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# PREVALENCE AND DETERMINANTS OF MALARIA-BACTERIAL BLOODSTREAM CO-INFECTIONS IN FEBRILE PATIENTS ATTENDING A TERTIARY HOSPITAL IN JALINGO, TARABA STATE, NIGERIA

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## Abstract

***Background:*** *Malaria and bacterial bloodstream infections (BSIs) continue to be major causes of febrile illness and death in Nigeria. These infections often occur together, creating significant diagnostic and treatment problems, though little is known about the prevalence and risk factors for these infections in the north-eastern part of Nigeria. This study aimed to determine the prevalence, distribution, and predictors of malaria-BSI co-infections among febrile patients attending Federal Medical Centre (FMC), Jalingo, Taraba State.*

***Methods:*** *A retrospective cross-sectional study was conducted using secondary data from hospital records of 310 febrile patients who attended FMC Jalingo between 2023 and 2025. Malaria test results, blood culture results, demographic data, and clinical data were collected and analyzed with descriptive statistics, chi-square tests, and binary logistic regression.*

***Results:*** *The overall prevalence of malaria parasitemia was 61.9% (192/310; 95% CI: 56.4%–67.2%), while bacterial BSIs were detected in 32.6% (101/310; 95% CI: 27.6%–38.0%) of patients. The proportion of malaria-BSI co-infection was 23.5% (73/310; 95% CI: 19.2%–28.6%). Co-infections among children had the highest burden among all age groups (31.3%), followed by those aged 5–14 years (24.4%). Rural residence was an independent predictor of co-infection (adjusted OR = 2.133; 95% CI: 1.226–3.713; p = 0.007). HIV/AIDS (p = 0.014) and diabetes mellitus (p = 0.031) were significantly associated with co-infection.*


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***Conclusion:*** *The prevalence of malaria-bacterial BSI co-infection in this group is about 25%, and young children, rural residents, and immunocompromised individuals are the highest-risk groups. The results emphasize the importance of integrated approaches to diagnosis, strengthening of laboratory capacity, and targeting interventions to high-risk groups in malaria-endemic areas in Nigeria.*

**Keywords:** *Malaria, bacterial bloodstream infection, co-infection, febrile illness, Jalingo, Nigeria*

## INTRODUCTION

Malaria is still one of the most important public health problems in sub-Saharan Africa, especially Nigeria, which is the country with the greatest burden of malaria in the world. Nigeria is estimated to have around 27% of the global cases and 31% of the deaths from malaria (Venkatesan, 2024). Infected female Anopheles mosquitoes transmit the disease, and in the region, the deadliest and most disease-causing species is *Plasmodium falciparum* (Kolawole et al., 2023). Although malaria control measures have been implemented, such as malaria control with insecticide-treated nets (ITNs) distribution, indoor residual spraying, and artemisinin-based combination therapy, malaria transmission has continued, especially in rural and peri-urban communities where the environmental conditions are conducive to the breeding of mosquitoes (Jonathan et al., 2018).

Another major source of febrile illness and mortality in health-care settings in Nigeria is bacterial bloodstream infections (BSIs). Organisms like *Staphylococcus aureus*, *Escherichia coli*, *Salmonella spp*., and *Klebsiella pneumoniae* have been frequently associated with poor food hygiene, lack of access to clean water, and overcrowding (Park et al., 2016; Popoola et al., 2019). If these bacterial pathogens enter the bloodstream, they can lead to sepsis, multi-organ dysfunction, and death if not diagnosed and treated immediately (Kern & Rieg, 2020). The non-specific clinical signs of BSIs (fever, chills, malaise, weakness) are very similar to those of malaria, and there is significant diagnostic confusion in low- and middle-income countries, where access to laboratory testing is often limited (Wilairatana et al., 2022).

When malaria and bacterial BSIs are co-infections, they create an even greater clinical challenge. The association of malaria infection with susceptibility to invasive bacterial infection has been reported through several mechanisms such as immune system suppression, alteration of gut barrier integrity, and alterations in iron metabolism (Abuga et al., 2021; Harding et al., 2020). Moreover, hemolysis due to malaria interferes with iron regulation, which provides a favorable environment for the proliferation of bacteria, worsening clinical malaria outcomes (Abuga et al., 2021). Co-infected patients typically tend to have more serious illness, longer hospitalisation, and increased mortality (Kotepui et al., 2023; Sriboonvorakul et al., 2023).

There have been several hospital-based studies that have investigated the epidemiological pattern of malaria-BSI co-infections in Nigeria, with some being geographically distinct and methodological variation observed. Popoola et al. (2019) reported that of febrile patients in Ibadan, 17.2% had bacteremia, with S. aureus (59.0%) and Salmonella enterica (29.1%) being the most common isolates, and 34 patients (5.0% of all patients) had bacteria and P. falciparum (Popoola et al., 2019). Ojuawo et al. (2021) reported that Gram (+) bacteria accounted for 70.7% of the bacterial isolates from children with severe malaria, with S. aureus being the most prevalent (65.9%) in Ilorin (Ojuawo et al., 2021).

Wilairatana et al. (2022) conducted a systematic review and meta-analysis of the prevalence of concurrent bacteremia and malaria in febrile patients globally, and within febrile patients diagnosed with malaria, estimating a pooled prevalence of 1.9% and 7.6%, respectively (Wilairatana et al., 2022). However, there is significant local variation, as higher rates are generally seen in children and in those who are hospitalised with more severe disease.

There is still a critical evidence gap in the clinical and public health importance of malaria-BSI co-infections in Taraba State of northeastern Nigeria. Jalingo, the state capital, has a tropical savanna climate which provides conducive conditions for the seasonal transmission of malaria and vector breeding in the rainy season (April–October) (Jonathan et al., 2018; Obadiah et al., 2023). The Federal Medical Centre, Jalingo, is the main referral hospital for the state and its neighboring states, with a large number of febrile patients treated in the facility every year. However, no previous study has systematically examined the prevalence, distribution, or determinants of malaria-bacterial BSI co-infections in this population.

There is a need to understand the burden and risk factors for co-infection to optimize clinical decision-making, empirical treatment protocols, and public health interventions. The aim of the study was therefore to establish the prevalence of co-infection with malaria with and without bacterial BSI among febrile patients at FMC Jalingo from 2023 to 2025, characterise the distribution of co-infection according to the demographic and clinical parameters of the febrile patients, and identify the sociodemographic and clinical predictors of co-infection.

## METHODS

### Study Design and Setting

The study was a retrospective cross-sectional study carried out at the Federal Medical Centre (FMC), Jalingo, Taraba State, Nigeria. Jalingo is situated in the north-east of Nigeria at the latitude of 8.89 N and longitude of 11.36 E in the tropical savanna climatic zone, which has a well-defined dry and rainy season (November–March and April–October, respectively). The city is the administrative and commercial center of Taraba State with a diversified ethnic population, who are mainly engaged in agriculture, trade, and small-scale business. FMC Jalingo is a Federal Tertiary health facility that was set up in 1999 and serves as the major referral hospital for Taraba State and neighbouring states and territories (Federal Medical Centre Jalingo, n.d.).

### Study Population and Sampling

All laboratory results of patients who attended FMC Jalingo from January 2023 to December 2025 and had documented results for malaria microscopy or rapid diagnostic test (RDT) and blood culture were included. Patients who had documented laboratory


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results of both malaria microscopy or rapid diagnostic test (RDT) and blood culture during attendance at FMC Jalingo between January 2023 and December 2025 were studied. Both inpatients and outpatients were included. Records were excluded if there was no laboratory confirmation of malaria or blood culture, if blood culture samples were contaminated, if blood culture samples were not interpretable, or if there was a missing major demographic or clinical variable.

The patient records from the electronic Health Information Management System and laboratory records from the hospital were used for the systematic random sampling technique, resulting in 310 patient records. The sampling interval was determined by dividing the number of eligible records by the number of samples required. The first record was randomly selected, and subsequent records were selected at regular intervals to reach the desired number of records. Cochran's formula was used with parameters of 95% Confidence Level, 5% margin of error, and a prevalence of malaria-BSI co-infection of 23.3% from a previous study conducted in Nigeria. (Ojuawo et al., 2021). to determine the minimum sample size required for the study, which was 275. Due to the possibility of data incompleteness, a final sample of 310 records was obtained.

**Data Collection**

A structured abstraction form was used to extract the data, which included:

**Demographic information**: age (<5 years, 5–14 years, 15-49 years, ≥50 years), sex (male/female), place of residence (urban/rural).

**Clinical information**: hospitalisation status (inpatient/outpatient) and documented comorbidities (HIV/AIDS, diabetes mellitus, sickle cell disease and typhoid fever).

**Laboratory results**: Malaria test results (positive/negative) and blood culture results (positive/negative).

Accurate and complete data were verified by cross-checking electronic and manual records. A unique patient code was used to ensure the confidentiality of patient records.

**Data Analysis**

Data were analyzed using SPSS version 26. Descriptive statistics were computed to determine the prevalence of malaria parasitemia, bacterial BSIs, and malaria-BSI co-infections, with 95% confidence intervals calculated for proportions. Demographic and clinical sub-groups were analyzed for the distribution of co-infections.

Bivariate associations between co-infection (present/absent) and categorical variables (age group, sex, residence, hospitalization status, and comorbidities) were assessed using Pearson's chi-square tests. Bivariate analyses of variables were conducted, and variables with p-values < 0.20 were included in binary logistic regression models to identify independent factors associated with co-infection. Odds ratios (ORs) with 95% confidence intervals (CIs) were reported. A p-value <0.05 was considered statistically significant.

**Ethical Considerations**

Ethical approval was obtained from the Research Ethics Committee of the University of Port Harcourt and the Federal Medical Centre, Jalingo. Individual informed consent was not needed for this study because it was a secondary analysis of de-identified patient records. To protect patient confidentiality, all patient identifiers were removed before analysis. The study has been carried out in compliance with ethical norms for research on human subjects and data protection laws.

## RESULTS

**Demographic Characteristics of the Study Population**

A total of 310 febrile patients were included in the study. Demographic and clinical features of the study population are shown in Table 1. The majority of patients were female (53.2%; 165/310), while males accounted for 46.8% (145/310). The mean age of the study population was 24.8 ± 18.7 years (range: 0.5–82 years). Children under five years constituted the largest age group (31.9%; 99/310), followed by those aged 5–14 years (25.2%; 78/310), adults aged 50 years and above (26.5%; 82/310), and the 15–49 years age group (16.4%; 51/310).

In terms of place of residence, over half (51.9%; 161/310) were from urban areas, and 48.1% (149/310) were from rural areas. The proportion of patients hospitalized was 61.3% (190/310), with 38.7% (120/310) being outpatients. The most prevalent comorbidity recorded was typhoid fever (10.6%; 33/310), followed by diabetes mellitus (5.8%; 18/310), sickle cell disease (5.5%; 17/310), and HIV/AIDS (3.5%; 11/310).

**Table 1: Demographic and Clinical Characteristics of Febrile Patients Attending FMC Jalingo (2023–2025)**

| Characteristic | Category | Frequency (n) | Percentage (%) |
|---|---|---|---|
| **Total** | | 310 | 100.0 |
| **Sex** | Male | 145 | 46.8 |
| | Female | 165 | 53.2 |
| **Age Group** | <5 years | 99 | 31.9 |
| | 5–14 years | 78 | 25.2 |
| | 15–49 years | 51 | 16.4 |
| | ≥50 years | 82 | 26.5 |
| **Residence** | Urban | 161 | 51.9 |
| | Rural | 149 | 48.1 |
| **Hospitalization Status** | Inpatient | 190 | 61.3 |
| | Outpatient | 120 | 38.7 |
| **Comorbidities** | HIV/AIDS | 11 | 3.5 |
| | Diabetes | 18 | 5.8 |
| | Sickle Cell | 17 | 5.5 |
| | Typhoid Fever | 33 | 10.6 |

**Overall Prevalence of Malaria, Bacterial BSIs, and Co-Infections**

**Table 2** presents the overall distribution of malaria parasitemia, bacterial bloodstream infections, and malaria-BSI co-infections among the 310 febrile patients. Malaria parasitemia was detected in 192 patients, yielding an overall prevalence of 61.9% (95% CI:


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56.4%–67.2%). Bacterial bloodstream infections were confirmed in 101 patients, representing a prevalence of 32.6% (95% CI: 27.6%–38.0%). The proportion of patients with both malaria parasitemia and bacterial BSI (co-infection) was 23.5% (73/310; 95% CI: 19.2%–28.6%).

**Table 2: Overall Prevalence of Malaria, Bacterial Bloodstream Infections, and Malaria-BSI Co-Infections Among Febrile Patients Attending FMC Jalingo (2023–2025)**

| Infection Type | Total Tested (N) | Positive Cases (n) | Proportion (%) | 95% CI |
|---|---|---|---|---|
| **Malaria (Overall)** | 310 | 192 | 61.9 | 56.4–67.2 |
| **Bacterial BSIs (Overall)** | 310 | 101 | 32.6 | 27.6–38.0 |
| **Malaria-BSI Co-infection** | 310 | 73 | 23.5 | 19.2–28.6 |

*Key: BSI = Bloodstream Infection; CI = Confidence Interval*

**Distribution of Co-Infections by Demographic and Clinical Characteristics**

**Age Distribution**

**Table 3** presents the age distribution of malaria-BSI co-infection. Children under five years of age had the highest co-infection prevalence at 31.3% (31/99). This was followed by children aged 5–14 years (24.4%; 19/78) and adults aged 50 years and above (20.7%; 17/82). The lowest prevalence was observed among adults aged 15–49 years (11.8%; 6/51). The association between age and co-infection approached statistical significance in bivariate analysis ($\chi^2 = 7.639$, df = 3, p = 0.054).

**Table 3: Age Distribution of Malaria-BSI Co-Infections Among Febrile Patients**

| Age Category | Total Cases (N) | Co-infection Present (n) | Co-infection Proportion (%) |
|---|---|---|---|
| <5 years | 99 | 31 | 31.3 |
| 5–14 years | 78 | 19 | 24.4 |
| 15–49 years | 51 | 6 | 11.8 |
| ≥50 years | 82 | 17 | 20.7 |
| Total | 310 | 73 | 23.5 |

*Key: BSI = Bloodstream Infection*

**Sex Distribution**

**Table 4** shows the sex distribution of malaria-BSI co-infections. Co-infection was slightly more prevalent among males (25.5%; 37/145) than females (21.8%; 36/165), but this difference was not statistically significant ($\chi^2 = 0.587$, df = 1, p = 0.444).

**Table 4: Sex Distribution of Malaria-BSI Co-Infections Among Febrile Patients**

| Sex | Total Cases (N) | Co-infection Present (n) | Co-infection Proportion (%) |
|---|---|---|---|
| **Male** | 145 | 37 | 25.5 |
| **Female** | 165 | 36 | 21.8 |
| **Total** | 310 | 73 | 23.5 |

*Key: BSI = Bloodstream Infection*

**Residence Distribution**

**Table 5** presents the residence-based distribution of malaria-BSI co-infections. Rural residents had a substantially higher co-infection prevalence of 30.2% (45/149) compared to 17.4% (28/161) among urban residents. This difference was statistically significant ($\chi^2 = 7.053$, df = 1, p = 0.040).

**Table 5: Residence Distribution of Malaria-BSI Co-Infections Among Febrile Patients**

| Residence | Total Cases (N) | Co-infection Present (n) | Co-infection Proportion (%) |
|---|---|---|---|
| Urban | 161 | 28 | 17.4 |
| Rural | 149 | 45 | 30.2 |
| Total | 310 | 73 | 23.5 |

*Key: BSI = Bloodstream Infection*

**Hospitalization Status Distribution**

**Table 6** shows the distribution of co-infections by hospitalization status. Inpatients had a higher crude prevalence of co-infection (28.4%; 54/190) compared to outpatients (15.8%; 19/120). This association was statistically significant ($\chi^2 = 6.473$, df = 1, p = 0.011).


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**Table 6: Hospitalization Status Distribution of Malaria-BSI Co-Infections**

| Status | Total Cases (N) | Co-infection Present (n) | Co-infection Proportion (%) |
|---|---|---|---|
| Inpatient | 190 | 54 | 28.4 |
| Outpatient | 120 | 19 | 15.8 |
| Total | 310 | 73 | 23.5 |

*Key: BSI = Bloodstream Infection*

**Association Between Comorbidities and Co-Infection**

**Table 7** presents the association between selected comorbidities and malaria-BSI co-infection. Among patients with HIV/AIDS, 54.5% (6/11) had co-infection compared to 45.5% (5/11) without co-infection ($\chi^2 = 6.087$, df = 1, p = 0.014). Similarly, 44.4% (8/18) of patients with diabetes had co-infection versus 55.6% (10/18) without ($\chi^2 = 4.635$, df = 1, p = 0.031). Sickle cell disease (35.3%; 6/17) and typhoid fever (36.4%; 12/33) showed higher co-infection proportions, but these associations were not statistically significant (p = 0.240 and p = 0.066, respectively).

**Table 7: Association Between Comorbidities and Malaria-BSI Co-Infection**

| Comorbidity | Total Cases (N) | Co-infection Present n (%) | Co-infection Absent n (%) | $\chi^2$ | df | p-value |
|---|---|---|---|---|---|---|
| HIV/AIDS | 11 | 6 (54.5) | 5 (45.5) | 6.087 | 1 | 0.014 |
| Diabetes | 18 | 8 (44.4) | 10 (55.6) | 4.635 | 1 | 0.031 |
| Sickle Cell | 17 | 6 (35.3) | 11 (64.7) | 1.378 | 1 | 0.240 |
| Typhoid Fever | 33 | 12 (36.4) | 21 (63.6) | 3.369 | 1 | 0.066 |

Key: $\chi^2$ = Pearson Chi-Square; df = degrees of freedom; *$p < 0.05$ (statistically significant)*

**Bivariate Association Between Demographic/Clinical Factors and Co-Infection**

**Table 8** summarizes the bivariate associations between demographic/clinical characteristics and malaria-BSI co-infection. Place of residence (p = 0.040) and hospitalization status (p = 0.011) were significantly associated with co-infection. Age group approached statistical significance (p = 0.054), while sex was not significantly associated (p = 0.444).

**Table 8: Bivariate Association Between Demographic/Clinical Factors and Malaria-BSI Co-Infection**

| Variable | Category | Co-infection Present n (%) | Co-infection Absent n (%) | $\chi^2$ | df | p-value |
|---|---|---|---|---|---|---|
| Sex | Male | 37 (25.5) | 108 (74.5) | 0.587 | 1 | 0.444 |
| | Female | 36 (21.8) | 129 (78.2) | | | |
| Age Group | <5 years | 31 (31.3) | 68 (68.7) | 7.639 | 3 | 0.054 |
| | 5–14 years | 19 (24.4) | 59 (75.6) | | | |
| | 15–49 years | 6 (11.8) | 45 (88.2) | | | |
| | ≥50 years | 17 (20.7) | 65 (79.3) | | | |
| Residence | Urban | 28 (17.4) | 133 (82.6) | 7.053 | 1 | 0.040 |
| | Rural | 45 (30.2) | 104 (69.8) | | | |
| Hospitalization | Inpatient | 54 (28.4) | 136 (71.6) | 6.473 | 1 | 0.011 |
| | Outpatient | 19 (15.8) | 101 (84.2) | | | |

Key: $\chi^2$ = Pearson Chi-Square; df = degrees of freedom; *$p < 0.05$ (statistically significant)*

**Multivariable Logistic Regression Analysis of Predictors**

**Table 9** presents the results of the binary logistic regression analysis examining independent predictors of malaria-BSI co-infection after adjusting for potential confounders. Place of residence remained a significant independent predictor: rural residents were more than twice as likely to have co-infection compared to urban residents (adjusted OR = 2.133; 95% CI: 1.226–3.713; p = 0.007). Hospitalization status also remained significant, with inpatients being less likely to have co-infection than outpatients (adjusted OR = 0.479; 95% CI: 0.263–0.874; p = 0.016). Age group and sex were not significant independent predictors in the adjusted model.


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**Table 9: Binary Logistic Regression Analysis of Predictors of Malaria-BSI Co-Infection**

| Variable | β (B) | SE | Wald $\chi^2$ | df | p-value | Adjusted OR | 95% CI |
|---|---|---|---|---|---|---|---|
| Age Group (Ref: <5 years) | | | 6.028 | 3 | 0.110 | | |
| 5–14 years | 0.494 | 0.358 | 1.909 | 1 | 0.167 | 1.639 | 0.813–3.305 |
| 15–49 years | 0.199 | 0.389 | 0.261 | 1 | 0.609 | 1.220 | 0.569–2.614 |
| ≥50 years | -0.658 | 0.524 | 1.577 | 1 | 0.209 | 0.518 | 0.185–1.447 |
| Sex (Ref: Female) | -0.097 | 0.280 | 0.120 | 1 | 0.729 | 0.908 | 0.525–1.571 |
| Residence (Ref: Urban) | 0.758 | 0.283 | 7.183 | 1 | 0.007 | 2.133 | 1.226–3.713 |
| Hospitalization (Ref: Outpatient) | -0.736 | 0.307 | 5.765 | 1 | 0.016 | 0.479 | 0.263–0.874 |

*Key: β = regression coefficient; SE = standard error; df = degrees of freedom; OR = odds ratio; CI = confidence interval; Ref = reference category*

**Table 10** presents the adjusted associations between comorbidities and malaria-BSI co-infection. HIV/AIDS was statistically associated with co-infection; however, the adjusted odds ratio indicated lower odds, which may reflect the small number of HIV-positive participants and should be interpreted cautiously (adjusted OR = 0.245; 95% CI: 0.070-0.858; p = 0.027), while sickle cell disease showed a borderline significant association (adjusted OR = 0.457; 95% CI: 0.210–0.995; p = 0.048). Diabetes (p = 0.224) and typhoid fever (p = 0.054) were not significant independent predictors. The adjusted OR of 0.245 suggests that after controlling for confounders, HIV-positive patients had lower odds of co-infection, which may be due to a small sample size (only 11 HIV-positive patients), different healthcare-seeking behaviours, or possible confounding by other variables

**Table 10: Binary Logistic Regression Analysis of Comorbidities and Malaria-BSI Co-Infection**

| Comorbidity | β (B) | SE | Wald $\chi^2$ | df | p-value | Adjusted OR | 95% CI |
|---|---|---|---|---|---|---|---|
| HIV/AIDS (Yes=1) | -1.406 | 0.636 | 4.880 | 1 | 0.027 | 0.245 | 0.070–0.858 |
| Diabetes (Yes=1) | -0.655 | 0.539 | 1.477 | 1 | 0.224 | 0.519 | 0.181–1.491 |
| Sickle Cell (Yes=1) | -0.784 | 0.396 | 3.921 | 1 | 0.048 | 0.457 | 0.210–0.995 |
| Typhoid Fever (Yes=1) | -0.985 | 0.511 | 3.719 | 1 | 0.054 | 0.373 | 0.137–1.016 |

*Key: β = regression coefficient; SE = standard error; df = degrees of freedom; OR = odds ratio; CI = confidence interval*

## DISCUSSION

This study is the first to give a complete picture of bloodstream co-infections with malaria and bacteria in febrile patients who attended a tertiary hospital in Jalingo, Taraba State, North-East Nigeria. The results show that co-infection is a significant burden, as almost one in four febrile patients had concurrent malaria parasitemia and bacteremia. The prevalence observed in this study was higher than the pooled estimate reported by Wilairatana et al. (2022), although differences in study populations, healthcare settings, and diagnostic approaches may explain the variation (Wilairatana et al., 2022). Ojuawo et al. (2021) reported on 115 children with severe malaria, 23.3% of whom had concomitant bacteremia (Ojuawo et al., 2021). The prevalence of malaria-BSI co-infections in these different settings is consistent, indicating the potential for malaria-BSI co-infection to be a clinically meaningful and unrecognized phenomenon in Nigeria.

The high level of malaria parasitemia found in this study (61.9%) is reflective of the malaria hyperendemic status of Nigeria, especially in areas that have conducive climatic conditions for malaria vectors to breed (Venkatesan, 2024; World Health Organization, 2025). The 2021 Nigeria Malaria Indicator Survey reported substantial zonal variation in malaria parasitaemia among children aged 6–59 months. Based on rapid diagnostic testing, prevalence ranged from 24.1% in the South West to 51.6% in the North West, while the North East recorded 43.0%. Microscopy results also showed that prevalence was highest in the North West rather than the North East (National Population Commission [NPC] & ICF, 2022). In Jalingo, the country's tropical savanna climate has two distinct rainy seasons, from April to October, which allow for the proliferation of Anopheles mosquitoes and sustained malaria transmission (Jonathan et al., 2018; Obadiah et al., 2023).

In the current study, it is evident that there was a clear vulnerability gradient, as children under five years of age were the most affected group (31.3%). This is reflected in the epidemic trends observed that young children are more vulnerable to malaria and invasive bacterial infections than older children, because they lack certain immunity and have underdeveloped immune systems (De Salazar et al., 2024). The prevalence of bacteremia with malaria reported in children under 5 years old in sub-Saharan Africa is estimated to be 9.1%, with 15.0% mortality (Berkley et al., 2005). In a separate study, Ojuawo et al. (2021) reported that one-quarter of children with severe malaria had concurrent bacteremia, which was associated with a higher number of days in hospital and fever clearance time in those children (Ojuawo et al., 2021). The high rate of co-infection in children in this current study further highlights the need to remain vigilant for the possibility of bacterial co-infection in febrile children, especially those with severe or persistent symptoms.

It is also noteworthy that adults 50 years and older had a higher co-infection prevalence of 20.7%. This could be due to immunosenescence with ageing or to the presence of chronic comorbidities. It is noted that older adults with pre-existing medical conditions, like diabetes or hypertension, are at a higher risk of invasive bacterial infections (Daryabor et al., 2020; Lang et


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al., 2022). The interaction and interplay of infectious and chronic diseases will increasingly be a public health issue in Nigeria as it becomes an ageing population and the burden of non-communicable diseases increases (Bello et al., 2023).

In this study, rural residence was the single most important predictor of malaria-BSI co-infection: rural residents were more than twice as likely to be co-infected as urban residents (adjusted OR = 2.133; p = 0.007). The finding is consistent with earlier studies that showed increased malaria prevalence in rural communities in Nigeria, which is due to such factors as inadequate housing, insufficient availability of insecticide-treated nets, proximity to mosquito breeding habitats, and limited access to health care services (National Population Commission [NPC] & ICF, 2022). These findings emphasize the importance of targeted interventions, specific to geographic regions, to tackle the particular vulnerabilities of rural communities, such as better water and sanitation facilities, better community-based malaria prevention, and better primary health care services.

Co-infection had a complex association with hospitalization status. The crude prevalence of co-infection was greater in inpatients (28.4%) than outpatients (15.8%); however, the adjusted analysis found inpatients were less likely to be co-infected (adjusted OR = 0.479; p = 0.016). This unexpected inverse association may reflect differences in case selection, documentation practices or clinical decision-making patterns, which require further investigation. Hospitalized patients (inpatients) are considered to have more extensive diagnostic evaluation, and the blood culture may be positive that would not be obtained from outpatients. In contrast, there is a high probability that outpatients with co-infection will be misdiagnosed as having malaria alone, and treated and discharged without taking a blood culture. This discovery highlights the need for enhancing the diagnosis capacity in the outpatient department to avoid missed co-infections and their related complications.

Co-infection with HIV/AIDS and diabetes mellitus is important clinically because they are significantly associated (p = 0.014, p = 0.031). HIV infection weakens cell-mediated immunity and consequently the ability of the host to control malaria parasitemia and bacterial invasion (Cachay, 2017; Lang et al., 2022). HIV-positive people with malaria have been found to have more parasites and a greater risk of developing severe disease as well as bacterial translocation and bloodstream invasion, which may be promoted by the immunosuppression seen in malaria patients (Figueroa-Romero et al., 2024). Likewise, diabetes mellitus also affects the function of neutrophils and innate immune responses, leading to increased susceptibility to bacterial infection (Daryabor et al., 2020). The results point to integrated methods of care taking into account the interaction between infectious and chronic diseases, especially in the context of an increasing burden of non-communicable diseases.

Co-infections were higher in two conditions (sickle cell disease and typhoid fever), though not significant in this study. This may be because the number of patients with these conditions in this sample was relatively small, reducing the power of the statistics. Sickle cell disease is biologically linked by functional asplenia**,** which predisposes to encapsulated bacteria and Salmonella infections (Uyoga et al., 2022). Typhoid fever has clinical features similar to malaria and is known to co-occur among children, especially those living in poor sanitary conditions (Olowolafe et al., 2024). Typhoid fever (p = 0.066) was almost significant**,** and further studies with larger patient cohorts may confirm a significant association, so physicians should be aware of this potential co-infection.

**Clinical and Public Health Implications**

The results of this study have several implications for the practice and public health policy in Jalingo and other situations. The high level of malaria BSI co-infection (23.5%) is a compelling reason to rethink the principle of presumptive treatment for malaria without exploring the possibility of bacterial co-infection. A high index of suspicion should be kept for bacteremia in febrile patients, especially those with severe or persistent symptoms, young children, and immunocompromised patients. Wherever possible, routine blood culture testing should be part of the diagnostic investigation of patients with fever, as they will be missing a significant number of co-infections if only malaria testing is done.

Secondly, as the urban-rural distribution of co-infection was strong, interventions have to be geographically specific. These should encompass enhanced access to ITNs, IRS, and environmental management that involves reducing breeding sites of mosquitoes in rural communities. Moreover, building capacity in the primary health system, particularly in rural areas, including being able to identify co-infections promptly and treat them, is crucial.

Third, the links between co-infection and HIV/AIDS and diabetes emphasize the need for comprehensive care for patients suffering from these conditions. Routine screening for malaria should be implemented with HIV or bacterial infection in patients with fever; the use of insecticide-treated nets and early treatment of febrile episodes should be encouraged.

**Limitations**

There are some limitations to this study which should be noted. First, the retrospective design and the use of secondary data from hospital records did not allow full control of the completeness and consistency of the information. The study was confined to a limited set of patient records, and other clinical parameters, such as nutritional status, previous antibiotic use, or clinical details, were not analyzed in detail. Second, the study was done in one tertiary hospital, and the results may not apply to primary healthcare units, community-based populations, or other areas of Nigeria with varying epidemiology. Third, the data are limited to the three years of the study, so long-term trends or the effects of seasonal variations may not be captured. Lastly, the number of patients in some subgroups (e.g., patients with certain comorbidities) was relatively small, resulting in limited statistical power for some analyses.

Despite these limitations, the study has several strengths. This is the first to present data on the malaria-BSI co-infection in Taraba State, a gap that needs to be bridged. All diagnoses are confirmed by laboratory tests, reducing the chance of inaccuracies. The systematic sampling approach and three-year time frame increase the representativeness of the data. Multivariable analysis provides strong evidence for targeting interventions through identification of independent predictors.

## CONCLUSION

The present study shows that malaria-bacterial co-infection is an important public health and clinical challenge in Jalingo Federal Medical Centre of Taraba State, as it affects about one-fourth of all


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febrile cases seeking care. Children under 5 years of age, rural people, and those with HIV/AIDS or diabetes are most affected.

The results have implications for clinical practice, health policy, and future research. All febrile patients should be viewed with heightened suspicion for a co-infection with bacteria, especially those at high risk, and blood culture should be performed in the clinical diagnostic work-up whenever feasible. The geographical targeting of public health interventions must take into account the unique vulnerabilities of rural communities, including through strengthening vector control and sanitation, and diagnostic capacity. HIV/AIDS and diabetes should be treated as complex diseases, and patients who have these conditions should be screened and treated for malaria and bacterial infection. Future studies should investigate the underlying mechanisms of co-infection, assess the clinical effectiveness of the combined diagnostic and treatment strategy, and extend surveillance to other areas of Nigeria, as this will provide a basis for national guidelines.

## RECOMMENDATIONS

The following recommendations are made based on the findings of this study for clinical practice, health policy and future research:

**Clinical Practice Recommendations**

Routine blood culture should be included in the list of laboratory examinations for febrile children, especially children who are under five years of age, people in rural communities, and immunocompromised persons. When used as a stand-alone approach, malaria testing will fail to capture around 25% of co-infections. Keep vigilance high for bacterial co-infection in patients with severe/ persistent symptoms, extended fever (>3 days), or not responding to initial malaria treatment. Implement integrated fever management protocols that involve simultaneous testing for malaria and bacterial pathogens where clinically appropriate, not sequential testing; and implement protocols for the treatment of suspected respiratory illness and fever, as well as new WHO guidelines for malaria and bacterial pathogens.

**Public health and policy recommendations**

Focus malaria and bacterial infection prevention interventions on rural communities, such as increased use of insecticide-treated nets, increased coverage of IRS, environmental management to reduce mosquito breeding grounds, and water and sanitation infrastructure improvements.

Improve primary health care systems in rural areas by providing rapid diagnostic tests for both malaria and bacterial infections, training health care workers on an integrated approach to the management of fever, and setting up referral systems. Ensure that malaria and bacterial infection screenings are conducted routinely as an integral part of HIV/AIDS and diabetes care services, and take actions to prevent infection (ITN distribution and prompt treatment of febrile episodes). Build laboratory expertise and capacity in reliable blood culture systems, quality assurance programs, training of laboratory workers, and antimicrobial susceptibility testing.

**Research Recommendations**

Carry out multi-centre studies in several centres in Nigeria to generate comparative information on regional differences in co-infection patterns and risk factors. Conduct prospective cohort studies to delineate causal relationships between malaria and bloodstream infections by bacteria and to assess patient outcomes. Incorporate routine antimicrobial susceptibility testing into co-infection studies to assess and track patterns of antimicrobial resistance and provide support for empirical therapy.

**COMPETING INTERESTS**

The authors declare that they have no competing interests.

**AUTHORS' CONTRIBUTIONS**

**Clement Abah Alexander**: Conceptualization, methodology, data collection, formal analysis, investigation, interpretation of findings, visualization, project administration, writing original draft, and writing review and editing.

**Ugoada Celestina Okwose**: Validation, interpretation of findings, writing- review and editing, and critical revision of the manuscript for important intellectual content.

**Ekwufulem Oluchi Ndidi**: Methodology, validation, clinical interpretation of findings, writing – review and editing, and critical revision of the manuscript.

**Chukwukwe Ifeyinwa Ogechi**: Validation, clinical interpretation of findings, writing – review and editing, and critical revision of the manuscript.

**Chianakwalam Emeka Akujuobi**: Validation, literature review, writing – review and editing, and critical revision of the manuscript.

**Ofem Etan Ofem:** Review and editing, and critical revision of the manuscript

All authors reviewed and approved the final version of the manuscript and agreed to be accountable for the integrity and accuracy of the work.

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