

International Journal of **Health Sciences** (IJHS)

**Determinants of Malaria and Maternal and Fetal Outcomes among
Pregnant Women in Lomami Province, Democratic Republic of the Congo**



CARI
Journals

Determinants of Malaria and Maternal and Fetal Outcomes among Pregnant Women in Lomami Province, Democratic Republic of the Congo



Jean-Claude Musasa Kasongo^{1*}, Bienfait Mwarabu Much'apa², Léonard Ngwej Mutshid³, Édouard Swana Kawawa⁴, Albert Mwembo Tambwe A-Nkoy^{2,4}, Jean-Baptiste Kakoma Sakatolo Zambèze^{2,4}

¹School of Public Health, University of Mwene-Ditu, Democratic Republic of the Congo

²School of Public Health, University of Lubumbashi, Democratic Republic of the Congo

³Faculty of Veterinary Medicine, University of Lubumbashi, Democratic Republic of the Congo

⁴Faculty of Medicine, University of Lubumbashi, Democratic Republic of the Congo.

Accepted: 12th Sep, 2026, Received in Revised Form: 28th Sep, 2026, Published: 12th Oct, 2026

ABSTRACT

Purpose: Malaria during pregnancy remains a major cause of maternal morbidity and adverse perinatal outcomes in sub-Saharan Africa. In the Democratic Republic of the Congo, particularly in Lomami Province, evidence on the determinants of malaria among pregnant women and its maternal and perinatal consequences remains limited. This study aimed to identify the determinants of malaria and assess its associated maternal and perinatal outcomes.

Methods: An unmatched case-control study was conducted from October to November 2025 in the urban Mwene-Ditu and rural Kanda-Kanda health zones, with follow-up data on pregnancy outcomes collected in April–May 2026. Cases were defined as pregnant women with malaria confirmed by a rapid diagnostic test and/or thick blood smear, whereas controls tested negative for malaria. Data were collected using a structured questionnaire and medical-record review. Associations were assessed using bivariate analyses followed by multivariable logistic regression.

Results: A total of 882 pregnant women were enrolled, including 294 cases of clinical malaria and 588 controls. After adjustment, factors associated with increased odds of malaria included non-attendance at antenatal care (adjusted odds ratio [aOR] = 2.41; $p < 0.05$), failure to receive intermittent preventive treatment with sulfadoxine-pyrimethamine (aOR = 1.87; $p < 0.01$), and proximity to mosquito breeding sites (aOR = 1.46; $p < 0.05$). Correct use of insecticide-treated nets was protective (aOR = 0.54; $p < 0.001$). Malaria was also associated with maternal anaemia (OR = 4.14; $p < 0.001$), maternal hospitalisation (OR = 10.50; $p < 0.001$), and low birth weight (OR = 2.99; $p < 0.001$).

Unique Contribution to Theory, Practice and Policy: Malaria among pregnant women in Lomami Province is primarily driven by modifiable preventive and environmental factors. Strengthening antenatal care attendance, uptake of intermittent preventive treatment with sulfadoxine-pyrimethamine, correct use of insecticide-treated nets, and community-based vector control could reduce malaria and its adverse maternal and perinatal outcomes.

Keywords: *Malaria; Pregnancy; Determinants; Maternal and Perinatal Outcomes; Democratic Republic of the Congo*

1. INTRODUCTION

Malaria remains a major global public health problem despite substantial progress over the past two decades. According to the *World Malaria Report*, the number of cases increased from 232 million in 2019 to 282 million in 2024, indicating a resurgence in transmission after a period of decline [1]. This reversal has been partly attributed to disruptions in health systems caused by the COVID-19 pandemic, which resulted in significant increases in malaria-related morbidity and mortality [2]. Consequently, the interim targets of the Global Technical Strategy for Malaria (GTS) have not been achieved, jeopardising the 2030 elimination goals if current trends persist [2].

The malaria burden is heavily concentrated in sub-Saharan Africa, which accounts for 94% of cases and 95% of malaria-related deaths worldwide [1]. In this region, pregnant women are particularly vulnerable because of the immunological and physiological changes associated with pregnancy, which facilitate parasite multiplication and the placental sequestration of *Plasmodium falciparum* [3]. The consequences are numerous and severe, including maternal anaemia, miscarriage, preterm delivery, low birth weight, and maternal and neonatal mortality [4–9].

A synthesis of recent evidence highlights the multifactorial nature of malaria among pregnant women. Individual determinants, particularly primigravidity and nulliparity, have consistently been associated with an increased risk of malaria infection because of insufficient acquired immunity [10]. Socioeconomic factors, such as low educational attainment and poverty, influence access to healthcare services and the uptake of preventive measures; an Indonesian study reported an adjusted odds ratio (aOR) of 4.18 [11]. Environmental factors, particularly the presence of mosquito breeding sites and poor sanitation conditions, also significantly increase exposure to malaria vectors.

Malaria-control interventions, particularly the use of insecticide-treated nets (ITNs) and intermittent preventive treatment in pregnancy with sulfadoxine–pyrimethamine (IPTp-SP), have proven effective in reducing malaria transmission and associated complications. However, their impact depends on their accessibility, acceptability, and effective use. Several studies have shown that ITN non-use and low IPTp-SP coverage are associated with significantly increased risks of malaria and anaemia among pregnant women [6,12].

In sub-Saharan Africa, the prevalence of malaria among pregnant women remains high but varies considerably across settings, ranging from less than 10% to more than 50%. High prevalence levels have been reported in Burkina Faso (42.6%), at two distinct sites in Ghana (42.6% and 56.4%), at two sites in Cameroon (22.4% and 22.9%), and in Nigeria (41.6%) [12–15]. However, lower prevalence estimates, such as the 8.9% reported in Ghana, suggest a beneficial effect of strengthened preventive interventions [16].

In the Democratic Republic of the Congo (DRC), malaria remains the leading cause of morbidity and mortality [17]. Despite the adoption of strategies recommended by the World Health Organization, including mass ITN distribution, IPTp-SP, and strengthened antenatal

care, intervention coverage remains inadequate. The 2023–2024 Demographic and Health Survey reported that only 60% of pregnant women had slept under an ITN on the night preceding the survey, while 22% had received at least two doses of SP for IPTp [18]. These coverage gaps reflect structural, sociocultural, and behavioural barriers that limit the effectiveness of malaria-control interventions.

The situation is particularly concerning in Lomami Province. Malaria accounts for 39.5% of proportional morbidity, and its incidence has increased in recent years, from 176 per 1,000 population in 2019 to 196 per 1,000 in 2022 [19]. The persistence of this burden despite ongoing control efforts suggests the presence of context-specific determinants that remain insufficiently explored, as previous studies have predominantly used descriptive or cross-sectional designs. Few studies in the DRC have employed a case-control design to examine simultaneously the determinants of malaria among pregnant women and its maternal and perinatal outcomes across contrasting urban and rural settings.

Therefore, an important knowledge gap remains regarding the factors underlying malaria occurrence among pregnant women and its maternal and fetal consequences in Lomami Province.

This study, conducted in the urban Mwene-Ditu and rural Kanda-Kanda health zones, aimed to identify the determinants of clinical malaria among pregnant women and assess its maternal and perinatal outcomes. Specifically, the study sought to describe the characteristics of the pregnant women surveyed, identify factors associated with clinical malaria, and evaluate the associated maternal and perinatal outcomes in Lomami Province.

2. MATERIALS AND METHODS

2.1. Study setting

This study was conducted in Lomami Province, located in the south-central region of the Democratic Republic of the Congo (DRC) and covering an area of 56,426 km². The province is classified as an area of stable, hyperendemic malaria transmission [20]. In 2024, its population was estimated at 4,806,254, with an average population density of 85 inhabitants per km². The provincial health system comprises 16 health zones, 316 health centres, and 16 general referral hospitals. A sentinel site for malaria surveillance is located in the Mwene-Ditu Health Zone [19].

The study was conducted in two health zones with contrasting epidemiological and socio-environmental contexts: the urban Mwene-Ditu Health Zone and the rural Kanda-Kanda Health Zone, located in Luilu Territory. These sites were selected to compare the determinants of malaria across different settings.

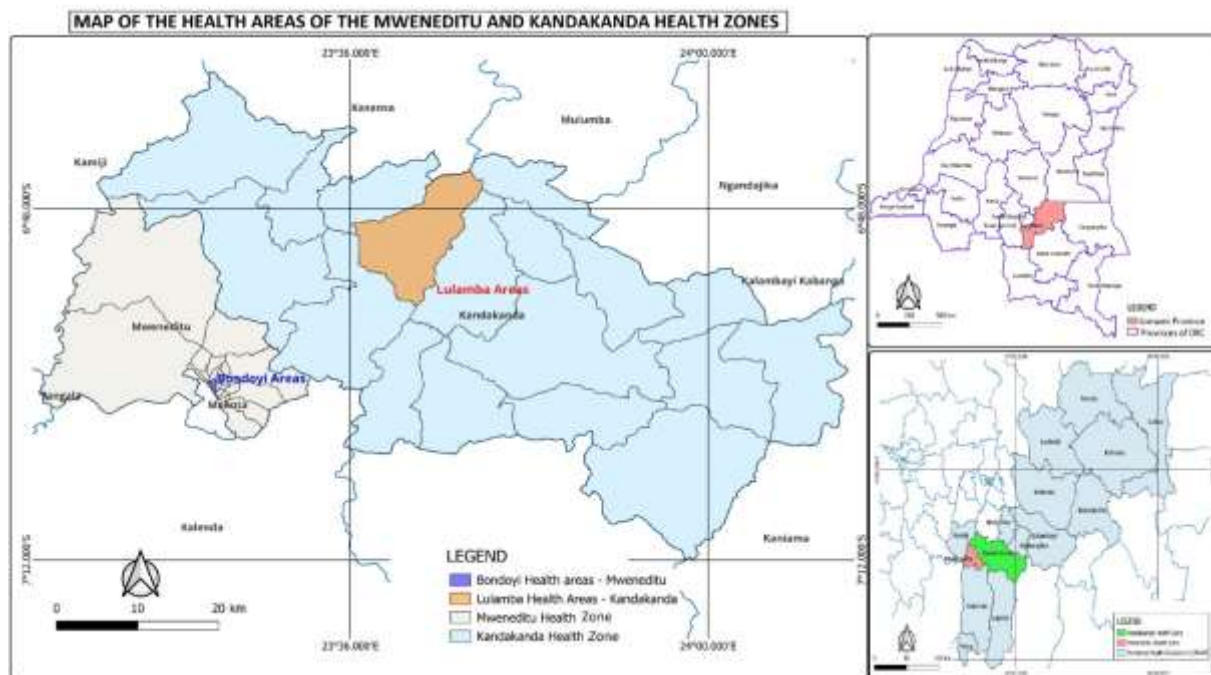


Figure 1. Map of the Mwene-Ditu and Kanda-Kanda health zones, Lomami Province, Democratic Republic of the Congo.

2.2. Study design, period, and population

This was an observational analytical unmatched case–control study conducted among pregnant women who had resided in the study areas for at least six months and were recruited from the selected health facilities.

Data collection was conducted in two phases. The first phase, from 1 October to 30 November 2025, collected data on participants' sociodemographic, obstetric, environmental, behavioural, and clinical characteristics. The second phase, from 1 April to 15 May 2026, collected follow-up data on maternal, fetal, and neonatal outcomes among women who delivered after the first survey.

Cases were defined as pregnant women presenting with fever or a history of fever within the preceding 48 hours, with a positive malaria rapid diagnostic test (RDT) and/or a positive thick blood smear. Controls were pregnant women with a negative RDT and/or thick blood smear and no clinical signs suggestive of malaria at the time of the survey.

Regular use of an insecticide-treated net (ITN) was defined as sleeping under an ITN every night during the week preceding the survey. Adequate environmental sanitation was defined as a clean household environment free from stagnant water.

2.3. Sampling and sample size

Participants were recruited from the selected health facilities using information recorded in outpatient and antenatal care registers. Systematic random sampling was used to identify eligible participants. Cases were enrolled consecutively after laboratory confirmation of

malaria, whereas controls from the same source population were recruited from antenatal care services during the same period, at a ratio of two controls per case (2:1).

The sample size was calculated using the StatCalc module in Epi Info, assuming a 95% confidence level, 90% statistical power, a case-to-control ratio of 1:2, an exposure prevalence of 40% among controls, and an expected odds ratio of 2.0. The exposure prevalence was estimated using data from the 2024 DRC Demographic and Health Survey, which reported that 60% of pregnant women used ITNs; exposure was therefore defined as ITN non-use [18]. The minimum required sample size was 399 participants, comprising 133 cases and 266 controls. After allowing an additional 10% for non-response and incomplete data, the target sample size was set at 441 participants per health zone, giving a total of 882 pregnant women, including 294 cases and 588 controls.

2.4. Study variables

The primary dependent variable was clinical malaria during pregnancy, defined as fever or a history of fever within the preceding 48 hours, with laboratory confirmation by a positive RDT and/or positive thick blood smear. The independent variables included sociodemographic characteristics (age, place of residence, educational attainment, marital status, occupation, and socioeconomic status); obstetric characteristics (gravidity, parity, gestational age, and number of antenatal care visits); preventive factors (ITN use and uptake of intermittent preventive treatment in pregnancy with sulfadoxine–pyrimethamine [IPTp-SP]); environmental factors (environmental sanitation and the presence of mosquito breeding sites); and behavioural factors (night-time exposure to mosquito bites). The secondary dependent variables were maternal anaemia, low birth weight, preterm delivery, miscarriage, haemorrhage, and other obstetric complications.

2.5. Data collection

Participants' previous exposure to the factors under investigation ($E+$ or $E-$) was assessed retrospectively. Data were collected through individual face-to-face interviews using a structured, pretested questionnaire administered by trained data collectors. The information was supplemented with data from antenatal care cards, health-facility registers, delivery registers, partographs, and laboratory results, including RDTs and thick blood smears. The questionnaire was pretested in two health zones with characteristics comparable to those of the study sites.

2.6. Statistical analysis

Data were entered into Microsoft Excel 2021 and subsequently analysed using Epi Info version 7.2.5 and SPSS Statistics version 28.

Descriptive analyses included the calculation of frequencies, proportions, means, and standard deviations. Associations between categorical variables were assessed using Pearson's chi-square test or Fisher's exact test, as appropriate. Crude odds ratios (ORs) and their 95% confidence intervals (95% CIs) were estimated in the bivariate analysis.

Factors independently associated with malaria during pregnancy were identified using logistic regression, from which adjusted odds ratios (aORs) and their 95% CIs were estimated. Statistical significance was set at $p < 0.05$.

2.7. Quality assurance

Data quality was ensured through prior training of the data collectors, pretesting of the data-collection tools, daily supervision of the field teams, systematic verification of questionnaire completeness, and quality control of laboratory tests by qualified medical laboratory scientists at the two participating general referral hospitals.

2.8. Ethical considerations

The research protocol was approved by the Medical Ethics Committee of the University of Lubumbashi (approval letter No. UNILU/CEM/014/2024, dated 26 February 2024). Voluntary informed consent was obtained from all participants before enrolment. Data confidentiality and participant anonymity were strictly maintained throughout the study. Pregnant women who tested positive for malaria received appropriate treatment in accordance with current national guidelines.

3. RESULTS

3.1. Participant characteristics

Table 1. Sociodemographic characteristics of the study participants.

Variable	Category	Cases, n	Cases, %	Controls, n	Controls, %	Total, n	Total, %
Health zone	Mwene-Ditu	147	50.0	294	50.0	441	50.0
	Kanda-Kanda	147	50.0	294	50.0	441	50.0
Maternal age	≥20 years	240	81.6	509	86.6	749	84.9
	<20 years	54	18.4	79	13.4	133	15.1
Marital status	Married/in union	294	100.0	584	99.3	878	99.5
	Unmarried	0	0.0	4	0.7	4	0.5
Educational attainment	Primary education or lower	202	68.7	418	71.1	620	70.3
	Secondary education or higher	92	31.3	170	28.9	262	29.7
Occupation	Homemaker	29	9.9	59	10.0	88	10.0
	Farmer	124	42.2	251	42.7	375	42.5
	Other occupation	141	48.0	278	47.3	419	47.5
Household income	Very low	212	72.1	407	69.2	619	70.2
	Low	53	18.0	106	18.0	159	18.0
	Middle	23	7.8	56	9.5	79	9.0
	Prefer not to answer	5	1.7	14	2.4	19	2.2
	High	1	0.3	5	0.9	6	0.7

A total of 882 pregnant women were included in the study, comprising 294 malaria cases and 588 controls. Half of the participants were recruited from the Mwene-Ditu Health Zone and the other half from the Kanda-Kanda Health Zone. Most participants were aged 20 years or older (84.9%), were married or living in union (99.5%), and had attained primary education or lower (70.3%). Farming was the most commonly reported occupation (42.5%), while 70.2% of households had very low incomes. Overall, the study population was characterised by low socioeconomic status and relatively limited educational attainment.

Table 2. Distribution of participants according to obstetric characteristics and use of malaria-prevention interventions in Lomami Province

Variable	Category	Cases, n	Cases, %	Controls, n	Controls, %	Total, n	Total, %
Gravidity	Primigravida	96	32.7	116	19.7	212	24.0
	Paucigravida	94	32.0	175	29.8	269	30.5
	Multigravida	62	21.1	185	31.5	247	28.0
	Grand multigravida	42	14.3	112	19.0	154	17.5
Parity	Nulliparous	98	33.3	118	20.1	216	24.5
	Primiparous	57	19.4	98	16.7	155	17.6
	Pauciparous	66	22.4	156	26.5	222	25.2
	Multiparous	45	15.3	165	28.1	210	23.8
	Grand multiparous	28	9.5	51	8.7	79	9.0
Current gestational age	<16 weeks	20	6.8	25	4.3	45	5.1
	16 to <28 weeks	151	51.4	340	57.8	491	55.7
	≥28 weeks	123	41.8	223	37.9	346	39.2
Antenatal care attendance	Attended ≥1 ANC visit	276	93.9	577	98.1	853	96.7
	No ANC attendance	18	6.1	11	1.9	29	3.3
IPTp-SP uptake	Received ≥1 dose of SP	233	79.3	523	88.9	756	85.7
	Received no SP dose	61	20.7	65	11.1	126	14.3

The obstetric characteristics of the study population showed that paucigravidae (30.5%), multigravidae (28.0%), and primigravidae (24.0%) were the most represented groups. Regarding parity, pauciparous (25.2%), nulliparous (24.5%), and multiparous women (23.8%) were represented in comparable proportions. More than half of the participants (55.7%) were in the second trimester of pregnancy, while 39.2% were in the third trimester. Antenatal care attendance was high, with 96.7% of women having attended at least one antenatal care visit.

Furthermore, 85.7% of participants had received at least one dose of sulfadoxine–pyrimethamine as part of intermittent preventive treatment in pregnancy, whereas 14.3% had received no dose.

3.2. Clinical presentation of malaria cases among pregnant women

Table 3. Clinical manifestations reported among pregnant women with clinical malaria in the Mwene-Ditu and Kanda-Kanda health zones, Lomami Province

Symptom	Frequency (<i>n</i> = 294)	%
Fever	269	91.5
Headache	219	74.5
Abdominal pain	169	57.5
Myalgia	106	36.1
General weakness	101	34.4
Cough/dyspnoea	75	25.5
Vomiting	42	14.3
Jaundice	30	10.2

Among pregnant women with clinical malaria, the clinical presentation was dominated by fever (91.5%), headache (74.5%), and abdominal pain (57.5%). General symptoms, including myalgia and weakness, were also common, whereas signs suggestive of severe malaria, particularly jaundice, were relatively uncommon. These findings indicate that malaria during pregnancy primarily presents as a polymorphic febrile syndrome, which may complicate the differential diagnosis in obstetric settings.

3.3. Association of age, occupation, and educational attainment with clinical malaria among pregnant women

Table 4. Association between the sociodemographic characteristics of pregnant women and clinical malaria in Lomami Province, Democratic Republic of the Congo.

Variable	Category	Cases, n (%)	Controls, n (%)	Total, n	OR	95% CI	<i>p</i>
Age	<20 years	54 (40.60)	79 (59.40)	133	1.90	1.12–3.22	0.01
	20–34 years	207 (33.17)	417 (66.83)	624	1.38	0.89–2.13	0.13
	≥35 years	33 (26.40)	92 (73.60)	125	1.00	Reference	—
	Total	294 (33.33)	588 (66.67)	882	—	—	—
Occupation	Farmer	124 (33.07)	251 (66.93)	375	1.01	0.61–1.64	0.98
	Other occupation	141 (33.65)	278 (66.35)	419	1.03	0.73–1.41	0.89
	Homemaker	29 (32.95)	59 (67.05)	88	1.00	Reference	—
	Total	294 (33.33)	588 (66.67)	882	—	—	—
Educational attainment	Secondary education or lower	293 (33.49)	582 (66.51)	875	3.02	0.36–25.20	0.50
	Higher education	1 (14.29)	6 (85.71)	7	1.00	Reference	—
	Total	294 (33.33)	588 (66.67)	882	—	—	—

In the bivariate analysis, maternal age was the only sociodemographic characteristic significantly associated with malaria during pregnancy. Compared with women aged 35 years or older, those younger than 20 years had nearly twice the odds of malaria (OR = 1.90; 95% CI: 1.12–3.22; $p < 0.05$). In contrast, no statistically significant association was observed between malaria and being aged 20–34 years, occupation, or educational attainment ($p > 0.05$).

3.4. Associations of obstetric characteristics, antenatal care attendance, and malaria-prevention measures with clinical malaria

Table 5. Associations of gravidity, parity, antenatal care attendance, and uptake of intermittent preventive treatment in pregnancy with sulfadoxine–pyrimethamine with clinical malaria among pregnant women.

Variable	Category	Cases, n (%)	Controls, n (%)	Total, n	OR	95% CI	<i>p</i>
Gravidity	Primigravida	96 (45.28)	116 (54.72)	212	1.97	1.43–2.70	<0.0001
	Paucigravida or higher	198 (29.55)	472 (70.45)	670	1.00	Reference	—
	Total	294 (33.33)	588 (66.67)	882	—	—	—
Parity	Nulliparous	98 (45.37)	118 (54.63)	216	1.99	1.45–2.73	<0.0001
	Primiparous or higher	196 (29.43)	470 (70.57)	666	1.00	Reference	—
	Total	294 (33.33)	588 (66.67)	882	—	—	—
Antenatal care attendance	No ANC attendance	18 (62.07)	11 (37.93)	29	3.42	1.59–7.34	<0.001
	≥1 ANC visit	276 (32.36)	577 (67.64)	853	1.00	Reference	—
	Total	294 (33.33)	588 (66.67)	882	—	—	—
IPTp-SP uptake	No SP dose received	61 (48.41)	65 (51.59)	126	2.10	1.43–3.08	<0.001
	≥1 SP dose received	233 (30.82)	523 (69.18)	756	1.00	Reference	—
	Total	294 (33.33)	588 (66.67)	882	—	—	—

The bivariate analysis showed that several obstetric and preventive characteristics were significantly associated with malaria during pregnancy. Compared with paucigravidae and multigravidae, primigravidae had nearly twice the odds of malaria (OR = 1.97; 95% CI: 1.43–2.70; $p < 0.0001$). A similar association was observed among nulliparous women compared with women who had previously given birth (OR = 1.99; 95% CI: 1.45–2.73; $p < 0.0001$). Furthermore, non-attendance at antenatal care (OR = 3.42; 95% CI: 1.59–7.34; $p < 0.001$) and failure to receive IPTp-SP (OR = 2.10; 95% CI: 1.43–3.08; $p < 0.001$) were each significantly associated with increased odds of malaria (Table 5).

3.5. Associations of insecticide-treated net use and household environmental characteristics with clinical malaria

Table 6. Associations of malaria-prevention measures and household environmental characteristics with clinical malaria among pregnant women in Lomami Province.

Variable	Category	Cases, n (%)	Controls, n (%)	Total, n	OR	95% CI	<i>p</i> -value
Correct ITN use	No	201 (40.20)	299 (59.80)	500	2.08	1.55–2.80	<0.0001
	Yes	93 (24.35)	289 (75.65)	382	1.00	Reference	—
	Total	294 (33.33)	588 (66.67)	882	—	—	—
Residence near mosquito breeding sites	Yes	120 (39.87)	181 (60.13)	301	1.55	1.16–2.09	0.002
	Unknown	9 (32.14)	19 (67.86)	28	1.11	0.49–2.51	0.79
	No	165 (29.84)	388 (70.16)	553	1.00	Reference	—
	Total	294 (33.33)	588 (66.67)	882	—	—	—

The bivariate analysis showed that several behavioural and environmental factors were significantly associated with malaria during pregnancy. Compared with women who regularly used an insecticide-treated net, those who did not use one correctly had approximately twice the odds of malaria (OR = 2.08; 95% CI: 1.55–2.80; $p < 0.0001$). Similarly, the presence of mosquito breeding sites near the home was associated with increased odds of malaria (OR = 1.55; 95% CI: 1.16–2.09; $p < 0.01$). In contrast, the “unknown” category regarding the presence of mosquito breeding sites was not significantly associated with malaria ($p > 0.05$).

3.6. Multivariable analysis: Potential determinants of malaria among pregnant women in Lomami Province

Table 7. Factors independently associated with malaria among pregnant women: multivariable logistic regression analysis.

Variable (comparison)	aOR	95% CI	Coefficient	SE	Z-statistic	<i>p</i>
Maternal age (<20 vs ≥20 years)	0.82	0.50–1.33	−0.2019	0.2467	−0.8184	0.4131
Gravidity (primigravida vs paucigravida or higher)	1.60	0.37–6.94	0.4708	0.7488	0.6287	0.5295
Parity (primiparous or higher vs nulliparous)	0.77	0.18–3.32	−0.2587	0.7437	−0.3478	0.7280
Antenatal care attendance (none vs ≥1 visit)	2.41	1.04–5.60	0.8792	0.4301	2.0440	0.0410
IPTp-SP uptake (no dose vs ≥1 dose)	1.87	1.23–2.84	0.6269	0.2130	2.9435	0.0032
Correct ITN use (yes vs no)	0.54	0.39–0.73	−0.6238	0.1583	−3.9412	0.0001
Residence near mosquito breeding sites (yes vs no)	1.46	1.08–1.99	0.3811	0.1574	2.4217	0.0154
Constant	—	—	−0.6115	0.7532	−0.8119	0.4169

The multivariable analysis identified four factors independently associated with malaria during pregnancy and considered potential determinants. Compared with women who had attended at least one antenatal care visit, those who had not attended antenatal care had higher adjusted odds of malaria (aOR = 2.41; 95% CI: 1.04–5.60; $p < 0.05$). Similarly, failure to receive intermittent preventive treatment with sulfadoxine–pyrimethamine and the presence of mosquito breeding sites near the home were independently associated with increased odds of malaria (aOR = 1.87; 95% CI: 1.23–2.84; $p < 0.01$ and aOR = 1.46; 95% CI: 1.08–1.99; $p < 0.05$, respectively). In contrast, correct use of an insecticide-treated net was independently associated with lower odds of malaria and was therefore considered a protective factor (aOR = 0.54; 95% CI: 0.39–0.73; $p < 0.001$). After adjustment, maternal age, gravidity, and parity were no longer significantly associated with malaria.

3.7. Maternal outcomes according to clinical malaria status

Table 8. Association between clinical malaria and maternal outcomes.

Category	Outcome	Cases, n (%)	Controls, n (%)	Valid cases, n	Valid controls, n	OR	95% CI	<i>p</i>
Maternal	Anaemia during pregnancy	34 (11.64)	18 (3.08)	292	584	4.14	2.30–7.48	<0.001
Maternal	Maternal hospitalisation	141 (48.45)	48 (8.22)	292	584	10.50	7.22–15.26	<0.001
Maternal	Eclampsia	22 (7.53)	48 (8.22)	292	584	0.91	0.54–1.54	0.725
Maternal	Haemorrhage	33 (11.30)	49 (8.39)	292	584	1.39	0.87–2.22	0.163
Maternal	Emergency caesarean delivery	8 (2.74)	7 (1.20)	292	584	2.32	0.83–6.47	0.097
Maternal	Maternal infection	32 (10.96)	53 (9.08)	292	584	1.23	0.78–1.96	0.375
Maternal	Maternal death	2 (0.68)	2 (0.34)	292	584	2.01	0.28–14.32	0.604

Malaria during pregnancy was significantly associated with certain maternal complications. Women with malaria had higher odds of anaemia during pregnancy than controls (OR = 4.14; 95% CI: 2.30–7.48; $p < 0.001$). Similarly, they had substantially higher odds of hospitalisation than women without malaria (OR = 10.50; 95% CI: 7.22–15.26; $p < 0.001$). In contrast, no statistically significant associations were observed between malaria and eclampsia, obstetric haemorrhage, emergency caesarean delivery, maternal infection, or maternal death ($p > 0.05$). In this study population, malaria was therefore primarily associated with maternal anaemia and a higher frequency of hospitalisation.

3.8. Fetal and neonatal outcomes according to clinical malaria status

Table 9. Association between clinical malaria and fetal and neonatal outcomes.

Category	Outcome	Cases, n (%)	Controls, n (%)	Valid cases, n	Valid controls, n	OR	95% CI	<i>p</i>
Maternal/fetal	Preterm delivery	78 (26.71)	146 (25.00)	292	584	1.09	0.79–1.51	0.584
Fetal/neonatal	Low birth weight	46 (16.31)	34 (6.12)	282	556	2.99	1.87–4.78	<0.001
Fetal/neonatal	Stillbirth	4 (1.37)	2 (0.34)	292	584	4.04	0.74–22.20	0.099
Fetal/neonatal	Early neonatal death	6 (2.06)	3 (0.51)	291	584	4.08	1.01–16.42	0.067
Fetal/neonatal	Admission to a neonatal unit	2 (0.68)	0 (0.00)	292	581	10.01	0.48–209.17	0.112

Analysis of fetal and neonatal outcomes showed that malaria during pregnancy was significantly associated with low birth weight. Infants born to mothers with malaria had higher odds of low birth weight, defined as a birth weight below 2,500 g, than those born to mothers

without malaria (OR = 2.99; 95% CI: 1.87–4.78; $p < 0.001$). In contrast, no statistically significant associations were observed between malaria during pregnancy and preterm delivery (OR = 1.09; 95% CI: 0.79–1.51; $p > 0.05$), stillbirth (OR = 4.04; 95% CI: 0.74–22.20; $p > 0.05$), early neonatal death (OR = 4.08; 95% CI: 1.01–16.42; $p > 0.05$), or admission to a neonatal unit (OR = 10.01; 95% CI: 0.48–209.17; $p > 0.05$). Although these outcomes were numerically more frequent among women who experienced an episode of malaria during pregnancy, the associations did not reach statistical significance.

4. DISCUSSION

4.1. Sociodemographic and obstetric profile of the participants and coverage of malaria-prevention interventions

This study, involving 882 pregnant women, including 294 cases of clinical malaria and 588 controls, identified a profile characteristic of populations living in malaria-endemic areas of sub-Saharan Africa. Most participants were aged 20 years or older (84.9%), were married or living in union (99.5%), had attained primary education or lower (70.3%), and belonged to low-income households (70.2%). Farming was the main economic activity (42.5%), reflecting a context of socioeconomic vulnerability that may influence malaria exposure and the uptake of preventive interventions.

Regarding obstetric characteristics, participants were predominantly paucigravidae (30.5%), multigravidae (28.0%), or primigravidae (24.0%), while more than half (55.7%) were in the second trimester of pregnancy. Coverage of preventive interventions appeared relatively high: 96.7% of women had attended at least one antenatal care (ANC) visit, and 85.7% had received at least one dose of intermittent preventive treatment in pregnancy with sulfadoxine–pyrimethamine (IPTp-SP). These findings suggest good initial access to maternal healthcare services in the two study health zones.

Our findings are consistent with those reported in several sub-Saharan African countries. In Ghana, Fondjo et al. also observed high ANC attendance and low socioeconomic status among pregnant women, while Ahadzie-Sogle et al. reported IPTp-SP coverage exceeding 80%. Studies conducted by Fana et al. in Nigeria and Anchang-Kimbi et al. in Cameroon described comparable profiles, characterised by low educational attainment, limited economic resources, and persistently incomplete coverage of preventive interventions despite high ANC attendance [16,6,15,12].

Unlike some studies that reported a direct association between low educational attainment and the risk of malaria during pregnancy [11], our findings suggest that socioeconomic characteristics primarily act as indirect determinants by influencing access to healthcare services, correct use of insecticide-treated nets (ITNs), and adherence to IPTp-SP. Furthermore, the predominance of farming activities may contribute to maintaining conditions conducive to vector proliferation, as also reported by Antonio-Nkondjio et al. across several Central African settings [21].

Despite the encouraging level of ANC attendance, 14.3% of participants had received no dose of IPTp-SP, which remains concerning in a setting of stable, hyperendemic malaria transmission. This finding is consistent with the 2023–2024 DRC Demographic and Health Survey, which showed that optimal IPTp-SP coverage remains below national and international targets, particularly because of late initiation of ANC, missed opportunities, and stock-outs of sulfadoxine–pyrimethamine [22,18].

These findings indicate that malaria during pregnancy occurs within a context of social, economic, and organisational vulnerability, in which the effectiveness of interventions depends not only on their availability but also on their appropriate use. In Lomami Province, malaria-control strategies should prioritise early initiation of ANC, systematic directly observed administration of IPTp-SP at every eligible contact, strengthened correct use of ITNs, and communication activities tailored to populations with limited educational attainment. These efforts should involve community health workers, Health Area Development Committees (*Comités de développement de l'aire de santé*, CODESAs), ANC providers, and local media to achieve sustained improvements in malaria prevention among pregnant women.

4.2. Clinical presentation of malaria among pregnant women

Among pregnant women with malaria in our study, the most frequent clinical manifestations were fever (91.5%), headache (74.5%), and abdominal pain (57.5%). This clinical presentation is consistent with the usual pattern of uncomplicated malaria during pregnancy. However, the high frequency of abdominal pain warrants particular attention because it may complicate the differential diagnosis of obstetric emergencies.

These findings are consistent with current evidence indicating that pregnancy increases susceptibility to symptomatic malaria because of maternal immunological changes and the placental sequestration of *Plasmodium falciparum* [3,23]. They also align with the observations of Bardají et al., who reported that 77.4% of pregnant women seeking care had symptoms suggestive of malaria and that 26.9% had confirmed parasitaemia. The most common symptoms were headache (86.5%), arthralgia and myalgia (74.8%), and a history of fever (65.4%). However, these symptoms had low positive predictive value for parasitological confirmation, highlighting the need for systematic laboratory diagnosis [24].

From a programmatic perspective, these findings support strengthening systematic malaria testing among all pregnant women presenting with fever or compatible symptoms, during both antenatal care and outpatient consultations, to improve early detection and case management in Lomami Province.

4.3. Sociodemographic, obstetric, and preventive factors associated with malaria among pregnant women

The bivariate analysis showed that pregnant women younger than 20 years were more likely to have malaria than those aged 35 years or older ($p = 0.01$). Primigravidae and nulliparous women also had higher odds of malaria ($p < 0.0001$). Similarly, non-attendance at antenatal care (ANC) and failure to receive intermittent preventive treatment in pregnancy with

sulfadoxine–pyrimethamine (IPTp-SP) were strongly associated with malaria ($p < 0.001$). In contrast, occupation and educational attainment were not significantly associated with malaria, possibly because of relatively homogeneous exposure to transmission risk and the small proportion of women with higher education.

These findings are consistent with several African studies. Cissé et al. in Burkina Faso and Fana et al. in Nigeria showed that adolescents, primigravidae, and nulliparous women were particularly vulnerable to malaria [5,12]. This increased vulnerability may be explained by insufficient pregnancy-specific immunity to *Plasmodium falciparum* during the first pregnancy, as described by Beeson and Duffy [3]. However, in our study, young maternal age, gravidity, and parity were no longer significant after adjustment, suggesting that their effects may be largely mediated by access to antenatal care and use of preventive interventions.

Conversely, non-attendance at ANC and failure to receive IPTp-SP remained independently associated with malaria after adjustment. This finding is consistent with the observations of Ahadzie-Sogle et al. and World Health Organization recommendations, which identify IPTp-SP and antenatal care as key interventions for preventing malaria during pregnancy [6,22].

These findings indicate that improving malaria prevention among pregnant women in Lomami Province should prioritise early initiation and regular attendance of ANC, systematic directly observed administration of IPTp-SP at every eligible visit, and targeted information, education, and communication interventions for adolescents and primigravidae.

4.4. Environmental and behavioural factors associated with malaria among pregnant women

Our study highlights the importance of environmental and behavioural factors associated with malaria during pregnancy. More than half of the participants (56.7%) did not use insecticide-treated nets (ITNs) correctly, and 34.1% lived near mosquito breeding sites. After adjustment, correct ITN use was independently associated with lower odds of malaria (aOR = 0.54; 95% CI: 0.39–0.73; $p < 0.001$) and was therefore considered a protective factor. Conversely, proximity to mosquito breeding sites was associated with higher odds of malaria (aOR = 1.46; 95% CI: 1.08–1.99; $p < 0.05$).

These findings suggest that malaria among pregnant women is associated not only with healthcare utilisation but also with the effective use of personal protective measures and the characteristics of the residential environment. Similar findings were reported by Anchang-Kimbi et al. in Cameroon and Hasyim et al. in Indonesia, where environmental factors were among the main determinants of malaria infection [11,15]. In the Democratic Republic of the Congo, Messina et al. showed that wealthier households had a significantly lower risk of malaria ($p < 0.001$), while high community-level ITN coverage had a protective effect ($p = 0.001$) [25]. Similarly, Ngatu et al. reported that 67.8% of households used ITNs as their primary preventive measure, whereas 7.3% used no protective strategy ($p < 0.01$) [26]. Furthermore, a meta-analysis by Sadoine et al. showed that ITN ownership significantly reduced the risk of malaria after adjustment for environmental factors (OR = 0.75; 95% CI:

0.60–0.95) [27]. Our findings are also consistent with those of Ahadzie-Sogle et al. and Fana et al., who demonstrated a significant protective effect of regular ITN use among pregnant women [6,12], as well as with World Health Organization recommendations identifying ITNs as an essential intervention for preventing malaria during pregnancy [28].

These findings indicate that malaria-control strategies in Lomami Province should combine ITN distribution with follow-up household visits to verify that nets are properly hung and consistently used. These strategies should also strengthen community-based environmental sanitation, mapping, and reduction of mosquito breeding sites, particularly in health areas with high malaria transmission.

4.5. Potential determinants of malaria among pregnant women

The multivariable analysis identified four potential determinants of malaria among pregnant women. Non-attendance at antenatal care (ANC) was associated with higher odds of malaria (aOR = 2.41; $p < 0.05$). Similarly, failure to receive intermittent preventive treatment in pregnancy with sulfadoxine–pyrimethamine (IPTp-SP) remained associated with higher odds of malaria (aOR = 1.87; $p < 0.01$). Conversely, correct use of insecticide-treated nets (ITNs) was associated with lower odds of malaria and represented a major protective factor (aOR = 0.54; $p < 0.001$). Finally, the presence of mosquito breeding sites near the home was also associated with higher odds of malaria (aOR = 1.46; $p < 0.05$).

These findings show that the main potential determinants of malaria among pregnant women in Lomami Province are largely modifiable and relate more closely to access to preventive interventions and environmental conditions than to the women's intrinsic biological characteristics. Maternal age, gravidity, and parity were no longer significantly associated with malaria after adjustment, suggesting that the effects observed in the bivariate analysis were largely mediated by access to healthcare services and uptake of preventive measures.

Our findings are consistent with those of Omer et al. in Sudan, who identified non-attendance at ANC (aOR = 11.9; $p < 0.001$) and non-use of ITNs (aOR = 3.5; $p < 0.001$) as independent risk factors for placental malaria [29]. Similarly, Apinjoh et al. in Cameroon showed that failure to receive IPTp-SP significantly increased the risk of malaria infection during pregnancy. These observations confirm the central role of preventive interventions recommended by the World Health Organization in reducing the burden of malaria during pregnancy [30].

The observed association between proximity to mosquito breeding sites and malaria also highlights the importance of environmental factors in transmission. This finding is consistent with that of Ngatu et al. in the DRC, who reported an association between household-level malaria and the absence of periodic water, sanitation, and hygiene interventions (OR = 1.63; $p < 0.05$) [26]. Furthermore, the systematic review by Keiser et al. concluded that environmental management and the reduction of mosquito breeding sites were effective and sustainable measures that could complement conventional vector-control strategies [31].

In Lomami Province, these findings suggest that strengthening early and regular ANC attendance, IPTp-SP coverage and adherence, and correct ITN use through targeted

communication activities could substantially reduce the malaria burden among pregnant women. They also support integrating community-based environmental sanitation interventions, including the identification and reduction of mosquito breeding sites around homes, to complement clinical preventive measures.

4.6. Maternal, fetal, and neonatal outcomes associated with malaria among pregnant women

Our study showed that malaria during pregnancy was significantly associated with maternal anaemia (OR = 4.14; $p < 0.001$) and maternal hospitalisation (OR = 10.50; $p < 0.001$), indicating greater maternal morbidity among women with malaria. In contrast, no statistically significant associations were observed with eclampsia, obstetric haemorrhage, maternal infection, emergency caesarean delivery, or maternal death. The small number of events, particularly maternal deaths, may have limited the precision of these estimates. Regarding fetal and neonatal outcomes, malaria was significantly associated with low birth weight (OR = 2.99; $p < 0.001$). Associations with preterm delivery, stillbirth, early neonatal death, and admission to a neonatal unit did not reach statistical significance, although these outcomes were numerically more frequent among women who experienced an episode of malaria.

These findings are consistent with the existing literature. In Ghana, Ahadzie-Sogle et al. reported an anaemia prevalence of 63.5% among pregnant women, with adolescents experiencing the highest frequencies of anaemia and malaria. In Ethiopia, Yosef et al. observed an association between malaria and anaemia during pregnancy (aOR = 7.83; $p < 0.01$), while Accrombessi et al. in Benin reported an association between malaria during the first trimester and anaemia during the third trimester (aOR = 2.25; $p < 0.05$) [6,9,32]. These findings are biologically plausible given the haemolysis of infected erythrocytes, splenic hyperactivity, and impaired erythropoiesis associated with *Plasmodium falciparum* infection [3,33].

The association between malaria and low birth weight is also consistent with mechanisms described in the literature. Guyatt and Snow and Rijken et al. showed that placental malaria may impair maternal–fetal exchanges and contribute to intrauterine growth restriction [34,35]. In Central Sudan, Mohammed et al. reported a strong association between submicroscopic *Plasmodium falciparum* infection and low birth weight (OR = 6.89; $p < 0.01$) [36]. Furthermore, a recent meta-analysis estimated that malaria during pregnancy significantly increased the risk of low birth weight (OR = 1.99; $p < 0.05$), as well as the risks of preterm birth and stillbirth [37]. In contrast, Tshiongo et al. in the DRC found no statistically significant association between placental malaria and low birth weight, despite a higher frequency among infected women [38]. Bakken and Iversen further emphasised that the protective effect of IPTp-SP against low birth weight depends on the number of doses administered and adherence to treatment [39].

These findings support strengthening IPTp-SP uptake, correct use of insecticide-treated nets, early malaria detection, and anaemia screening during antenatal care. These measures should

be prioritised, particularly in rural areas of Lomami Province where malaria transmission is high.

4.7. Strengths, limitations, and programmatic implications

This study has several strengths, including its case-control design, the simultaneous assessment of determinants and maternal and fetal outcomes, and the inclusion of both urban and rural settings. Its limitations include its observational nature, the risk of recall bias, and the small number of certain rare outcomes.

5. CONCLUSION AND RECOMMENDATIONS

This case-control study involving 882 pregnant women in the Mwene-Ditu and Kanda-Kanda health zones examined potential determinants of malaria during pregnancy and associated maternal, fetal, and neonatal outcomes in Lomami Province, Democratic Republic of the Congo. Malaria was independently associated with non-attendance at antenatal care, failure to receive intermittent preventive treatment with sulfadoxine-pyrimethamine, incorrect use of insecticide-treated nets, and mosquito breeding sites near the home. Correct net use was associated with lower odds of malaria, whereas non-attendance at antenatal care was associated with higher odds. Malaria primarily presented with fever, headache, and abdominal pain and was significantly associated with maternal anaemia and hospitalisation. Among fetal and neonatal outcomes, malaria was significantly associated with low birth weight, while associations with preterm delivery, stillbirth, and early neonatal death were not statistically significant. Overall, the findings highlight modifiable preventive and environmental factors associated with malaria during pregnancy and its maternal and newborn health burden.

Achieving a sustained reduction in the burden of malaria during pregnancy in Lomami Province requires an integrated approach combining early initiation and regular attendance of antenatal care, systematic directly observed administration of IPTp-SP at every eligible contact, promotion of correct ITN use, early screening for malaria and anaemia, and community-based environmental sanitation activities aimed at reducing mosquito breeding sites. Particular attention should be given to adolescents and primigravidae, given their vulnerability observed in the bivariate analysis. Finally, longitudinal studies are needed to better assess the associations between malaria—including placental malaria—and maternal, fetal, and neonatal outcomes, as well as the effectiveness of preventive interventions in this setting.

Authors' contributions

Jean-Claude Musasa Kasongo contributed to the conceptualisation, methodology, investigation, formal analysis, and preparation of the original draft. Bienfait Mwarabu Much'apa, Léonard Ngwej Mutshid, Édouard Swana, Albert Mwembo Tambwe A-Nkoy, and Jean-Baptiste Kakoma Sakatolo Zambèze contributed to reviewing and editing the manuscript and preparing the final version. Jean-Baptiste Kakoma Sakatolo Zambèze also provided overall supervision of the research. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no financial or personal competing interests that could have influenced the conduct of the research or the preparation of this original scientific article.

Funding

This study received no external funding and was entirely self-funded by the authors.

Références

1. World Health Organization. World malaria report 2025 [Internet]. Geneva: World Health Organization; 2025 [cited 2026 Mar 20]. Available from: <https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2025>
2. World Health Organization. World malaria report 2022 [Internet]. Geneva: World Health Organization; 2022 [cited 2023 Jul 10]. 293 p. Available from: <https://www.who.int/publications/i/item/9789240064898>
3. Beeson JG, Duffy PE. The immunology and pathogenesis of malaria during pregnancy. *Curr Top Microbiol Immunol*. 2005;297:187-227. doi:10.1007/3-540-29967-X_6.
4. Rijken MJ, De Livera AM, Lee SJ, Boel ME, Rungwilailaekhiri S, Wiladphaingern J, et al. Quantifying low birth weight, preterm birth and small-for-gestational-age effects of malaria in pregnancy: a population cohort study. *PLoS One*. 2014;9(7):e100247. doi:10.1371/journal.pone.0100247.
5. Cissé M, Sangaré I, Lougué G, Bamba S, Bayane D, Guiguemdé RT. Prevalence and risk factors for Plasmodium falciparum malaria in pregnant women attending antenatal clinic in Bobo-Dioulasso (Burkina Faso). *BMC Infect Dis*. 2014;14:631. doi:10.1186/s12879-014-0631-z.
6. Ahadzie-Sogle A, Addai-Mensah O, Abaka-Yawson A, Setroame AM, Kwadzokpui PK. Prevalence and risk factors of malaria and anaemia and the impact of preventive methods among pregnant women: a case study at the Akatsi South District in Ghana. *PLoS One*. 2022;17(7):e0271211. doi:10.1371/journal.pone.0271211.
7. Imbert P, Nizard J, Werkoff G, Kendjo E, Ficko C, Thellier M, et al. Pregnancy outcomes in women with imported malaria in mainland France: a retrospective study from 2004 to 2014. *Travel Med Infect Dis*. 2024;60:102727. doi:10.1016/j.tmaid.2024.102727.
8. Yosef T, Gizachew A, Shifera N. Determinants of anemia among antenatal care attendees in Southwest Ethiopia: a case-control study. *Health Sci Rep*. 2025;8(11):e71290. doi:10.1002/hsr2.71290.
9. Yosef T, Gizachew A, Fetene G, Girma D, Setegn M, Tesfaw A, et al. Infectious and obstetric determinants of anemia among pregnant women in Southwest Ethiopia. *Front Glob Womens Health*. 2024;5:1421884. doi:10.3389/fgwh.2024.1421884.

10. Sohail M, Shakeel S, Kumari S, Bharti A, Zahid F, Anwar S, et al. Prevalence of malaria infection and risk factors associated with anaemia among pregnant women in semiurban community of Hazaribag, Jharkhand, India. *Biomed Res Int.* 2015;2015:740512. doi:10.1155/2015/740512.
11. Hasyim H, Dale P, Groneberg DA, Kuch U, Müller R. Social determinants of malaria in an endemic area of Indonesia. *Malar J.* 2019;18(1):134. doi:10.1186/s12936-019-2760-8.
12. Fana SA, Bunza MDA, Anka SA, Imam AU, Nataala SU. Prevalence and risk factors associated with malaria infection among pregnant women in a semi-urban community of north-western Nigeria. *Infect Dis Poverty.* 2015;4:24. doi:10.1186/s40249-015-0054-0.
13. Tahita MC, Tinto H, Menten J, Ouedraogo JB, Guiguemdé RT, Van Geertruyden JP, et al. Clinical signs and symptoms cannot reliably predict *Plasmodium falciparum* malaria infection in pregnant women living in an area of high seasonal transmission. *Malar J.* 2013;12:464. doi:10.1186/1475-2875-12-464.
14. Dako-Gyeke M, Kofie HM. Factors influencing prevention and control of malaria among pregnant women resident in urban slums, Southern Ghana. *Afr J Reprod Health.* 2015;19(1):44-53.
15. Anchang-Kimbi JK, Nkweti VN, Ntonifor HN, Apinjoh TO, Tata RB, Chi HF, et al. *Plasmodium falciparum* parasitaemia and malaria among pregnant women at first clinic visit in the Mount Cameroon Area. *BMC Infect Dis.* 2015;15:439. doi:10.1186/s12879-015-1211-6.
16. Fondjo LA, Addai-Mensah O, Annani-Akollor ME, Quarshie JT, Boateng AA, Assafuah SE, et al. A multicenter study of the prevalence and risk factors of malaria and anemia among pregnant women at first antenatal care visit in Ghana. *PLoS One.* 2020;15(8):e0238077. doi:10.1371/journal.pone.0238077.
17. National Malaria Control Program, Democratic Republic of the Congo. Annual report 2022 on malaria control activities [report]. Kinshasa: Ministry of Health; 2023. 66 p.
18. National Institute of Statistics, Kinshasa School of Public Health, ICF. Democratic Republic of the Congo Demographic and Health Survey 2023-2024: DRC-DHS III [final report]. Kinshasa: National Institute of Statistics; 2025. 955 p.
19. Bulobo FM. Consolidated operational action plan of the Provincial Division of Public Health, Hygiene and Prevention 2024 [action plan]. Kabinda: Lomami Provincial Health Division; 2024. 106 p.
20. Ministry of Public Health, Democratic Republic of the Congo. National strategic plan for malaria control 2016-2020. Kinshasa: General Secretariat of Health; 2015.
21. Antonio-Nkondjio C, Ndo C, Njiokou F, Bigoga JD, Awono-Ambene P, Etang J, et al. Review of malaria situation in Cameroon: technical viewpoint on challenges and prospects for disease elimination. *Parasit Vectors.* 2019;12(1):501. doi:10.1186/s13071-019-3753-8.

22. World Health Organization. WHO guidelines for malaria [Internet]. Geneva: World Health Organization; 2022 Jun 3 [cited 2026 Jun 10]. Report No.: WHO/UCN/GMP/2022.01 Rev.2. Available from: <https://iris.who.int/items/c993d729-96e1-4fbf-b97a-3d0aa0cd7061>
23. Rogerson SJ, Hviid L, Duffy PE, Leke RFG, Taylor DW. Malaria in pregnancy: pathogenesis and immunity. *Lancet Infect Dis.* 2007;7(2):105-117. doi:10.1016/S1473-3099(07)70022-1.
24. Bardaji A, Sigauque B, Bruni L, Romagosa C, Sanz S, Mabunda S, et al. Clinical malaria in African pregnant women. *Malar J.* 2008;7:27. doi:10.1186/1475-2875-7-27.
25. Messina JP, Taylor SM, Meshnick SR, Linke AM, Tshefu AK, Atua B, et al. Population, behavioural and environmental drivers of malaria prevalence in the Democratic Republic of Congo. *Malar J.* 2011;10:161. doi:10.1186/1475-2875-10-161.
26. Ngatu NR, Kanbara S, Renzaho A, Wumba R, Mbelambela EP, Muchanga SMJ, et al. Environmental and sociodemographic factors associated with household malaria burden in the Congo. *Malar J.* 2019;18(1):53. doi:10.1186/s12936-019-2679-0.
27. Sadoine ML, Smargiassi A, Ridde V, Tusting LS, Zinszer K. The associations between malaria, interventions, and the environment: a systematic review and meta-analysis. *Malar J.* 2018;17(1):73. doi:10.1186/s12936-018-2220-x.
28. World Health Organization. Insecticide-treated nets to reduce the risk of malaria in pregnant women [Internet]. Geneva: World Health Organization; 2023 [cited 2026 Jun 10]. Available from: <https://www.who.int/tools/elena/interventions/bednets-malaria-pregnancy>
29. Omer SA, Idress HE, Adam I, Abdelrahim M, Noureldein AN, Abdelrazig AM, et al. Placental malaria and its effect on pregnancy outcomes in Sudanese women from Blue Nile State. *Malar J.* 2017;16(1):374. doi:10.1186/s12936-017-2028-0.
30. Apinjoh TO, Ntui VN, Chi HF, Moyeh MN, Toussi CT, Mayaba JM, et al. Intermittent preventive treatment with sulphadoxine-pyrimethamine (IPTp-SP) is associated with protection against sub-microscopic *Plasmodium falciparum* infection in pregnant women during the low transmission dry season in southwestern Cameroon: a semi-longitudinal study. *PLoS One.* 2022;17(9):e0275370. doi:10.1371/journal.pone.0275370.
31. Keiser J, Singer BH, Utzinger J. Reducing the burden of malaria in different eco-epidemiological settings with environmental management: a systematic review. *Lancet Infect Dis.* 2005;5(11):695-708. doi:10.1016/S1473-3099(05)70268-1.
32. Accrombessi M, Yovo E, Fievet N, Cottrell G, Agbota G, Gartner A, et al. Effects of malaria in the first trimester of pregnancy on poor maternal and birth outcomes in Benin. *Clin Infect Dis.* 2019;69(8):1385-1393. doi:10.1093/cid/ciy1073.
33. Steketee RW, Nahlen BL, Parise ME, Menendez C. The burden of malaria in pregnancy in malaria-endemic areas. In: Breman JG, Alilio MS, White NJ, editors. *The intolerable*

- burden of malaria: a new look at the numbers. *Am J Trop Med Hyg.* 2001;64(1-2 Suppl):28-35. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK2623/>
34. Guyatt HL, Snow RW. Impact of malaria during pregnancy on low birth weight in sub-Saharan Africa. *Clin Microbiol Rev.* 2004;17(4):760-769. doi:10.1128/CMR.17.4.760-769.2004.
35. Rijken MJ, McGready R, Boel ME, Poespoprodjo R, Singh N, Syafruddin D, et al. Malaria in pregnancy in the Asia-Pacific region. *Lancet Infect Dis.* 2012;12(1):75-88. doi:10.1016/S1473-3099(11)70315-2.
36. Mohammed AH, Salih MM, Elhassan EM, Mohammed AA, Elzaki SE, El-Sayed BB, et al. Submicroscopic *Plasmodium falciparum* malaria and low birth weight in an area of unstable malaria transmission in Central Sudan. *Malar J.* 2013;12:172. doi:10.1186/1475-2875-12-172.
37. Das JK, Lakhani S, Rahman AR, Siddiqui F, Ali Padhani Z, Rashid Z, et al. Malaria in pregnancy: meta-analyses of prevalence and associated complications. *Epidemiol Infect.* 2024;152:e39. doi:10.1017/S0950268824000177.
38. Tshiongo JK, Kuseke L, Maketa Tevuzula V, Luzolo F, Kafala Y, Ngelesi E, et al. Congenital malaria in newborns of mothers living in highly endemic parts of Kinshasa, Democratic Republic of Congo. *Paediatr Int Child Health.* 2025;45(1-2):26-33. doi:10.1080/20469047.2025.2459964.
39. Bakken L, Iversen PO. The impact of malaria during pregnancy on low birth weight in East-Africa: a topical review. *Malar J.* 2021;20(1):348. doi:10.1186/s12936-021-03883-z.



2026 by the Authors. This Article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>)