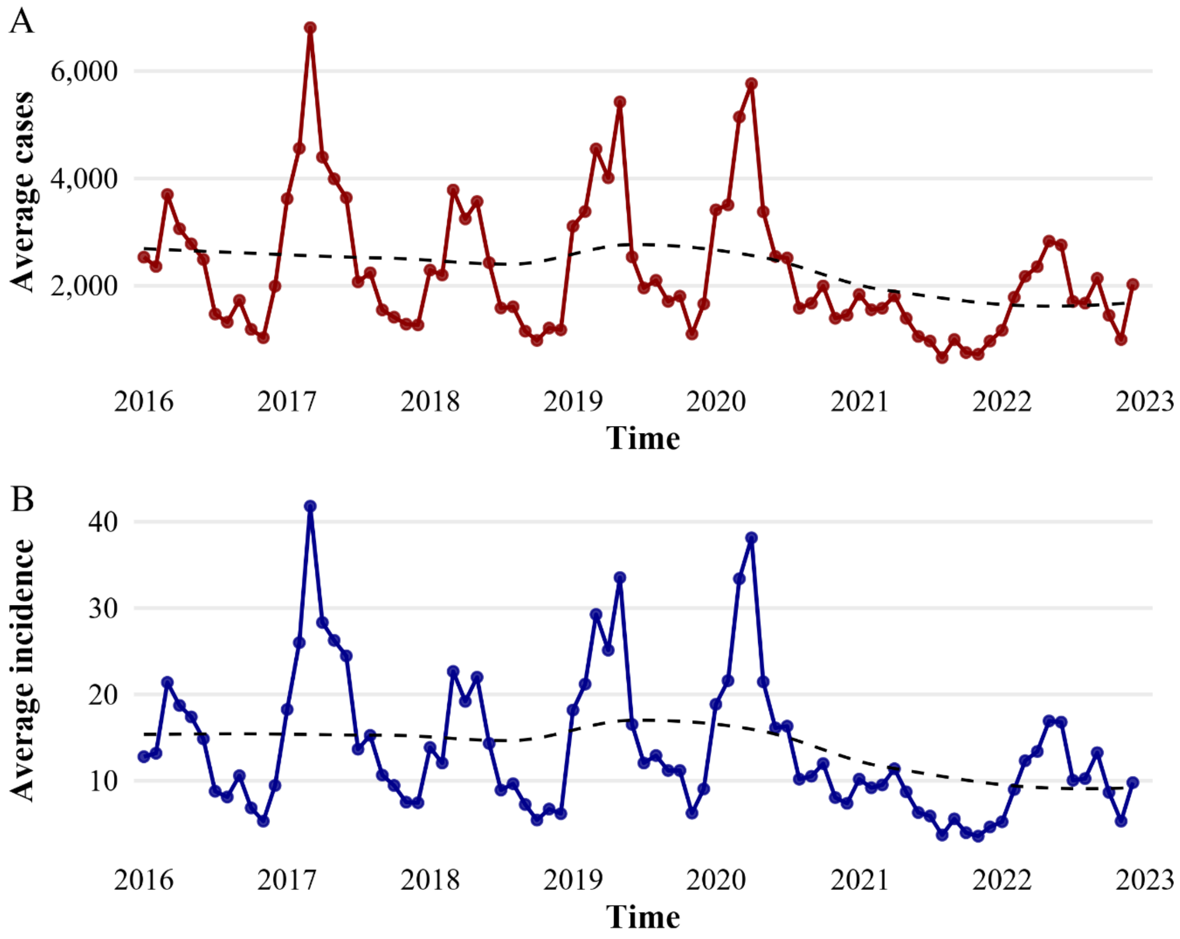


**Figure 3 -** Monthly average cases (A) and average incidence (B), 2016–2022. The dashed line represents a LOESS-smoothed trend to highlight the overall temporal pattern while reducing short-term variability. **Source**: Authors (2026).

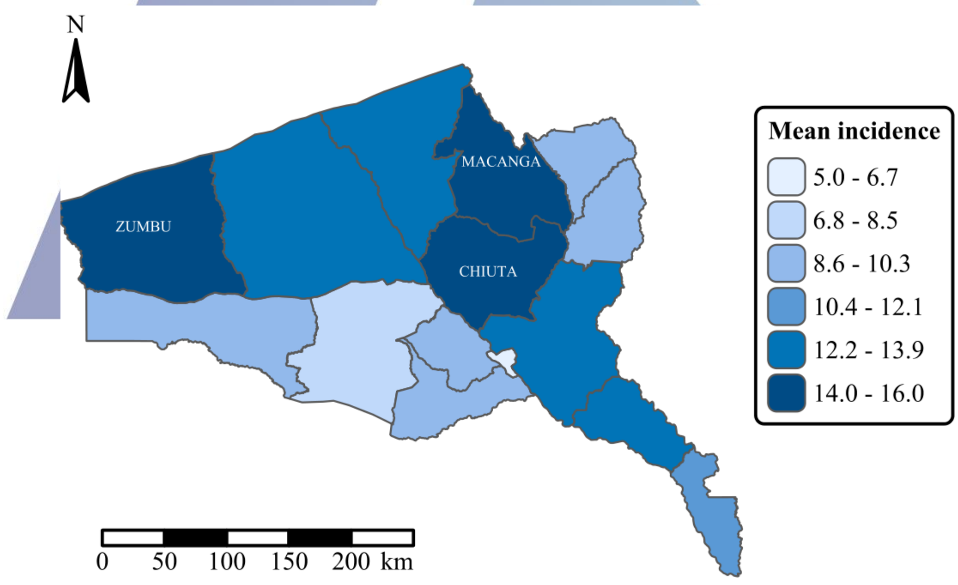


**Figure 4 -** Spatial distribution of average annual malaria incidence by district in Tete Province, 2016–2022. **Source**: Authors (2026).

## Interannual spatial variation and annual relative risk patterns

Analysis of interannual spatial variation in incidence (Figure 5) demonstrates that, although overall transmission intensity fluctuated across years, some districts recurrently maintained high incidence levels. Assessment of annual relative risk (Figure 6), calculated in relation to the provincial mean for each year, reveals persistent spatial inequalities, with certain districts showing systematically higher risk even during periods of lower overall transmission. These findings indicate that spatial heterogeneity in malaria transmission is not driven solely by annual transmission magnitude, but also by persistent local characteristics.

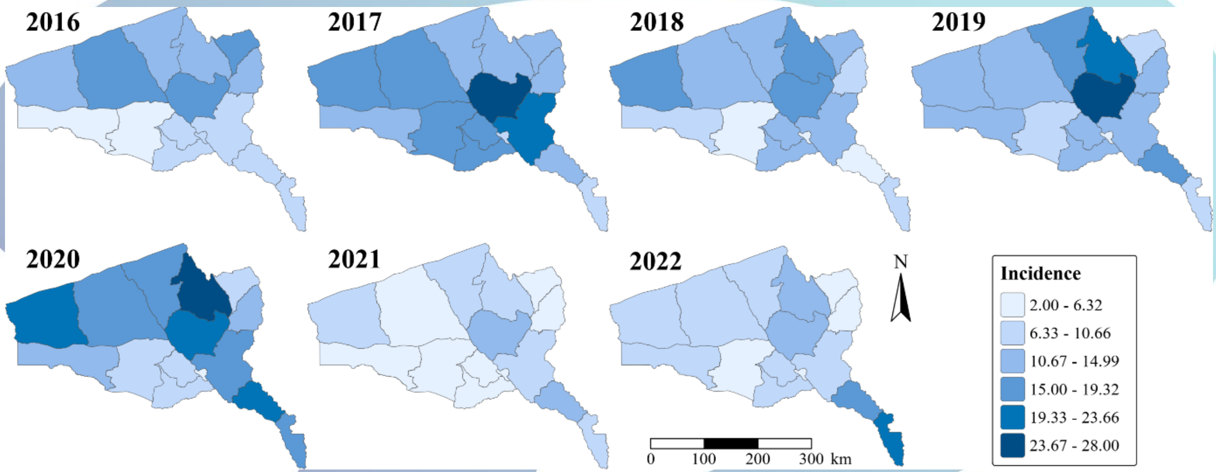


**Figure 5 -** Annual malaria incidence by district in Tete Province, 2016–2022. **Source**: Authors (2026).

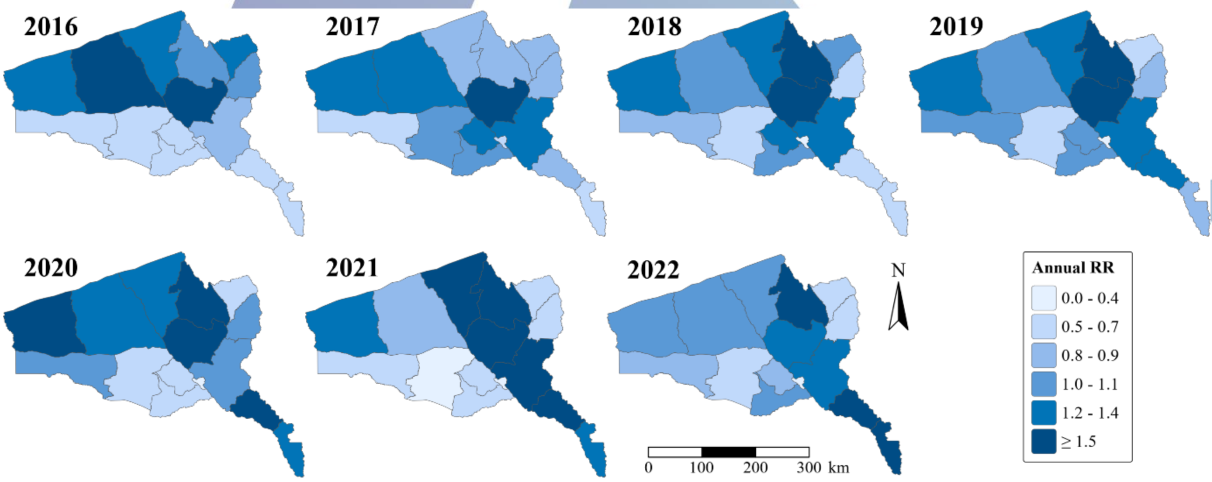


**Figure 6 -** Spatial distribution of annual relative risk (RR) of malaria incidence by district, calculated as an ecological rate ratio relative to the provincial mean, 2016–2022. **Source**: Authors (2026).

## Persistence of malaria incidence above the provincial median

Spatial persistence of malaria incidence, expressed as the proportion of years in which each district's incidence exceeded the provincial median (Figure 7), synthesizes the spatio-temporal dynamics observed during the study period. Results show that some districts remained above the median in most years, characterizing areas of persistent risk, whereas others exhibited predominantly lower values. This indicator enables the identification of priority territories for continuous malaria surveillance and control actions, beyond responses to isolated temporal peaks.

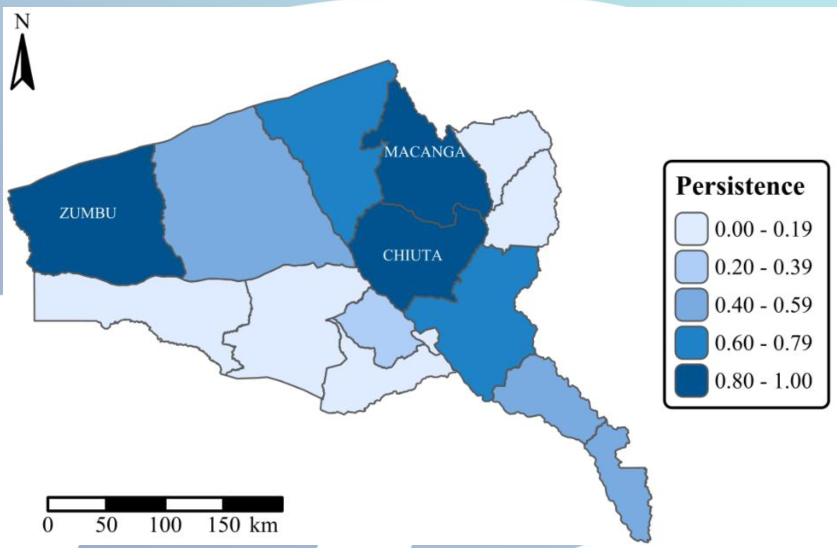


**Figure 7 -** Proportion of years (2016–2022) in which district-level malaria incidence exceeded the provincial median, highlighting areas of persistent annual relative risk above the provincial benchmark. **Source**: Authors (2026).

## Discussion

This study provided a comprehensive description of the temporal, spatial, and spatio-temporal patterns of malaria incidence in Tete Province between 2016 and 2022, revealing marked intra-annual variability, persistent spatial heterogeneity, and a concentration of risk in specific districts, even in a context of widespread endemic transmission. These findings reinforce the notion that aggregated averages tend to obscure local dynamics that are fundamental for the planning and prioritization of effective malaria control interventions. This interpretation is consistent with high-resolution global evidence indicating that malaria risk is highly uneven within countries and that national-level summaries often mask substantial subnational heterogeneity, underscoring the operational value of spatially explicit monitoring for targeted control strategies (Weiss et al., 2025).

Monthly descriptive analyses revealed pronounced dispersion in both malaria case counts and incidence rates, as reflected by high standard deviations relative to the means. This pattern is consistent with findings from other endemic settings, where intense fluctuations have been associated with seasonal transmission dynamics and transmission instability (Armando et al., 2025). Similar strong temporal variability has also been documented in Mozambican settings using routine time-series data, reinforcing that high dispersion and episodic peaks are expected features of malaria dynamics in high-endemicity contexts subject to seasonal forcing (Ferrão et al., 2021). The occurrence of extremely high maximum values suggests episodic intensification of transmission, compatible with seasonal outbreaks previously described in the regional literature.

The relative reduction observed in 2021–2022 should be interpreted with caution. Although similar declines have been reported in other settings and may reflect a combination of climatic variability, changes in intervention intensity, or broader health system disruptions, the present study did not include direct data on intervention coverage, diagnostic practices, or healthcare access. Therefore, these explanations remain contextual and cannot be formally assessed within the scope of this descriptive analysis. In this regard, spatio-temporal analyses conducted elsewhere have shown that apparent declines in malaria indicators may follow the scale-up of control interventions; however, such reductions are often heterogeneous across regions and should be interpreted cautiously when direct intervention data are unavailable (Ssempiira et al., 2017; Cao et al., 2025).

The annual boxplots further highlighted distributional asymmetry and the presence of outliers, indicating that a limited number of months concentrated disproportionately high numbers of cases and incidence rates. This pattern is recurrent in areas characterized by unstable or highly seasonal transmission and has been widely documented in spatio-temporal analyses of malaria across sub-Saharan Africa (Mogeni et al., 2017). Evidence from fine-scale geostatistical studies suggests that such asymmetry reflects localized, temporally variable transmission hotspots that may persist even when overall incidence appears to decline (Mategula and Gichuki, 2023).

Monthly temporal trends showed recurrent seasonal patterns, with transmission peaks concentrated between February and June, consistent with post-rainy-season dynamics recognized in the region. Previous analyses in Mozambican and other African settings have shown strong associations between rainfall, temperature, and seasonal increases in malaria incidence, supporting the interpretation that the temporal patterns observed in Tete Province reflect broader climate-linked processes that structure malaria transmission in high-endemicity environments (Ferrão et al., 2021).

From a spatial perspective, the distribution of average annual incidence by district revealed pronounced heterogeneity, with some districts recurrently exceeding the provincial mean. Importantly, districts contributing the largest absolute number of cases did not always coincide with those exhibiting the highest incidence rates. This finding underscores the importance of complementary interpretations of absolute burden and ecological relative risk when prioritizing malaria control actions (Zacarias and Andersson, 2010). Evidence from fine-scale spatial analyses in other African countries similarly demonstrates that localized hotspots may persist within broader endemic settings, reinforcing the limitations of national or provincial averages for operational decision-making (Mategula and Gichuki, 2023).

Analysis of annual relative risk further strengthened this interpretation by showing that certain districts recurrently experienced higher risk than the provincial average over multiple years, suggesting a structurally elevated transmission level. This pattern is particularly relevant from an operational perspective, as it highlights priority areas for targeted interventions rather than uniform approaches. Comparable spatio-temporal studies have shown that geographically persistent excess risk often reflects localized transmission dynamics that are not adequately addressed by generalized control strategies (Mogeni et al., 2017).

The spatial persistence indicator showed that some districts remained above the provincial median incidence for most of the study period, characterizing persistent transmission foci. The identification of such districts is critical, as evidence from other endemic settings indicates that areas with recurrent or persistent high transmission may sustain broader regional transmission, even in the presence of widespread control efforts (Nigussie et al., 2022). These findings support the need for territorially differentiated strategies that prioritize districts with sustained excess risk.

Although this study is descriptive in nature and based on routine surveillance data, the results demonstrate the value of integrating temporal, spatial, and spatio-temporal analyses for subnational malaria monitoring. Routine facility-based surveillance systems provide high-frequency and territorially extensive information, but they may underestimate true incidence due to underreporting, variations in healthcare-seeking behavior, and differential access to health services (Hyde et al., 2021). These limitations should be carefully considered when interpreting observed trends, particularly the reduction observed in the final years of the study period. Nevertheless, when interpreted with appropriate caution, routine surveillance data remain indispensable for continuous monitoring, pattern identification, and evidence-informed decision-making in settings where population-based survey data are limited or infrequent (Pujol et al., 2023).

## Conclusions

The findings indicate persistent district-level heterogeneity in malaria incidence in Tete Province, with recurrent seasonal peaks and districts that remained recurrently above provincial benchmarks over multiple years. Higher transmission intensity was observed up to 2020, followed by a relative reduction in 2021–2022; however, elevated incidence persisted in specific districts, indicating the continued presence of priority areas for control.

Seasonality was pronounced, with higher transmission between February and June, consistent with post-rainy-season dynamics documented in Mozambican routine time series. Importantly, districts contributing the largest absolute number of cases did not always coincide with those with the highest incidence, reinforcing the need to jointly interpret absolute burden and relative risk for operational prioritization.

Because the analyses are based on routine surveillance, the late-period reduction should be interpreted cautiously, considering potential changes in reporting and healthcare access. Even with these limitations, routine data remain valuable for continuous subnational monitoring when interpreted with appropriate caution, and the identification of districts with persistent excess risk supports territorially differentiated strategies rather than uniform interventions across the province. Even in high-endemicity settings, stable high-risk districts persist over time; therefore, spatially differentiated control is operationally justified.

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Conflict of interest

The authors declare no conflicts of interest in this study.

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