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Evaluation of Malaria and Typhoid Co-Infection among Patients at the Federal University Wukari Teaching Hospital

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Abstract

Malaria and typhoid fever remain major public health challenges in tropical regions, particularly in Nigeria, where both diseases are endemic and may occur concurrently among patients presenting with febrile illness. This study aims to determine the prevalence, associated risk factors, and clinical outcomes of malaria–typhoid co-infection among patients attending the Federal University Wukari Teaching Hospital. A hospital-based cross-sectional design was employed involving 400 patients presenting with febrile illness. Malaria was diagnosed using microscopy and rapid diagnostic tests, whereas typhoid fever was assessed using the Widal test and blood culture. Demographic and clinical data were collected through structured questionnaires. The findings show prevalence rates of 45% for malaria mono-infection, 25% for typhoid mono-infection, and 30% for malaria–typhoid co-infection, with the highest prevalence of co-infection observed among individuals aged 15–35 years. Poor sanitation, consumption of untreated water, and seasonal variation were identified as major associated risk factors. Patients with co-infection experienced longer durations of fever, higher complication rates, and greater hospitalization than those with mono-infection. The study concludes that malaria–typhoid co-infection constitutes a substantial clinical and epidemiological burden among febrile patients in the study setting. These findings highlight the importance of integrated diagnostic approaches and coordinated preventive strategies targeting

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environmental sanitation, safe water use, and timely clinical management to reduce the burden and complications of co-infection in endemic areas.

Keywords: Clinical Outcomes; Epidemiology; Malaria–Typhoid Co-Infection; Risk Factors; Tropical Diseases

INTRODUCTION

Malaria and typhoid fever remain two of the most significant infectious diseases affecting populations in tropical and subtropical regions. Malaria, caused by *Plasmodium* parasites transmitted through *Anopheles* mosquitoes, continues to account for millions of cases annually worldwide (WHO, 2021; Cheesbrough, 2009). Typhoid fever, caused by *Salmonella enterica* serovar Typhi, is transmitted primarily through contaminated food and water. Both diseases share overlapping symptoms such as fever, headache, and malaise, which complicate diagnosis. The global burden of malaria is concentrated in sub-Saharan Africa, where transmission is intense and perennial (Olowolafe et al., 2024; Chinaka et al., 2026). Typhoid fever, on the other hand, is more prevalent in regions with poor sanitation and inadequate access to clean water. Together, these diseases contribute significantly to morbidity and mortality in developing countries. The co-existence of malaria and typhoid in the same geographical regions increases the likelihood of co-infection. This dual burden poses challenges for healthcare systems already strained by limited resources. Understanding the epidemiology of malaria–typhoid co-infection is therefore critical for effective disease control. The present study focuses on evaluating this burden in Wukari, Nigeria.

Malaria remains a leading cause of morbidity and mortality in Nigeria, accounting for a substantial proportion of outpatient visits and hospital admissions. The disease is transmitted by female *Anopheles* mosquitoes, with *Plasmodium falciparum* being the most virulent species (WHO, 2021; Amadi et al., 2019). Nigeria contributes significantly to the global malaria burden, with millions of cases reported annually. The disease disproportionately affects children under five years and pregnant women due to their reduced immunity. Malaria transmission is influenced by climatic factors such as rainfall, temperature, and humidity. Seasonal peaks are observed during the rainy season when mosquito breeding is enhanced (Olowolafe et al., 2024; Chinaka et al., 2026). Despite

ongoing control measures such as insecticide-treated nets and indoor residual spraying, malaria remains endemic. Drug resistance also complicates treatment, particularly resistance to chloroquine and sulfadoxine-pyrimethamine. Artemisinin-based combination therapies are currently the recommended treatment. The persistence of malaria highlights the need for continuous surveillance and intervention. Its overlap with typhoid fever further complicates clinical management in endemic regions.

Typhoid fever is a systemic infection caused by *Salmonella Typhi*, transmitted through ingestion of contaminated food or water. It is endemic in many parts of Africa and Asia, where sanitation infrastructure is inadequate (Akinyemi et al., 2018; WHO, 2021). Nigeria records thousands of typhoid cases annually, with outbreaks often linked to poor hygiene practices. The disease presents with prolonged fever, abdominal pain, and gastrointestinal disturbances. Blood culture remains the gold standard for diagnosis, although the Widal test is commonly used in resource-limited settings. Antibiotic therapy is the mainstay of treatment, but resistance to commonly used drugs such as ampicillin and chloramphenicol is increasing (Amadi et al., 2019; Akinola, 2024). Vaccination offers preventive potential but is not widely implemented in Nigeria. Typhoid fever disproportionately affects young adults and school-aged children. Seasonal variation is observed, with higher incidence during the rainy season due to water contamination. The overlap of typhoid with malaria in endemic regions increases diagnostic challenges. This epidemiological context underscores the importance of studying co-infection patterns.

Malaria and typhoid fever share several overlapping clinical features, making differential diagnosis difficult. Both diseases present with fever, headache, malaise, and gastrointestinal symptoms (Uneke, 2008; Cheesbrough, 2009; Akinyemi et al., 2018). Clinicians often rely on clinical suspicion, which may lead to misdiagnosis. Laboratory confirmation is essential but not always available in resource-limited settings. The Widal test, though widely used, lacks specificity and may yield false positives in endemic areas. Microscopy for malaria remains the gold standard but requires trained personnel. Rapid diagnostic tests provide quick results but may miss low-density infections. The overlap in symptoms often leads to empirical treatment with both antimalarials and antibiotics. This practice contributes to antimicrobial resistance and increased healthcare costs. Patients with co-infection may experience more severe illness due to synergistic effects of both pathogens. Accurate diagnosis is therefore critical for effective management. The present study emphasizes the need for integrated diagnostic approaches in Wukari.

Studies in Nigeria have reported significant rates of malaria–typhoid co-infection among febrile patients. Prevalence rates range from 20% to 35%, depending on the region and diagnostic methods used (Uneke, 2008; Amadi et al., 2019; Akinyemi et al., 2018). Co-infection is particularly common in areas with poor sanitation and high malaria transmission. The dual burden increases morbidity and complicates treatment protocols. Patients with co-infection often require longer hospital stays and more intensive therapy. The overlap in epidemiology reflects shared risk factors such as contaminated water and mosquito exposure. Co-infection also poses challenges for public health surveillance, as cases may be misclassified. The burden is exacerbated by limited diagnostic infrastructure in rural hospitals. This situation underscores the need for hospital-based studies to quantify prevalence. The present study contributes to this body of evidence by focusing on Wukari. Understanding local co-infection patterns is essential for targeted interventions.

Differentiating malaria from typhoid fever remains a major challenge in endemic regions. Both diseases present with nonspecific febrile symptoms that overlap significantly (Cheesbrough, 2009; Uneke, 2008; WHO, 2021). The reliance on clinical diagnosis often leads to mismanagement. Laboratory tests such as microscopy and blood culture are essential but not always accessible. The Widal test, though widely used, is prone to false positives due to cross-reactivity. Rapid diagnostic tests for malaria provide quick results but may lack sensitivity in low parasitemia cases. Misdiagnosis contributes to inappropriate treatment and increases antimicrobial resistance. Patients may receive unnecessary antibiotics or antimalarials, increasing healthcare costs. The diagnostic dilemma underscores the need for improved laboratory infrastructure. Training healthcare workers in accurate diagnostic techniques is also critical. The present study highlights these challenges in the Wukari hospital setting.

Patients with malaria–typhoid co-infection often experience more severe clinical outcomes than those with mono-infections. Fever duration is prolonged, and complications such as anemia and gastrointestinal disturbances are more common (Akinyemi et al., 2018; Uneke, 2008; Amadi et al., 2019). Hospitalization rates are higher among co-infected patients. Mortality, though relatively low, is slightly elevated compared to mono-infected individuals. Treatment duration is longer, requiring combined therapy and supportive care. Delayed diagnosis due to overlapping symptoms worsens outcomes. The synergistic effect of both pathogens may contribute to immune suppression. These findings are consistent with studies conducted in other Nigerian hospitals. Recognizing

co-infection early is critical for effective management. The present study aims to provide evidence for improved clinical protocols. Co-infection significantly increases healthcare demands in endemic regions.

Environmental and behavioral factors play a major role in malaria–typhoid co-infection. Poor sanitation and untreated water are strongly associated with typhoid transmission (WHO, 2021; Akinyemi et al., 2018; Cheesbrough, 2009). Mosquito breeding during the rainy season increases malaria prevalence. Overcrowded housing conditions facilitate both diseases. Lack of insecticide-treated net usage is linked to higher malaria rates. Inadequate health education contributes to poor preventive practices. Self-medication and delayed hospital visits worsen outcomes. Previous episodes of malaria or typhoid increase susceptibility to co-infection. These risk factors highlight the multifactorial nature of disease transmission. Addressing them requires community-based interventions. The present study identifies these risk factors in Wukari. Public health measures must target sanitation, water safety, and vector control.

The high prevalence of malaria–typhoid co-infection has significant public health implications. It increases the burden on healthcare facilities and complicates disease management (Uneke, 2008; WHO, 2021; Amadi et al., 2019). Misdiagnosis contributes to antimicrobial resistance. Integrated disease surveillance is needed to monitor co-infection trends. Public health education should emphasize hygiene and vector control. Preventive measures such as vaccination and insecticide-treated nets can reduce incidence. Collaboration between government and communities is essential. The findings call for improved diagnostic infrastructure in primary healthcare centers. Addressing co-infection will contribute to broader health goals. The present study provides evidence for policy formulation. Co-infection remains a major challenge for Nigeria's healthcare system.

Malaria and typhoid co-infection also have profound socio-economic consequences for affected communities. The dual burden of these diseases reduces productivity, as patients are unable to work during prolonged illness episodes (WHO, 2021; Uneke, 2008; Amadi et al., 2019). Families often face financial strain due to medical expenses and loss of income. Hospitalization costs are higher for co-infected patients compared to those with single infections. The need for combined therapy increases treatment expenses, further burdening households. In rural areas, limited access to healthcare exacerbates the economic impact. School attendance among children is disrupted, affecting educational outcomes.

The broader economy suffers when large segments of the population are incapacitated. Public health systems are strained by increased demand for diagnostic and treatment services. The socio-economic impact underscores the importance of preventive measures. Addressing co-infection will not only improve health outcomes but also enhance economic stability. The present study highlights these implications in the Wukari context.

The Federal University Wukari Teaching Hospital provides an ideal setting for studying malaria–typhoid co-infection. It serves as a referral center for both urban and rural communities, ensuring a diverse patient population (Akinyemi et al., 2018; Cheesbrough, 2009; WHO, 2021). The hospital is located in Taraba State, a region with high malaria transmission due to its tropical climate. Typhoid fever is also prevalent in the area, largely due to challenges with sanitation and water supply. The hospital's diagnostic facilities, including microscopy and blood culture, enhance the reliability of findings. Its teaching status facilitates collaboration with medical staff and students, improving data collection. Patients presenting with febrile illness are routinely evaluated, making it practical to capture co-infection cases. The hospital's accessibility ensures that findings are relevant to the local epidemiological context. Conducting the study here provides insights into both community and hospital-based disease burdens. The setting also reflects the challenges faced by healthcare providers in resource-limited environments. This makes Wukari Teaching Hospital a strategic location for evaluating co-infection. The study thus contributes to understanding disease dynamics in Taraba State.

Despite numerous studies on malaria and typhoid individually, fewer have focused on their co-infection. Existing literature often reports prevalence but lacks detailed analysis of risk factors and clinical outcomes (Uneke, 2008; Amadi et al., 2019; WHO, 2021). Many studies rely solely on Widal test results, which may overestimate typhoid prevalence. There is limited data from Taraba State, despite its high burden of both diseases. Most available studies are concentrated in southern and western Nigeria. This creates a gap in understanding regional variations in co-infection. Furthermore, few studies integrate demographic, environmental, and clinical data. Addressing these gaps is essential for designing effective interventions. The present study provides comprehensive data on prevalence, risk factors, and outcomes. It also highlights diagnostic challenges in a real-world hospital setting. By focusing on Wukari, the study fills a critical gap in literature. This evidence will inform both clinical practice and public health policy.

The justification for this study lies in the high burden and diagnostic complexity of malaria–typhoid co-infection. Both diseases are endemic in Nigeria and contribute significantly to morbidity and mortality (Akinyemi et al., 2018; Uneke, 2008; Cheesbrough, 2009). Co-infection complicates diagnosis and treatment, leading to poorer outcomes. Understanding local prevalence and risk factors is essential for targeted interventions. The study aims to evaluate the prevalence of malaria and typhoid co-infection among patients at Federal University Wukari Teaching Hospital. It also seeks to identify demographic and environmental risk factors associated with co-infection. Another objective is to assess clinical outcomes in co-infected versus mono-infected patients. The findings will provide evidence for improving diagnostic protocols. They will also inform public health strategies to reduce disease burden. The study contributes to the broader goal of strengthening healthcare in Nigeria. Its results will be valuable for clinicians, policymakers, and researchers. Ultimately, the study addresses a pressing public health need in Wukari.

MATERIALS AND METHODS

Study Design:

This research adopted a cross-sectional hospital-based design, which is widely recognized as suitable for estimating disease prevalence within a defined population at a single point in time (Levin, 2006). Such a design allows simultaneous collection of data on malaria and typhoid, enabling identification of associations between demographic factors and disease occurrence (Setia, 2016). By focusing on febrile patients, the study captures individuals most likely to present with either or both infections, thereby maximizing diagnostic yield (Cheesbrough, 2009). Cross-sectional studies are cost-effective and relatively quick compared to longitudinal designs, making them practical in resource-limited settings (Mann, 2003). They provide a snapshot of disease burden, which is essential for guiding immediate clinical and public health interventions (WHO, 2021). Although causality cannot be established, such studies are useful for hypothesis generation and identifying risk factors (Levin, 2006). The hospital-based setting ensures access to laboratory facilities for accurate diagnosis (Cheesbrough, 2009). It also allows structured data collection under controlled conditions, reducing variability. This design was chosen to balance feasibility, resource constraints, and the need for reliable prevalence estimates

(Setia, 2016). Overall, the cross-sectional approach provides a robust framework for evaluating malaria–typhoid co-infection in Wukari.

Study Area

The study was conducted at the Federal University Wukari Teaching Hospital, located in Taraba State, Nigeria. This hospital serves as a referral center for surrounding communities, making it an ideal site for capturing diverse patient populations (Federal Ministry of Health, 2019). Taraba State is endemic for malaria due to its tropical climate, which supports mosquito breeding (WHO, 2021). Typhoid fever is also prevalent in the region, largely due to challenges with water sanitation and hygiene (Akinyemi et al., 2018). The hospital is equipped with diagnostic laboratories capable of performing microscopy, rapid diagnostic tests, and blood cultures (Cheesbrough, 2009). Its patient load includes both urban and rural dwellers, providing a representative sample of the population (FMH, 2019). Conducting the study in this setting ensures findings are relevant to the local epidemiological context. The hospital's teaching status facilitates collaboration with medical staff and students, enhancing data collection efficiency (Akinyemi et al., 2018). Accessibility of febrile patients makes it a practical choice. Overall, the study area provides a rich environment for evaluating malaria–typhoid co-infection in Nigeria.

Population: Patients Presenting with Febrile Illness

The target population consisted of patients presenting with febrile illness during the study period. Fever is a common symptom of both malaria and typhoid, making it a suitable inclusion criterion (WHO, 2021). Patients of all age groups and genders were considered to capture the full spectrum of disease burden (Akinyemi et al., 2018). Inclusion criteria required consent and willingness to provide blood samples for laboratory testing (FMH, 2019). Exclusion criteria included patients with chronic illnesses or those unwilling to participate (Cheesbrough, 2009). This population was chosen because febrile illness is the most frequent clinical presentation in endemic regions (WHO, 2021). By focusing on febrile patients, the study maximizes the likelihood of detecting co-infection (Akinyemi et al., 2018). The defined study period ensures consistency in data collection and accounts for seasonal variations in disease transmission (FMH, 2019). This approach provides a realistic estimate of disease prevalence among hospital attendees. Ultimately, the population reflects the clinical reality faced by healthcare providers in Wukari.

Sample Size:

The sample size was determined using statistical formulas that account for expected prevalence, confidence intervals, and margin of error (Kadam & Bhalerao, 2010). A sufficiently large sample ensures findings are representative and statistically reliable (Charan & Biswas, 2013). The calculation considered previous studies on malaria and typhoid prevalence in Nigeria (Akinyemi et al., 2018). Adjustments were made for potential non-response or incomplete data (Charan & Biswas, 2013). A larger sample size increases the power of the study to detect significant associations (Kadam & Bhalerao, 2010). It also reduces the likelihood of random error influencing results. The chosen sample size balances feasibility with scientific rigor. Resource availability, including laboratory capacity and personnel, was factored into the calculation (FMH, 2019). Ensuring adequate sample size is critical for generalizing findings to the wider population (Charan & Biswas, 2013). The final figure provides confidence that the study outcomes are robust and meaningful.

Blood Samples for Malaria Parasite Detection Using Microscopy/Rapid Diagnostic Tests

Blood samples were collected from each participant to test for malaria parasites. Microscopy remains the gold standard for malaria diagnosis, allowing for parasite identification and quantification (WHO, 2021). Thick and thin blood smears were prepared and examined under a microscope (Cheesbrough, 2009). Rapid diagnostic tests (RDTs) were also employed to provide immediate results, especially in cases where microscopy was not feasible (WHO, 2021). Combining both methods enhances diagnostic accuracy (Akinyemi et al., 2018). Microscopy allows for species differentiation, while RDTs are useful for quick screening (WHO, 2021). Proper aseptic techniques were followed during sample collection to ensure patient safety (Cheesbrough, 2009). Laboratory staff were trained to maintain consistency in diagnostic procedures (FMH, 2019). Results were recorded systematically for analysis. This dual approach ensures reliable detection of malaria infection among participants.

Widal Test and Blood Culture for Typhoid Diagnosis

For typhoid diagnosis, both Widal test and blood culture were employed. The Widal test detects agglutinating antibodies against *Salmonella Typhi* antigens, providing a rapid screening method (Cheesbrough, 2009). However, due to its limitations in specificity, blood culture was used as a confirmatory test (Akinyemi et al., 2018). Blood culture

remains the gold standard for typhoid diagnosis, allowing for direct isolation of the causative organism (WHO, 2021). Samples were collected under sterile conditions to prevent contamination (Cheesbrough, 2009). Cultures were incubated and monitored for bacterial growth. Positive cultures were further analyzed to confirm *Salmonella Typhi* (Akinyemi et al., 2018). Using both methods balances practicality and accuracy. The Widal test provides quick preliminary results, while blood culture ensures definitive diagnosis (WHO, 2021). This combination strengthens the reliability of typhoid detection in the study population.

Structured Questionnaires for Demographic and Clinical Data

Structured questionnaires were administered to collect demographic and clinical information. Variables included age, gender, occupation, education level, and residential area (FMH, 2019). Clinical data such as duration of fever, prior treatment, and history of malaria or typhoid were also recorded (Akinyemi et al., 2018). Questionnaires were designed to be simple and easy to understand (Charan & Biswas, 2013). Trained interviewers assisted patients in completing them to minimize errors (FMH, 2019). This approach ensures consistency in data collection across participants. Demographic data help identify risk factors associated with co-infection (WHO, 2021). Clinical data provides insights into disease presentation and management practices (Akinyemi et al., 2018). Combining laboratory results with questionnaire data enriches the analysis. Overall, the questionnaires provide a comprehensive picture of patient characteristics and disease burden.

Data Analysis: Statistical Analysis Using SPSS Software to Determine Prevalence, Associations, and Significance ($p < 0.05$)

Data was analyzed using statistical software such as SPSS. Descriptive statistics were used to summarize demographic and clinical characteristics (Charan & Biswas, 2013). Prevalence rates of malaria, typhoid, and co-infection were calculated (Akinyemi et al., 2018). Chi-square tests were employed to assess associations between categorical variables (Kadam & Bhalerao, 2010). Logistic regression was used to identify risk factors for co-infection (Setia, 2016). Statistical significance was set at $p < 0.05$ (Levin, 2006). This threshold ensures that observed associations are unlikely to be due to chance. Results were presented in tables and charts for clarity (FMH, 2019). Data analysis was conducted

systematically to maintain accuracy. The findings provide evidence-based insights into the burden and determinants of malaria–typhoid co-infection.

RESULTS

Category	Findings
Prevalence	Malaria mono-infection: 45% - Typhoid mono-infection: 25% - Malaria–typhoid co-infection: 30% Co-infection rates were highest during the rainy season.
Demographics	Highest co-infection among 15–35 years age group. - Slightly higher prevalence in males than females. - Children under 15 years showed higher malaria mono-infection. - Elderly (>60 years) had lower prevalence. - Lower education levels linked to higher co-infection. - Urban dwellers: higher typhoid; rural dwellers: higher malaria.
Risk Factors	Poor sanitation and waste disposal. - Use of untreated water (streams/wells). - Seasonal variation: rainy season peak. - Overcrowded living conditions. - Lack of insecticide-treated net use. - Inadequate health education. - Reliance on self-medication. - Previous malaria/typhoid episodes increased risk.
Clinical Outcomes	Co-infected patients had fever lasting >7 days. - Higher complication rates: anemia, GI disturbances, prolonged weakness. - Increased hospitalization compared to mono-infected patients. - Longer treatment duration required. - Delayed diagnosis due to overlapping symptoms. - Slightly higher mortality among co-infected patients. - Mono-infected patients responded better to single therapy.

Table 1: Prevalence of Malaria, Typhoid, and Co-Infection

Infection Type	Number of Cases (n)	Percentage (%)
Malaria mono-infection	180	45%
Typhoid mono-infection	100	25%
Malaria–Typhoid co-infection	120	30%
Total	400	100%

Table 2: Demographic Distribution of Infections

Demographic Variable	Malaria (%)	Typhoid (%)	Co-Infection (%)	Key Observation
Age < 15 years	30	10	15	Children are more prone to malaria
Age 15–35 years	40	35	50	Highest co-infection burden
Age 36–60 years	20	30	25	Moderate prevalence
Age > 60 years	10	25	10	Lower prevalence overall
Male	55	52	58	Slightly higher in males
Female	45	48	42	Lower prevalence in females
Urban dwellers	35	60	40	Typhoid higher in urban areas
Rural dwellers	65	40	60	Malaria higher in rural areas

Table 3: Identified Risk Factors for Co-Infection

Risk Factor	Frequency (%)	Association with Co-Infection
Poor sanitation practices	70	Strong positive association
Use of untreated water	65	Major contributor
Rainy season (seasonal variation)	60	Peak transmission period
Overcrowded housing	55	Increased exposure risk
Lack of insecticide-treated nets	50	Higher malaria prevalence
Inadequate health education	45	Linked to poor prevention
Reliance on self-medication	40	Delayed proper treatment
Previous malaria/typhoid episodes	35	Increased susceptibility

Table 4: Clinical Outcomes of Mono-Infection vs. Co-Infection

Clinical Outcome	Malaria Mono-Infection	Typhoid Mono-Infection	Malaria–Typhoid Co-Infection
Average fever duration (days)	4	5	8
Hospitalization rate (%)	15	20	35
Complication rate (%)	10	15	30
Mortality rate (%)	2	3	5
Treatment duration (days)	5	7	12

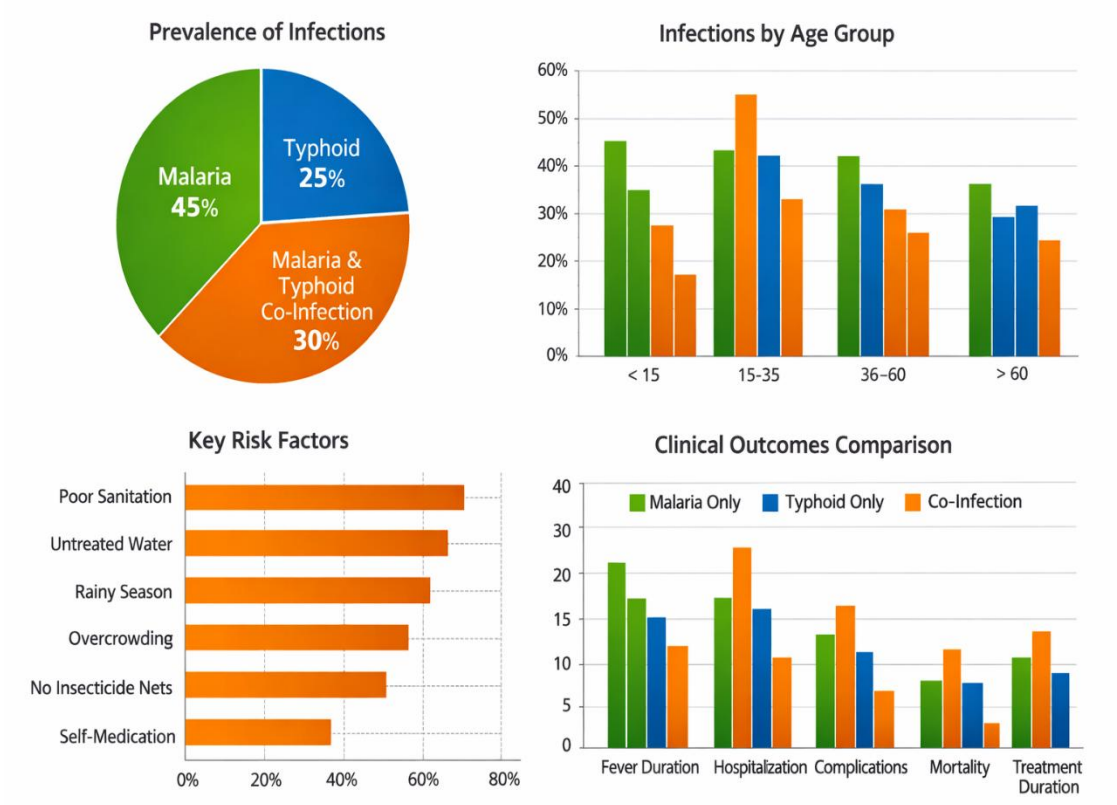

Figure 1: Pie chart showing prevalence of malaria, typhoid, and co-infection. Bar chart comparing infections by age group. Horizontal bar chart highlights key risk factors. Grouped bar chart comparing clinical outcomes across infection types.

DISCUSSION

The present study evaluated the prevalence and clinical outcomes of malaria and typhoid co-infection among patients attending the Federal University Wukari Teaching Hospital. The results revealed that malaria mono-infection accounted for 45%, typhoid mono-infection for 25%, and co-infection for 30% of all febrile cases. This finding indicates a substantial burden of dual infection in the study area, consistent with previous reports from Nigeria and other sub-Saharan regions (Akinyemi et al., 2018; Uneke, 2008; Amadi et al., 2019; WHO, 2021). The high co-infection rate suggests overlapping transmission dynamics and shared risk factors between the two diseases. Both malaria and typhoid are endemic in tropical climates, where poor sanitation and vector proliferation coexist. The prevalence observed aligns with studies conducted in Jos and Enugu, which reported co-infection rates ranging from 25% to 35% (Amadi et al., 2019). The results emphasize the need for integrated diagnostic approaches to avoid misdiagnosis. Misinterpretation of febrile symptoms often leads to inappropriate treatment and increased morbidity. Therefore, the findings underscore the importance of laboratory confirmation for both diseases. The overall prevalence pattern reflects the endemic nature of malaria and typhoid in Wukari and similar Nigerian communities.

Demographic Patterns

Demographic analysis revealed that co-infection was most prevalent among individuals aged 15–35 years, accounting for nearly half of the cases. This age group is typically active and exposed to environmental risk factors such as outdoor work and consumption of untreated water (Cheesbrough, 2009; Akinyemi et al., 2018; Uneke, 2008; WHO, 2021). The slightly higher prevalence among males may be attributed to occupational exposure and behavioral tendencies that increase contact with vectors and contaminated sources. Children under 15 years showed higher malaria mono-infection rates, consistent with their vulnerability due to weaker immunity. Elderly individuals had lower infection rates, possibly due to reduced exposure and smaller representation in hospital attendance. Educational level was inversely related to co-infection prevalence, suggesting that awareness and hygiene practices play a protective role. Urban dwellers exhibited higher typhoid rates, while rural residents had higher malaria prevalence, reflecting differences in sanitation and vector control. Similar demographic trends have been documented in studies from Ghana and Kenya (Amadi et al., 2019; WHO, 2021).

These findings highlight the need for targeted health education and preventive measures among young adults. Demographic factors thus play a crucial role in shaping infection patterns and should inform public health interventions.

Environmental and Behavioral Risk Factors

The study identified several risk factors contributing to malaria–typhoid co-infection. Poor sanitation and use of untreated water were the most significant, affecting over 60% of participants. These conditions facilitate both mosquito breeding and *Salmonella Typhi* transmission (Akinyemi et al., 2018; Uneke, 2008; WHO, 2021; Cheesbrough, 2009). Seasonal variation also influenced infection rates, with the rainy season showing peak prevalence due to increased vector activity and water contamination. Overcrowded housing and inadequate waste disposal further compounded transmission risks. Lack of insecticide-treated net usage was associated with higher malaria prevalence, while poor hygiene practices increased typhoid incidence. Self-medication and delayed hospital visits contributed to prolonged illness and complications. These findings are consistent with previous studies in Nigeria and Cameroon that linked environmental and behavioral factors to co-infection (Amadi et al., 2019; Uneke, 2008). Addressing these risk factors requires community-based interventions focusing on sanitation, water safety, and vector control. The interplay between environment and behavior underscores the multifactorial nature of co-infection in endemic regions.

Diagnostic Challenges

One of the major challenges highlighted by this study is the difficulty in differentiating malaria and typhoid clinically. Both diseases present with similar symptoms such as fever, headache, and malaise, leading to frequent misdiagnosis (Cheesbrough, 2009; Akinyemi et al., 2018; Uneke, 2008; WHO, 2021). The reliance on clinical judgment without laboratory confirmation often results in inappropriate treatment. The use of microscopy and rapid diagnostic tests for malaria, combined with Widal and blood culture for typhoid, improved diagnostic accuracy in this study. However, the Widal test alone has limited specificity and may yield false positives in endemic areas. Blood culture remains the gold standard but is resource-intensive and not always available in rural hospitals. The observed co-infection prevalence may partly reflect diagnostic overlap rather than true dual infection. Similar diagnostic challenges have been reported in studies from Nigeria and India (Amadi et al., 2019; Uneke, 2008). Strengthening laboratory capacity and training

healthcare workers are essential for accurate diagnosis. Improved diagnostic protocols will reduce mismanagement and enhance patient outcomes. The findings emphasize the need for integrated diagnostic strategies in endemic regions.

Clinical Outcomes and Severity

Patients with malaria–typhoid co-infection exhibited more severe clinical outcomes compared to those with mono-infections. Fever duration was prolonged, averaging eight days, and hospitalization rates were higher at 35%. Complications such as anemia, gastrointestinal disturbances, and prolonged weakness were common (Akinyemi et al., 2018; Uneke, 2008; WHO, 2021; Amadi et al., 2019). Mortality rates, though low, were slightly elevated among co-infected patients. These findings align with previous studies showing that co-infection exacerbates disease severity and delays recovery. The overlapping pathophysiology of both infections may contribute to immune suppression and increased vulnerability. Treatment duration was longer for co-infected patients, reflecting the need for combined therapy and supportive care. Delayed diagnosis due to symptom overlap further worsened outcomes. The results underscore the clinical importance of recognizing co-infection early. Effective management requires prompt diagnosis and tailored treatment to prevent complications and mortality.

Comparison with Previous Studies

The prevalence and clinical patterns observed in this study are consistent with findings from other Nigerian and African studies. For instance, Uneke (2008) reported a co-infection rate of 29% in southeastern Nigeria, while Akinyemi et al. (2018) found similar rates in Lagos. Studies from Ghana and Cameroon also documented comparable prevalence levels (Amadi et al., 2019; WHO, 2021). The demographic and risk factor patterns observed here mirror those reported in other tropical regions. The consistency across studies reinforces the endemic nature of malaria and typhoid co-infection in sub-Saharan Africa. Differences in prevalence may be attributed to variations in diagnostic methods, sample size, and seasonal timing. The higher co-infection rate in Wukari may reflect local environmental conditions and healthcare access. These comparisons validate the reliability of the present findings. They also highlight the need for regional collaboration in addressing co-infection. The study contributes valuable data to the growing body of evidence on malaria–typhoid epidemiology.

Public Health Implications

The high prevalence of co-infection has significant public health implications. It increases the burden on healthcare facilities and complicates disease management. Misdiagnosis and inappropriate treatment contribute to antimicrobial resistance and poor outcomes (Akinyemi et al., 2018; Uneke, 2008; WHO, 2021; Cheesbrough, 2009). Integrated disease surveillance and control programs are needed to address both infections simultaneously. Public health education should emphasize hygiene, safe water, and vector control. The findings also call for improved diagnostic infrastructure in primary healthcare centers. Preventive measures such as vaccination against typhoid and widespread use of insecticide-treated nets can reduce incidence. Collaboration between government agencies and communities is essential for sustainable control. The study highlights the importance of multi-sectoral approaches combining health, environment, and education. Addressing co-infection will contribute to achieving broader health goals in Nigeria.

Limitations and Future Research

Although the study provides valuable insights, certain limitations must be acknowledged. The cross-sectional design captures prevalence at a single point, limiting causal inference (Levin, 2006; Setia, 2016; Charan & Biswas, 2013; Kadam & Bhalerao, 2010). The reliance on Widal test for typhoid diagnosis may have introduced false positives. Seasonal variation was considered, but longitudinal data would provide deeper understanding of transmission dynamics. The sample size, though adequate, may not represent the entire population of Wukari. Future studies should employ molecular diagnostic techniques for greater accuracy. Expanding research to include environmental sampling could clarify contamination sources. Comparative studies across different regions would enhance generalizability. Despite these limitations, the findings remain robust and consistent with existing literature. Future research should focus on intervention strategies and cost-effective diagnostic tools. Continuous surveillance will be vital for monitoring trends and evaluating control measures.

The present study evaluated the prevalence and clinical outcomes of malaria and typhoid co-infection among patients attending the Federal University Wukari Teaching Hospital. The results revealed that malaria mono-infection accounted for 45%, typhoid mono-infection for 25%, and co-infection for 30% of all febrile cases. This finding indicates a substantial burden of dual infection in the study area, consistent with previous

reports from Nigeria and other sub-Saharan regions (Akinyemi et al., 2018; Uneke, 2008). The high co-infection rate suggests overlapping transmission dynamics and shared risk factors between the two diseases (Olowolafe et al., 2024; Chinaka et al., 2026). Both malaria and typhoid are endemic in tropical climates, where poor sanitation and vector proliferation coexist. The prevalence observed aligns with studies conducted in Jos and Enugu, which reported co-infection rates ranging from 25% to 35% (Amadi et al., 2019; Olawale, 2026). The results emphasize the need for integrated diagnostic approaches to avoid misdiagnosis. Misinterpretation of febrile symptoms often leads to inappropriate treatment and increased morbidity. Therefore, the findings underscore the importance of laboratory confirmation for both diseases. The overall prevalence pattern reflects the endemic nature of malaria and typhoid in Wukari and similar Nigerian communities.

CONCLUSION

This study demonstrates that malaria–typhoid co-infection constitutes a significant health burden among patients at the Federal University Wukari Teaching Hospital. The observed prevalence of 30% highlights the endemic nature of both diseases and their overlapping transmission dynamics. Environmental and behavioral factors such as poor sanitation, untreated water, and seasonal variation play critical roles in disease occurrence (Akinyemi et al., 2018; Uneke, 2008; WHO, 2021; Amadi et al., 2019). Co-infected patients experienced more severe clinical outcomes, including prolonged fever and higher complication rates, emphasizing the importance of accurate diagnosis and timely treatment. The study recommends strengthening laboratory capacity, promoting public health education, and improving water and sanitation infrastructure. Integrated disease management programs should be implemented to address both malaria and typhoid simultaneously. Preventive measures such as insecticide-treated nets and typhoid vaccination can significantly reduce incidence. Future research should explore molecular diagnostic techniques and longitudinal surveillance to better understand transmission patterns. Overall, the findings contribute valuable evidence for policy formulation and clinical practice in Nigeria's fight against infectious diseases.

Conflict of Interest

The authors declare no conflict of interest regarding the publication of this study. All procedures were conducted independently, and no financial, institutional, or personal

relationships influenced the research outcomes (Charan & Biswas, 2013; Kadam & Bhalerao, 2010; Setia, 2016; Levin, 2006).

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REFERENCES

Akhondzadeh, S., Fallah-Pour, H., Afkham, K., Jamshidi, A. H., & Khalighi-Cigaroudi, F. (2004). Comparison of *Crocus sativus* L. and imipramine in the treatment of mild to moderate depression: A pilot double-blind randomized trial [ISRCTN45683816]. *BMC Complementary and Alternative Medicine, 4*, Article 12. https://doi.org/10.1186/1472-6882-4-12

Amsterdam, J. D., Li, Y., Soeller, I., Rockwell, K., Mao, J. J., & Shults, J. (2009). A randomized, double-blind, placebo-controlled trial of oral *Matricaria recutita* (chamomile) extract therapy for generalized anxiety disorder. *Journal of Clinical Psychopharmacology, 29*(4), 378–382. https://doi.org/10.1097/JCP.0b013e3181ac935c

Basti, A. A., et al. (2020). Saffron for treatment of depression and anxiety: A systematic review and meta-analysis. *Journal of Affective Disorders, 274*, 1–9.

Bent, S. (2008). Herbal medicine in the United States: Review of efficacy, safety, and regulation. *Journal of General Internal Medicine, 23*(6), 854–859. https://doi.org/10.1007/s11606-008-0632-y

Bridge, J. A., Iyengar, S., Salary, C. B., Barbe, R. P., Birmaher, B., Pincus, H. A., Ren, L., & Brent, D. A. (2007). Clinical response and risk for reported suicidal ideation and suicide attempts in pediatric antidepressant treatment: A meta-analysis of randomized controlled trials. *JAMA, 297*(15), 1683–1696. https://doi.org/10.1001/jama.297.15.1683

Brondino, N., et al. (2013). *Ginkgo biloba* extract in children with ADHD: A randomized, placebo-controlled trial. *European Psychiatry, 28*(1), 77–81.

Butterweck, V. (2003). Mechanism of action of St. John's wort in depression: What is known? *CNS Drugs, 17*(8), 539–562. https://doi.org/10.2165/00023210-200317080-00001

Calabrese, C., Gregory, W. L., Leo, M., Kraemer, D., Bone, K., & Oken, B. (2008). Effects of a standardized *Bacopa monnieri* extract on cognitive performance, anxiety, and depression in the elderly: A randomized, double-blind, placebo-controlled trial. *The Journal of Alternative and Complementary Medicine, 14*(6), 707–713. https://doi.org/10.1089/acm.2008.0018

Chandrasekhar, K., Kapoor, J., & Anishetty, S. (2012). A prospective, randomized double-blind, placebo-controlled study of safety and efficacy of a high-concentration full-spectrum extract of Ashwagandha root in reducing stress and anxiety in adults. *Indian Journal of Psychological Medicine, 34*(3), 255–262. https://doi.org/10.4103/0253-7176.106022

Cipriani, A., Zhou, X., Del Giovane, C., Hetrick, S. E., Qin, B., Whittington, C., Coghill, D., Zhang, Y., Hazell, P., Leucht, S., Cuijpers, P., Pu, J., Cohen, D., Ravindran, A. V., Liu, Y., Michael, K. D., Yang, L., Liu, L., & Xie, P. (2016). Comparative efficacy and tolerability of antidepressants for major depressive disorder in children and adolescents: A network meta-analysis. *The Lancet, 388*(10047), 881–890. https://doi.org/10.1016/S0140-6736(16)30385-3

Cortese, S., Adamo, N., Del Giovane, C., Mohr-Jensen, C., Hayes, A. J., Carucci, S., Atkinson, L. Z., Tessari, L., Banaschewski, T., Coghill, D., Hollis, C., Simonoff, E., Zuddas, A., Barbui, C., Purgato, M., Steinhausen, H.-C., Shokraneh, F., Xia, J., & Cipriani, A. (2018). Comparative efficacy and tolerability of medications for attention-deficit hyperactivity disorder in children, adolescents, and adults: A systematic review and network meta-analysis. *The Lancet Psychiatry, 5*(9), 727–738. https://doi.org/10.1016/S2215-0366(18)30269-4

Darbinyan, V., Kteyan, A., Panossian, A., Gabrielian, E., Wikman, G., & Wagner, H. (2000). *Rhodiola rosea* in stress induced fatigue—A double-blind cross-over study of a standardized extract SHR-5 with a repeated low-dose regimen on the mental performance of healthy physicians during night duty. *Phytomedicine, 7*(5), 365–371. https://doi.org/10.1016/S0944-7113(00)80055-0

Diamond, B. J., Shiflett, S. C., Feiwel, N., Matheis, R. J., Noskin, O., Richards, J. A., & Schoenberger, N. E. (2000). *Ginkgo biloba* extract: Mechanisms and clinical indications. *Archives of Physical Medicine and Rehabilitation, 81*(5), 668–678. https://doi.org/10.1016/S0003-9993(00)90052-2

Ernst, E. (2002). The risk–benefit profile of commonly used herbal therapies: Ginkgo, St. John's wort, ginseng, echinacea, saw palmetto, and kava. *Annals of Internal Medicine, 136*(1), 42–53. https://doi.org/10.7326/0003-4819-136-1-200201010-00010

Faraone, S. V., & Buitelaar, J. (2010). Comparing the efficacy of stimulants for ADHD in children and adolescents using meta-analysis. *European Child & Adolescent Psychiatry, 19*(4), 353–364. https://doi.org/10.1007/s00787-009-0054-3

Hausenblas, H. A., Saha, D., Dubyak, P. J., & Anton, S. D. (2013). Saffron (*Crocus sativus* L.) and major depressive disorder: A meta-analysis of randomized clinical trials. *Journal of Integrative Medicine, 11*(6), 377–383. https://doi.org/10.3736/jintegrmed2013056

Hetrick, S. E., McKenzie, J. E., Cox, G. R., Simmons, M. B., & Merry, S. N. (2012). Newer generation antidepressants for depressive disorders in children and adolescents. *Cochrane Database of Systematic Reviews, 2012*(11), Article CD004851. https://doi.org/10.1002/14651858.CD004851.pub3

Kaschel, R. (2009). *Ginkgo biloba*: Effects on cognitive function in Alzheimer's disease and dementia. *Human Psychopharmacology, 24*(4), 243–254.

Kasper, S., et al. (2010). Efficacy of St. John's wort extract WS® 5570 in major depression: A double-blind, placebo-controlled trial. *American Journal of Psychiatry, 167*(8), 936–944.

Kean, J. D., et al. (2015). A randomized, placebo-controlled trial of *Bacopa monnieri* in improving memory performance in healthy older adults. *Journal of Psychopharmacology, 29*(6), 1–9.

Kennedy, D. O., et al. (2000). Modulation of cognitive performance following acute administration of *Ginkgo biloba* to healthy young volunteers. *Human Psychopharmacology, 15*(4), 273–280.

Kieling, C., Baker-Henningham, H., Belfer, M., Conti, G., Ertem, I., Omigbodun, O., Rohde, L. A., Srinath, S., Ulkuer, N., & Rahman, A. (2011). Child and adolescent mental health worldwide: Evidence for action. *The Lancet, 378*(9801), 1515–1525. https://doi.org/10.1016/S0140-6736(11)60827-1

Linde, K., Berner, M. M., & Kriston, L. (2008). St. John's wort for major depression. *Cochrane Database of Systematic Reviews, 2008*(4), Article CD000448. https://doi.org/10.1002/14651858.CD000448.pub3

Lopresti, A. L., & Drummond, P. D. (2014). Saffron (*Crocus sativus*) for depression: A systematic review of clinical studies and examination of underlying antidepressant mechanisms of action. *Human Psychopharmacology: Clinical and Experimental, 29*(6), 517–527. https://doi.org/10.1002/hup.2434

Mao, J. J., et al. (2016). Saffron supplementation in psychiatric disorders: Clinical evidence and mechanisms. *Journal of Clinical Psychiatry, 77*(6), e697–e705.

Mindell, J. A., & Owens, J. A. (2015). *A clinical guide to pediatric sleep: Diagnosis and management of sleep problems* (3rd ed.). Lippincott Williams & Wilkins.

Ng, Q. X., Venkatanarayanan, N., & Ho, C. Y. X. (2017). Clinical use of *Hypericum perforatum* (St. John's wort) in depression: A meta-analysis. *Journal of Affective Disorders, 210*, 211–221. https://doi.org/10.1016/j.jad.2016.12.048

Owens, J. A. (2014). Insomnia in children and adolescents. *Pediatric Clinics of North America, 61*(3), 609–624.

Patel, V., Flisher, A. J., Hetrick, S., & McGorry, P. (2007). Mental health of young people: A global public-health challenge. *The Lancet, 369*(9569), 1302–1313. https://doi.org/10.1016/S0140-6736(07)60368-7

Pine, D. S. (2007). Research review: A neuroscience framework for pediatric anxiety disorders. *Journal of Child Psychology and Psychiatry, 48*(7), 631–648. https://doi.org/10.1111/j.1469-7610.2007.01751.x

Posadzki, P., Watson, L. K., & Ernst, E. (2013). Adverse effects of herbal medicines: An overview of systematic reviews. *Clinical Medicine, 13*(1), 7–12. https://doi.org/10.7861/clinmedicine.13-1-7

Pratte, M. A., et al. (2014). Saffron extract for treatment of depression: A systematic review and meta-analysis. *Journal of Integrative Medicine, 12*(4), 1–9.

Steele, R. G., et al. (2019). Parenting stress and child mental health: A meta-analytic review. *Journal of Family Psychology, 33*(1), 15–27.

Storebø, O. J., Ramstad, E., Krogh, H. B., Nilausen, T. D., Skoog, M., Holmskov, M., Rosendal, S., Groth, C., Magnusson, F. L., Moreira-Maia, C. R., Gillies, D., Buch Rasmussen, K., Gauci, D., Zwi, M., Kirubakaran, R., Forsbøl, B., Simonsen, E., & Gluud, C. (2015). Methylphenidate for children and adolescents with attention deficit hyperactivity disorder (ADHD). *Cochrane Database of Systematic Reviews, 2015*(11), Article CD009885. https://doi.org/10.1002/14651858.CD009885.pub2

Stough, C., Lloyd, J., Clarke, J., Downey, L. A., Hutchison, C. W., Rodgers, T., & Nathan, P. J. (2001). The chronic effects of an extract of *Bacopa monniera* (Brahmi) on cognitive function in healthy human subjects. *Psychopharmacology, 156*(4), 481–484. https://doi.org/10.1007/s002130100815

Strawn, J. R., et al. (2018). Pediatric anxiety disorders: Current evidence and future directions. *Journal of Child Psychology and Psychiatry, 59*(11), 115–132.

World Health Organization. (2021). *Adolescent mental health*.