International Journal of Community Medicine and Public Health
Tembo I et al. Int J Community Med Public Health. 2024 Nov;11(11):4432-4440
http://www.ijcmph.com
pISSN 2394-6032 | eISSN 2394-6040

DOI: https://dx.doi.org/10.18203/2394-6040.ijcmph20243309

Meta-Analysis

Prevalence and predictors of malaria in pregnant women in Sub-Saharan Africa: a systematic review and meta-analysis

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Received: 22 August 2024
Accepted: 17 October 2024

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ABSTRACT

Malaria remains a significant threat to pregnant women in sub-Saharan Africa. This systematic review and meta-analysis aims to estimate the prevalence and identify predictors of malaria infection among pregnant women in the region. Following preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines, a comprehensive search of PubMed Central, Google Scholar, EMBASE, ScienceDirect, and Cochrane Library was conducted, including 15 studies published between 2013 and 2023. The pooled prevalence of malaria, calculated using a random-effects model, was 19.0% (95% CI: 0.13-0.26), with heterogeneity (I^2=81.9%) reflecting geographical and climatic diversity. Prevalence rates ranged from 6.4% in Burkina Faso to 36.4% in Tanzania. Asymptomatic cases had a prevalence of 19.0% (95% CI: 0.10-0.38), while symptomatic cases were slightly lower at 17.0% (95% CI: 0.12-0.23). Predictors of malaria included maternal age, parity, insecticide-treated net usage, intermittent preventive treatment, trimester-specific risk, and education level. These findings underscore the need for targeted, context-specific interventions to mitigate malaria risk among pregnant women in sub-Saharan Africa and inform effective malaria control strategies.

Keywords: Malaria, Pregnant women, Sub-Saharan Africa, Prevalence, Predictors

INTRODUCTION

Malaria remains a significant public health challenge in sub-Saharan Africa, particularly for expectant mothers, despite control efforts. In 2021, global estimates indicated 247 million malaria cases and 619,000 deaths, with the African region accounting for 95% of cases and 96% of deaths – approximately 234 million cases and 593,000 deaths.[1,2] Children under five made up 80% of these deaths. Additionally, of the estimated 40 million pregnancies in 2021, 13.3 million (32%) were at risk of malaria, reflecting a 1.2 million increase from 2020 due to rising malaria risk in certain countries.[2]

Regionally, West Africa had the highest exposure, with 6.5 million (40.7%) of 16 million pregnant women affected by malaria. In Central Africa, 3.4 million (39.8%) of 8.4 million pregnant women were infected. East and Southern Africa reported a lower infection rate of 20%, but the total number of affected women (3.5 million) exceeded that of Central Africa.[2]

Several factors influence malaria in pregnancy, including maternal age, use of preventive measures like insecticide-treated nets and intermittent preventive treatment, parity, trimester-specific risks, and education. This systematic review aims to examine the prevalence and key predictors of malaria among pregnant women in sub-Saharan Africa, to support more effective interventions.

METHODS

Following the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines, a comprehensive search was conducted in databases including Google Scholar, PubMed Central, ScienceDirect, and Cochrane Library, focusing on studies from 2013 to 2023 that examined the prevalence and predictors of malaria in pregnant women in sub-Saharan Africa. Boolean operators (AND, OR) and keywords such as "malaria OR *Plasmodium* infection," "pregnant OR gravidity," "prevalence OR risk," and "sub-Sahara" were used to identify relevant articles.

Inclusion criteria

Peer-reviewed observational studies (cross-sectional, cohort, case-control) reporting on the prevalence of malaria diagnosed through rapid diagnostic tests, microscopy, or polymerase chain reaction, and related predictors in pregnant women from sub-Saharan Africa were included. Only research published in English between 2013 and 2023, with a well-defined methodology and statistical parameters, were eligible.

Exclusion criteria

Qualitative studies, reviews, case reports, editorials, and studies outside the sub-Saharan Africa region or not focused on pregnant women were excluded. Studies lacking explicit data on malaria prevalence or predictors, those with methodological flaws (e.g., sample size under 50 participants), or those published before 2013 were also omitted.

Search criteria and quality assessment

Authors TI, KJ, SB, MT, and MT conducted independent searches across databases for studies published between 2013 and 2023, with EK, SM, and RM verifying content validity. After removing duplicates, 162 records were screened, leading to a comprehensive review of 111 full-text articles. Ultimately, 15 studies met the inclusion criteria. The quality of these studies was evaluated using the strengthening the reporting of observational studies (STROBE) checklist.

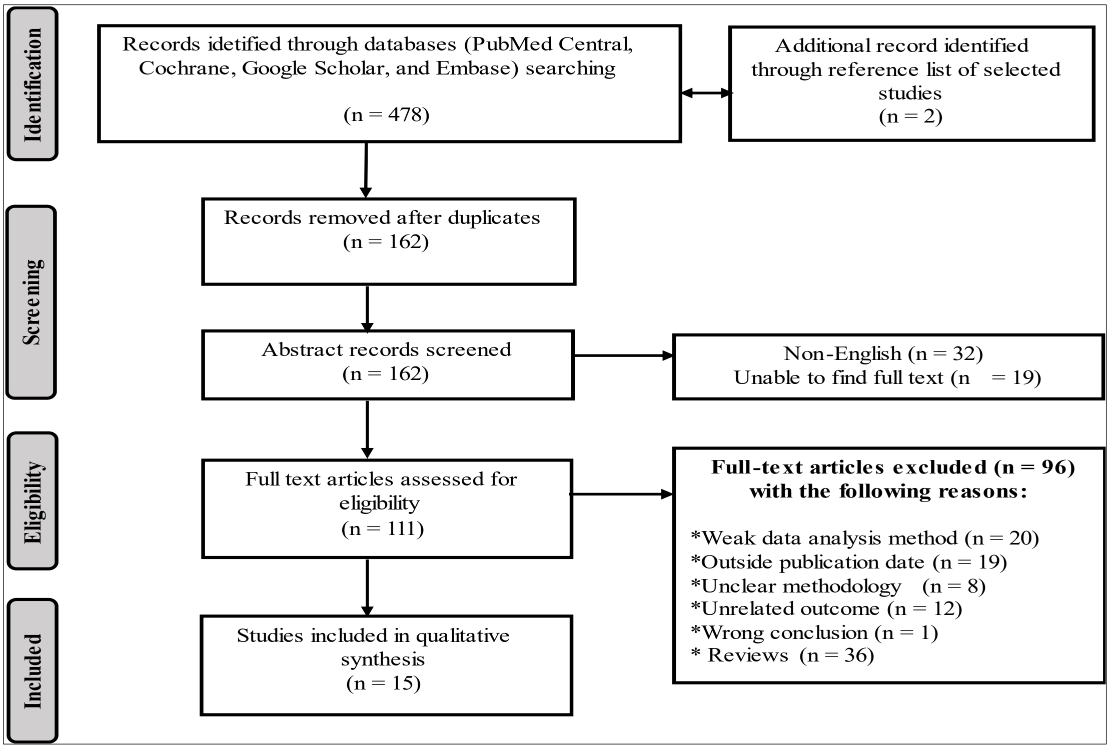

Figure 1: PRISMA Flow diagram showing study selection process.

Data extraction and analysis

Data were extracted using a table in Microsoft Word, capturing details such as authors, publication year, study title, publisher, objectives, methodology (research design, population, sample size, sampling method, data collection, and analysis), findings (malaria prevalence and risk factors), research questions, and conclusions. Statistical data were recorded in Microsoft excel and analyzed using STATA version 14.2 (StataCorp LP). Forest plots were used to estimate pooled effect sizes and assess individual study impacts, along with confidence intervals. Heterogeneity across studies was evaluated using the index of heterogeneity.

RESULTS

Study characteristics

Our meta-analysis included 15 studies conducted from 2013 to 2023 across several sub-Saharan African countries, including Benin, Nigeria, Ghana, Burkina Faso, Ethiopia, Tanzania, Uganda, and Zambia. Most studies (13 of 15) used a cross-sectional design, while two employed a cohort approach. Sample sizes ranged from 200 participants in Ghana to 1,931 in Burkina Faso.[3,4] Nine studies focused on symptomatic malaria, while the others examined asymptomatic cases. Reported malaria prevalence varied widely, from 6.4% in Burkina Faso to 36.4% in Tanzania.

Meta-analysis of the prevalence of malaria among pregnant women

To estimate the pooled prevalence shown in Figure 2, we used a random-effects model with the DerSimonian-Laird method. The pooled prevalence was 19.0% (95% CI: 0.13-0.26), which was statistically significant (Z= -9.899, p<0.001). The weights assigned to each study, based on the inverse-variance method, ranged from 5.64% to 7.42%, reflecting variations within and between studies. The overall effect size was calculated using the formula.

$$\theta = \frac{\Sigma\, w_i \times y_i}{\Sigma\, w_i}$$

Where y_i represents the logit-transformed prevalence rates and w_i denotes the weights based on within-study variances and the DerSimonian-Laird estimate of between-study variance. The variability in odds ratios (0.068 to 0.572) across different settings justified the use of the random-effects model. Significant heterogeneity was confirmed by the I^2 test (I^2=81.9%, p<0.001), indicating substantial differences in malaria prevalence among the studies.

Subgroup meta-analysis of malaria prevalence by case type

Our meta-analysis categorized malaria prevalence into asymptomatic and symptomatic groups (Figure 3). Using a random-effects inverse-variance model and the DerSimonian-Laird method, the overall pooled prevalence was 18% (95% CI: 0.12-0.25), with significant heterogeneity across studies (I^2=98.6%, p<0.0001).

For the asymptomatic group, the pooled prevalence was 19% (95% CI: 0.10-0.38), accounting for 40.31% of the total weight. Individual study prevalence ranged from 6.8% in Burkina Faso to 57.2% in Tanzania, with high heterogeneity (I^2=99.2%, p<0.0001).[4,5]

The symptomatic group showed a slightly lower pooled prevalence of 17% (95% CI: 0.12-0.23), contributing 59.69% to the total weight. Prevalence ranged from 8.3% in South-west Nigeria to 35.3% in North-western Uganda, with heterogeneity also high (I^2=95.2%, p<0.0001).

Table 1: General characteristics and outcomes of the included studies (n=15).

Authors	Study design	Region and country	Type of cases	Sample size	Prevalence of malaria (%)	Study quality
Accrombessi et al (2018)	Cohort	South-central Benin	Asymptomatic	387	19.7	Good
Agomo and Oyibo (2013)	Cross-sectional	South-west Nigeria	Symptomatic	384	7.7	Good
Ahadzie-Soglie et al (2022)	Cross-sectional	South Ghana	Symptomatic	200	11	Good
Almaw et al (2022)	Cross-sectional	North-west Ethiopia	Symptomatic	312	20.8	Good
Braun et al (2015)	Cross-sectional	Western Uganda	Asymptomatic	915	8.9	Good
Chaponda et al (2015)	Cohort	North Zambia	Asymptomatic	1086	31.8	Good
Cisse et al (2014)	Cross-sectional	South-west Burkina Faso	Symptomatic	579	18.1	Good
Dosoo et al (2020)	Cross-sectional	Middle-belt Ghana	Symptomatic	1655	20.4	Good
Gontie et al (2020)	Cross-sectional	West Ethiopia	Symptomatic	504	10.2	Good
Mangusho et al (2023)	Cross-sectional	North-western Uganda	Symptomatic	238	26.1	Good
Mlugu et al (2020)	Cross-sectional	South-east Tanzania	Asymptomatic	819	36.4	Good
Ndesurua et al (2015)	Cross-sectional	South-east Tanzania	Symptomatic	350	8	Good
Nega et al (2015)	Cross-sectional	South Ethiopia	Asymptomatic	346	9.7	Good

Continued.

Authors	Study design	Region and country	Type of cases	Sample size	Prevalence of malaria (%)	Study quality
Rouamba et al (2021)	Cross-sectional	Burkina Faso	Asymptomatic	1931	6.4	Good
Yaro et al (2021)	Cross-sectional	Central Burkina Faso	Symptomatic	346	15.75	Good

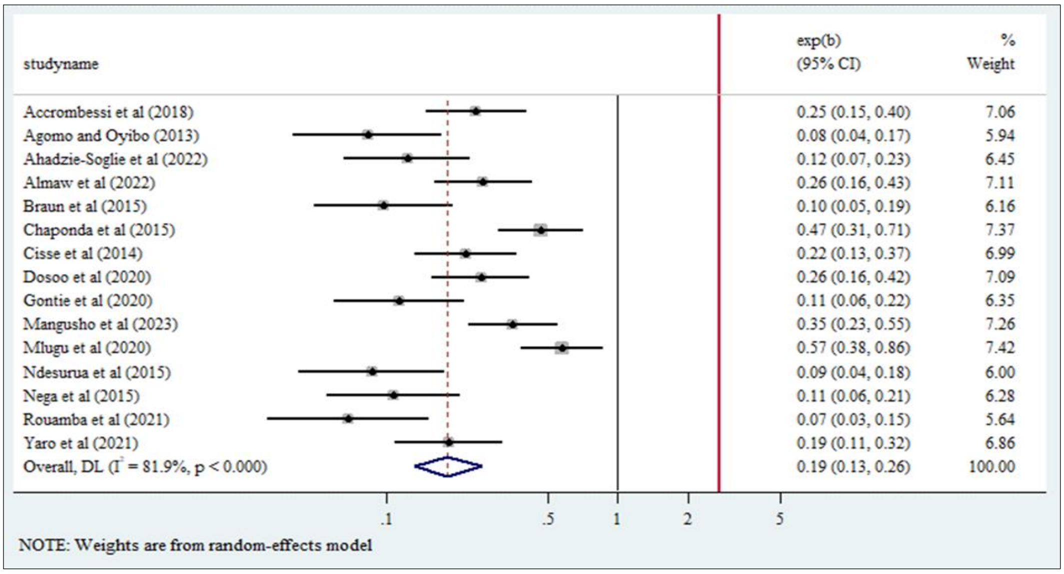

Figure 2: Meta-analysis of malaria prevalence in pregnant women.

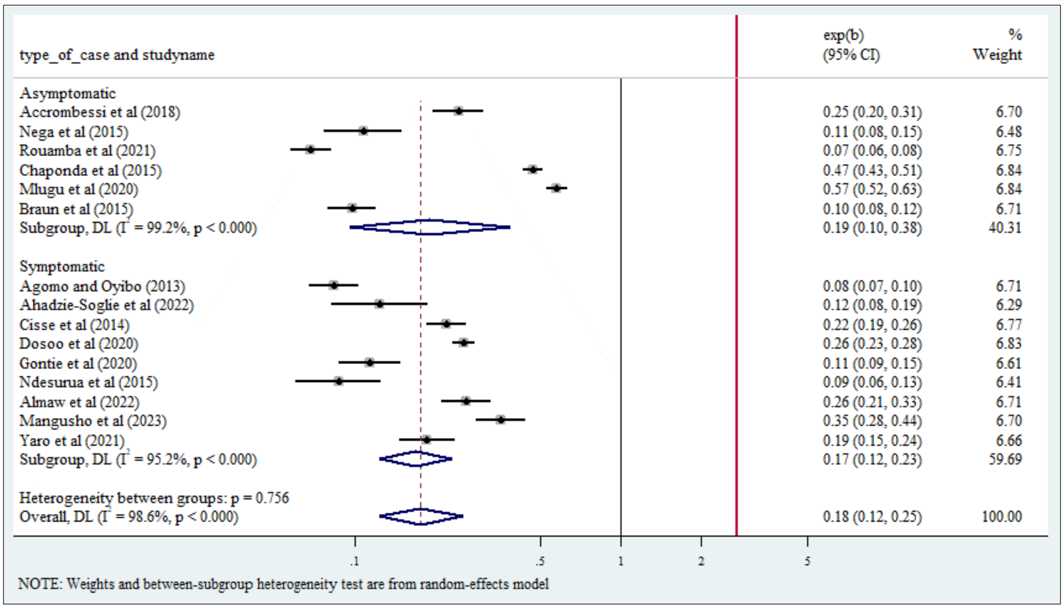

Figure 3: Subgroup meta-analysis of malaria prevalence by case type.

Predictors of malaria in pregnant women in sub-Saharan Africa

Our systematic review identified several statistically significant predictors of malaria in pregnant women across multiple studies, based on multivariate analyses from at least two studies. These predictors include maternal age, use of insecticide-treated nets (ITNs), intermittent preventive treatment (IPTp), parity, trimester-specific risk, and education level.

Maternal age

Younger mothers, especially those under 20, were found to be more susceptible to malaria. In South-west Nigeria, they were over twice as likely to contract malaria (AOR=2.61).[6]

Studies in Ghana and Ethiopia also found that younger age correlated with higher malaria risk.[7,8]

Insecticide-treated nets

Not using insecticide-treated nets (ITNs) significantly increased malaria risk. In Ghana, the risk of malaria for pregnant women not using ITNs (AOR=8.07), while in Ethiopia, the risk increased by 4.6 to 15 times depending on the region.[3,8,12,13]

Intermittent preventive treatment

Lack of intermittent preventive treatment (IPTp) with sulfadoxine-pyrimethamine (IPTp-SP) greatly increased malaria risk. In Ghana, women not using IPTp-SP were 11 times more likely to develop malaria (AOR=11.70) compared to those who did, while each additional dose in Burkina Faso significantly reduced the risk by 44%.[3,9]

Parity

Women in their first (primigravidae) or second (secundigravidae) pregnancies are at higher risk of malaria compared to multigravidae. In South-west Burkina Faso, primigravidae women had five times the risk (AOR=5.0), while in South Ethiopia, this risk increased to 9.40 times.[8,12]

Secundigravidae women in South Ethiopia had a 6.3 times higher risk, with similar findings in West Ethiopia and North Tanzania, where the risk for secundigravidae was 5.87 and 6.3 times higher, respectively.[8,14]

Trimester-specific risk

Malaria risk was higher in the first trimester. In West Ethiopia, first-trimester women were 23 times more likely to contract malaria than those in the third trimester (AOR=23.33), and similar trends were found in North-west Ethiopia and Uganda.[8,11,13]

Education

Lower education levels were associated with higher malaria risk. In Ghana and Ethiopia, illiterate women were almost eight times more likely to contract malaria compared to those with secondary education or higher (AOR=7.9), while in Burkina Faso, women with lower education had nearly double the risk (AOR=1.9).[7,10,13]

Publication bias

We assessed potential small-study effects (publication bias) by visually inspecting the funnel plot (Figure 4), which revealed an imbalance. Nine studies were located to the left, three to the right, and only three within the triangular area, suggesting possible publication bias. Egger's regression test confirmed this with a positive slope of 1.435 (95% CI: 1.027-1.843, p<0.001) and a significant negative bias of -10.783 (95% CI: -12.260 to -9.306, p<0.001) (Table 2). These findings support the indication of publication bias, as smaller studies tended to show greater variability in effect sizes. This highlights the importance of cautious interpretation of the pooled estimates and suggests a need for further research and potential corrections for publication bias.

Table 2: Egger's regression test.

Std_Eff	Coef.	Std. Err.	t	P>t	(95% Conf.)	
Slope	1.435	0.189	7.610	0.000	1.027	1.843
Bias	-10.783	0.684	-15.770	0.000	-12.260	-9.306

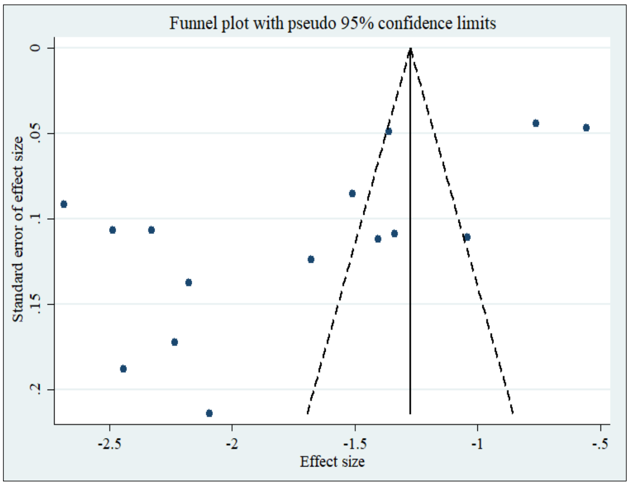

Figure 4: Funnel plot of malaria prevalence among pregnant women in sub-Saharan Africa.

DISCUSSION

The overall prevalence of malaria among pregnant women in this study was 19.0%, a decrease from the 33% reported in a prior systematic review for sub-Saharan Africa.[15] This reduction can likely be attributed to improved malaria control measures, such as increased usage of IPTp, ITNs, and better availability of effective antimalarial drugs.[16,17]

Our pooled prevalence of 19% was higher than in studies conducted in coastal Ghana (5%), Southern Laos (8.3%), Ethiopia (12.72%), India (5.4%), and Colombia (3.4%).[18-22] These differences may be due to seasonal variations, climatic conditions affecting malaria vector breeding and distribution, differing malaria control strategies, and sample size variations.[23]

The high heterogeneity (I^2=81.9%) observed in this study suggests that local factors such as healthcare interventions, climate, and environmental conditions play significant roles in malaria outcomes. This study fills a gap, as no other systematic reviews or meta-analyses have focused on malaria prevalence among pregnant women in sub-Saharan Africa during this period.

Subgroup analysis showed that asymptomatic cases made up a significant portion of the malaria burden, despite representing only 40% of the study's weight. Our asymptomatic rate of 17% was lower than rates reported by Yimam et al (26.1%) and Gemuchu et al (24.1%).[24,25] However, it was higher than rates in the Republic of Congo (7%), Bangladesh (2.3%), Merti district, Ethiopia (3.6%), and Colombia (4.2%).[26-29] The higher prevalence of asymptomatic parasitemia in our study may be explained by differences in parasite detection methods and the seasonal transmission of malaria. Regardless, asymptomatic malaria remains a public health concern due to its association with anemia and adverse birth outcomes, underscoring the need for early detection during surveillance.

Using the Köppen climate classification system (Table 3), we found higher malaria prevalence in regions with increased rainfall and humidity, such as Uganda (26.1%), Tanzania (36.4%), and Zambia (31.8%). These findings align with studies linking rainfall to increased mosquito breeding sites.[30] In contrast, drier regions like South-west Burkina Faso (18.1%) and South Ethiopia (9.7%) showed lower prevalence, supporting studies that suggest arid climates reduce mosquito survival and malaria transmission.[31]

Our review also highlighted the varied malaria prevalence across different temperature zones. For instance, regions with subtropical highland climates, such as North-west Ethiopia (20.8%) and West Ethiopia (10.2%), displayed moderate malaria prevalence, aligning with studies showing that moderate temperatures optimize mosquito survival and parasite development.[32] Conversely, in semi-arid regions like South-west and Central Burkina Faso, malaria prevalence remained significant, though research indicates that high temperatures support transmission less efficiently than moderate temperatures.[33] The varying climatic and environmental conditions between regions suggest the need for adaptive, region-specific vector control strategies and public health interventions.[34]

Our results confirm that not using ITNs significantly increases the risk of malaria, consistent with Lengeler's review and WHO reports demonstrating the efficacy of ITNs in reducing malaria risk.[35-38] Younger mothers were more susceptible to malaria, as seen in studies from Togo, Ghana, and Ethiopia, likely due to lower acquired immunity.[39-41] Some studies reported higher susceptibility among older women, though they did not account for factors like antenatal care timing, IPTp, or ITN usage.[42,43] Additionally, women in their first and second pregnancies faced higher malaria risk, which is consistent with previous research, possibly due to reduced immune responses during first pregnancies.[44,45]

Malaria was more common in the first trimester, potentially due to weakened immune responses early in pregnancy, as noted in Nigerian studies.[46,47] However, future research should explore malaria testing at multiple antenatal visits to better understand this trend. Not participating in IPTp-SP programs significantly increased malaria risk, as supported by studies in Ghana.[48] This aligns with WHO recommendations for IPTp-SP at every antenatal care (ANC) visit.[49,50]

Finally, the lack of formal education was identified as a risk factor for malaria, as educated women are more likely to seek early ANC, access IPTp-SP, and use ITNs, reducing their malaria risk.[51,52] This highlights the importance of raising awareness and promoting malaria prevention measures.

Table 3: Köppen climate classification system for included studies.

Authors	Country/region	MIP prevalence (%)	*Average annual temperature (°C)	*Average annual precipitation (mm)	Köppen classification
Accrombessi et al (2018)	South-central Benin	19.70	27.68	1054.17	Aw (Tropical savanna, dry-winter)
Agomo and Oyibo (2013)	South-west Nigeria	7.70	27.01	1164.95	Aw (Tropical savanna, dry-winter)
Ahadzie-Soglie et al (2022)	South Ghana	11.00	27.31	1236.04	Aw (Tropical savanna, dry-winter)
Almaw et al (2022)	North-west Ethiopia	20.80	22.88	845.03	Cwb (Subtropical highland, dry-winter)
Braun et al (2015)	Western Uganda	8.90	22.45	1217.89	Af (Tropical rainforest)
Chaponda et al (2015)	North Zambia	31.80	21.73	999.63	Cwa (Subtropical highland, dry-winter)

Continued.

Authors	Country/region	MIP prevalence (%)	*Average annual temperature (°C)	*Average annual precipitation (mm)	Köppen classification
Cisse et al (2014)	South-west Burkina Faso	18.10	28.78	840.42	BSh (Hot semi-arid)
Dosoo et al (2020)	Middle-belt Ghana	20.40	27.31	1236.04	Aw (Tropical savanna, dry-winter)
Gontie et al (2020)	West Ethiopia	10.20	22.88	845.03	Cwb (Subtropical highland, dry-winter)
Mangusho et al (2023)	North-western Uganda	26.10	22.45	1217.89	Af (Tropical rainforest)
Mlugu et al (2020)	South-east Tanzania	36.40	22.32	966.19	Aw (Tropical savanna, dry-winter)
Ndesurua et al (2015)	South-east Tanzania	8.00	22.32	966.19	Aw (Tropical savanna, dry-winter)
Nega et al (2015)	South Ethiopia	9.70	22.88	845.03	Cwb (Subtropical highland, dry-winter)
Rouamba et al (2021)	Burkina Faso	6.40	28.78	840.42	BSh (Hot semi-arid)
Yaro et al (2021)	Central Burkina Faso	15.75	28.78	840.42	BSh (Hot semi-arid)

*Temperature and precipitation data obtained from the World Bank Group, Climate Change Knowledge Portal (2023)

Implications for practice and policy

This meta-analysis emphasizes the importance of public health campaigns to ensure the widespread availability and use of ITNs and IPTp. Targeted interventions for younger mothers and those in their first or second pregnancies are crucial. The impact of social determinants, such as education and late ANC booking, highlights the need for comprehensive strategies that integrate both medical and educational initiatives.

Limitations

Despite its comprehensiveness, this study has limitations. Most studies (87%) were cross-sectional, limiting causal inferences. Additionally, the focus on symptomatic malaria may underestimate the burden of asymptomatic cases.

CONCLUSION

This meta-analysis advances the understanding of malaria epidemiology among pregnant women in sub-Saharan Africa, revealing the need for context-specific interventions addressing both biological and socio-demographic risk factors. Given the heterogeneity of findings, flexible, locally tailored approaches are essential for reducing the malaria burden, aligning with global malaria eradication goals.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

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Cite this article as: Tembo I, Kalele JC, Simwinga B, Mgemezulu T, Mwanza T, Kazonga E, et al. Prevalence and predictors of malaria in pregnant women in Sub-Saharan Africa: a systematic review and meta-analysis. Int J Community Med Public Health 2024;11:4432-40.