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Research Article

Occurrence, Risk Factors, and Clinical Implications of Malaria–typhoid Co-infection among Febrile Patients Attending Camrail Medical Center, Douala, Cameroon

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Keywords: Malaria; Typhoid fever; Co-infection; Febrile illness; Risk factors; Cameroon; Douala

Abstract

Background: Malaria and typhoid fever remain major public health problems and important causes of febrile illness in sub-Saharan Africa, particularly in urban settings characterized by poor sanitation, unsafe water supply, overcrowding, and persistent malaria transmission. The clinical manifestations of both diseases frequently overlap, making accurate diagnosis difficult and often leading to empirical treatment, inappropriate antimicrobial use, and delayed patient management. This study assessed the occurrence, associated risk factors, and clinical implications of malaria–typhoid co-infection among febrile patients attending the Camrail Medical Center in Douala, Cameroon.

Methods: A hospital-based analytical cross-sectional study was conducted among 220 febrile patients recruited systematically at the outpatient department. Data were collected using structured questionnaires, clinical assessment forms, and laboratory investigations. Malaria infection was diagnosed using standard parasitological methods, while typhoid fever was assessed using routine laboratory procedures. Data were analyzed using descriptive statistics, chi-square tests, and multivariate logistic regression in SPSS version 25.

Results: Malaria mono-infection accounted for 31.8% of cases, typhoid mono-infection for 10.9%, and malaria–typhoid co-infection for 15.5%, whereas 41.8% of participants had neither infection. Significant predictors of co-infection included unsafe water sources (AOR = 3.12; $p = 0.001$), poor food hygiene (AOR = 3.85; $p < 0.001$), non-use of bed nets (AOR = 2.21; $p = 0.021$), and exposure to stagnant water (AOR = 2.76; $p = 0.004$). Co-infected patients experienced significantly more severe clinical manifestations, including high fever, vomiting, diarrhea, abdominal pain, and headache. Age-stratified analysis showed a higher proportion of co-infection among participants aged ≤25 years (18.8%) compared with those aged ≥26 years (12.9%), although the difference was not statistically significant ($p = 0.194$). Gender-based analysis demonstrated no significant association between sex and infection category ($p = 0.606$).

Conclusion and recommendations: Malaria–typhoid co-infection remains a significant public health concern in Douala. Integrated diagnostic approaches, improved environmental sanitation, safe water access, food hygiene promotion, and strengthened malaria prevention measures are essential to reducing the burden of co-infection and limiting inappropriate antimicrobial use.

Introduction

Malaria remains one of the leading causes of morbidity and mortality worldwide, particularly in sub-Saharan Africa, where the World Health Organization (WHO) African Region accounts for the overwhelming majority of global malaria cases and deaths [1]. Despite substantial progress in malaria prevention and control through the use of long-lasting insecticide-treated nets (LLINs), rapid diagnostic tests (RDTs), indoor residual spraying, and artemisinin-based combination therapies (ACTs), malaria continues to impose a major burden on healthcare systems in many African countries [1,2]. Cameroon remains among the countries with high malaria transmission, where malaria contributes significantly to outpatient consultations, hospital admissions, and mortality, especially among children and pregnant women [2]. Urbanization, environmental degradation, poor drainage systems, overcrowding, and inadequate sanitation continue to favor mosquito breeding and sustain malaria transmission in urban settings such as Douala [3].

Typhoid fever also remains a major public health challenge in many low- and middle-income countries, particularly in areas characterized by unsafe drinking water, poor sanitation, inadequate waste disposal, and poor food hygiene practices [4]. The disease, caused mainly by *Salmonella enterica* serovar Typhi, is commonly transmitted through contaminated food and water and continues to contribute substantially to febrile illnesses in sub-Saharan Africa [5]. In Cameroon, recurrent typhoid outbreaks have been associated with poor environmental sanitation and contaminated water supplies, especially in densely populated urban communities [6]. Studies conducted in several African countries have shown that inadequate water, sanitation, and hygiene (WASH) infrastructure significantly increases the risk of enteric infections, including typhoid fever [4,5].

Malaria and typhoid fever frequently coexist in tropical regions because they share several environmental, socioeconomic, and behavioral determinants [7]. Both diseases commonly present with non-specific clinical manifestations such as fever, headache, vomiting, abdominal pain, malaise, and gastrointestinal disturbances, making clinical differentiation difficult without laboratory confirmation [8]. Consequently, febrile illnesses are often treated empirically with simultaneous administration of antimalarial and antibiotic therapies in many resource-limited settings. This practice may contribute to delayed diagnosis, inappropriate treatment, increased healthcare costs, and the growing problem of antimicrobial resistance [9,10].

Several studies conducted in Cameroon and other African countries have reported varying prevalence rates of malaria–typhoid co-infection among febrile patients [7,11,12]. However, differences in ecological settings, study populations, and diagnostic methods have contributed to inconsistent findings regarding the true burden and determinants of co-infection. Furthermore, limited data are available regarding malaria–typhoid co-infection in occupational and urban healthcare settings such as the Camrail Medical Center in Douala, where environmental and occupational exposures may influence disease transmission patterns.

Understanding the occurrence, associated risk factors, and clinical implications of malaria–typhoid co-infection is essential for improving clinical management, strengthening integrated disease control strategies, and reducing inappropriate antimicrobial use. This study therefore aimed to determine the occurrence, associated risk factors, and clinical implications of malaria–typhoid co-infection among febrile patients attending the Camrail Medical Center in Douala, Cameroon.

Methods

Study Area

The study was conducted at the Camrail Medical Center located in Douala, the economic capital of Cameroon. Douala is characterized by a humid tropical climate with high rainfall, poor drainage systems, overcrowding, and rapid urbanization, conditions that favor both malaria transmission and the spread of waterborne diseases [3,6]. The Camrail Medical Center provides outpatient, laboratory, and primary healthcare services to railway workers, their dependents, and surrounding community members. The health facility receives a high number of febrile patients, making it an appropriate setting for investigating malaria–typhoid co-infection.

Study Design and Study Population

A hospital-based analytical cross-sectional study was conducted among febrile patients attending the Camrail Medical Center during the study period. The study targeted patients presenting with fever irrespective of age or sex. The cross-sectional design was considered appropriate for determining the occurrence of malaria–typhoid co-infection and identifying associated risk factors within the study population [13].

Inclusion and Exclusion Criteria

Participants included in the study were febrile patients with body temperature ≥ 38°C at the time of consultation who consented to participate in the study. For minors, informed consent was obtained from parents or guardians. Both ambulatory and non-hospitalized febrile patients were eligible for participation.

Patients who had received antimalarial or antibiotic treatment within the previous two weeks were excluded from the study. Individuals with chronic febrile illnesses such as tuberculosis, HIV/AIDS-related opportunistic infections, or autoimmune disorders were also excluded unless they presented with acute febrile symptoms during consultation.

Sample Size Determination

The sample size was determined using Cochran's formula for prevalence studies [13]:

$$n = \frac{Z^2 \cdot p(1-p)}{d^2}$$

Where:

n = required sample size

Z = standard normal deviation at 95% confidence interval (1.96)

p = estimated prevalence of malaria–typhoid co-infection (15%) based on similar studies conducted in Cameroon [12]

d = margin of error (0.05)

After adjusting for a 10% non-response rate, a minimum sample size of 216 participants was obtained. However, 220 febrile patients were eventually enrolled in the study.

Sampling technique

A systematic random sampling technique was used to recruit study participants. Every fifth eligible febrile patient presenting at the outpatient department was selected until the desired sample size was achieved. The sampling interval was determined based on the average monthly attendance of febrile patients at the health facility.

Data Collection Procedures

Data were collected using structured questionnaires, clinical assessment forms, and laboratory investigations. The questionnaire was developed according to the study objectives and included information on socio-demographic characteristics, clinical symptoms, environmental exposures, and behavioral practices associated with malaria and typhoid fever. Variables collected included age, sex, educational level, occupation, water source, food hygiene practices, bed net utilization, handwashing habits, and exposure to stagnant water. The questionnaires were administered through face-to-face interviews by trained research assistants. Local language interpretation was provided when necessary to facilitate communication and improve the accuracy of responses. Completed questionnaires were checked daily for completeness and consistency before data entry.

Laboratory Procedures

Malaria diagnosis was performed using standard parasitological techniques based on microscopic examination of Giemsa-stained thick and thin blood films prepared from capillary blood samples [1]. Typhoid fever diagnosis was assessed using routine laboratory procedures available at the health facility. Standard laboratory precautions and quality control measures were maintained throughout the study period.

Data Analysis

Data were entered into Microsoft Excel and analyzed using the Statistical Package for Social Sciences (SPSS) version 25. Descriptive statistics, including frequencies, percentages, tables, and figures, were used to summarize socio-demographic and clinical characteristics of participants. Chi-square and Fisher's exact tests were used to assess associations between categorical variables and malaria–typhoid co-infection. Variables with statistically significant associations at the bivariate level were included in the multivariate logistic regression analysis to identify independent predictors of co-infection. Adjusted odds ratios (AORs) with 95% confidence intervals were calculated, and statistical significance was considered at $p < 0.05$.

Ethical Considerations

Ethical approval for the study was obtained from the appropriate Institutional Review Board before data collection. Administrative authorization was also obtained from the Camrail Medical Center management. Written informed consent was obtained from all participants or guardians before enrolment into the study. Confidentiality and privacy were strictly maintained by assigning unique identification codes instead of participant names. Participation in the study was voluntary, and participants were informed of their right to withdraw at any stage without any consequences. Positive cases identified during laboratory investigations were managed according to national and WHO treatment guidelines [14].

Results

Socio-demographic Characteristics of Participants

A total of 220 febrile patients were enrolled in the study. More than half of the participants (56.4%) were aged 26 years and above, while 43.6% were aged 25 years or below. Female participants constituted 53.2% of the study population, whereas males accounted for 46.8%. Regarding educational level, most participants had attained secondary education (41.8%), followed by primary education (30.9%), while only 5.5% had no formal education. In terms of occupation, unskilled workers represented the largest proportion of respondents (41.8%), followed by students (25.5%), skilled workers (21.8%), and unemployed participants (10.9%) (Table 1).

Distribution of Infection Categories among Participants

Malaria mono-infection was the most common infection category identified among participants, accounting for 31.8% of cases. Typhoid fever mono-infection represented 10.9% of cases, while malaria–typhoid co-infection accounted for 15.5%. However, 41.8% of participants tested negative

Table 1: Socio-demographic Characteristics of Participants (N = 220)

Variable	Frequency	Percentage (%)
Age group		
≤ 25 years	96	43.6
≥ 26 years	124	56.4
Sex		
Male	103	46.8
Female	117	53.2
Education level		
No formal education	12	5.5
Primary	68	30.9
Secondary	92	41.8
Tertiary	48	21.8
Occupation		
Unskilled	92	41.8
Skilled	48	21.8
Student	56	25.5
Unemployed	24	10.9

for both malaria and typhoid fever. Statistical analysis demonstrated a significant difference in the distribution of infection categories among participants (Table 2).

(χ^2 = 54.47, df = 3, p < 0.001

Table 2: Distribution of Infection Categories among Participants.

Infection Category	Frequency	Percentage (%)
Malaria only	70	31.8
Typhoid only	24	10.9
Malaria–Typhoid co-infection	34	15.5
No infection	92	41.8

Age-Stratified Distribution of Infection Categories among Participants

Table 3 shows the age-stratified distribution of infection categories among participants. Malaria–typhoid co-infection was more frequent among participants aged ≤25 years (18.8%) compared with participants aged ≥26 years (12.9%). However, this association did not reach statistical significance.

χ^2 = 4.72; df = 3; p = 0.194

Table 3: Age-Stratified Distribution of Infection Categories among Participants (N = 220)

Age Group	Malaria Only	Typhoid Only	Co-infection	No Infection	Total
≤25 years	32 (33.3%)	10 (10.4%)	18 (18.8%)	36 (37.5%)	96
≥26 years	38 (30.6%)	14 (11.3%)	16 (12.9%)	56 (45.2%)	124
Total	70	24	34	92	220

Gender-Based Distribution of Infection Categories among Participants

Table 4 shows the gender-based distribution of infection categories among participants. Malaria mono-infection was the predominant infection category among both males and females. Although co-infection appeared slightly more frequent among males, no statistically significant association was observed between sex and infection category.

χ^2 = 1.84; df = 3; p = 0.606

Table 4: Gender-Based Distribution of Infection Categories among Participants (N = 220)

Sex	Malaria Only	Typhoid Only	Co-infection	No Infection	Total
Male	34 (33.0%)	11 (10.7%)	18 (17.5%)	40 (38.8%)	103
Female	36 (30.8%)	13 (11.1%)	16 (13.7%)	52 (44.4%)	117
Total	70	24	34	92	220

Risk Factors Associated with Malaria–Typhoid Co-infection

Several environmental and behavioral factors were significantly associated with malaria–typhoid co-infection. Participants who did not regularly use bed nets had significantly higher co-infection rates compared to regular bed net users (p = 0.004). Similarly, participants using unsafe water sources and those practicing poor food hygiene were significantly more likely to experience co-infection (p ≤ 0.001). Exposure to stagnant water was also significantly associated with malaria–typhoid co-infection (p = 0.002) (Table 5).

Table 5: Bivariate Analysis of Risk Factors for Malaria–Typhoid Co-infection

Risk Factor	Negative	Positive	P-value
Bed net use			
Yes	124	12	
No	62	22	0.004
Water source			
Safe	130	10	
Unsafe	56	24	0.001
Food hygiene			
Good	138	8	
Poor	48	26	<0.001
Stagnant water exposure			
No	120	10	
Yes	66	24	0.002

Clinical Presentation According to Infection Status

Participants with malaria–typhoid co-infection experienced more severe clinical manifestations compared to participants with malaria or typhoid mono-infection. High fever, headache, vomiting, diarrhea, and abdominal pain were significantly more common among co-infected participants (p < 0.05) (Table 6).

Table 6: Clinical Presentation According to Infection Status

Symptom	Malaria (%)	Typhoid (%)	Co-infection (%)	P-value
High fever (>39°C)	58.6	46.2	79.4	0.001
Headache	72.9	65.4	85.3	0.032
Vomiting	35.7	48.1	67.6	0.015
Diarrhea	18.6	52.3	61.8	0.001
Abdominal pain	22.9	56.7	64.7	0.001

Independent Predictors of Malaria–Typhoid Co-infection

Multivariate logistic regression analysis identified several independent predictors of malaria–typhoid co-infection. Participants using unsafe water sources were approximately three times more likely to develop co-infection compared to those using safe water sources (AOR = 3.12; 95% CI: 1.62–5.98; p = 0.001). Poor food hygiene emerged as the strongest predictor of co-infection (AOR = 3.85; 95% CI: 1.98–7.49; p < 0.001). Similarly, non-use of bed nets and exposure to stagnant water significantly increased the odds of co-infection (Table 7).

Table 7: Independent Predictors of Malaria–Typhoid Co-infection

Variable	AOR	95% CI	P-value
Unsafe water source	3.12	1.62 – 5.98	0.001
Poor food hygiene	3.85	1.98 – 7.49	<0.001
No bed net use	2.21	1.12 – 4.35	0.021
Stagnant water exposure	2.76	1.39 – 5.46	0.004

Discussion

This study assessed the occurrence, associated risk factors, and clinical implications of malaria–typhoid co-infection among febrile patients attending the Camrail Medical Center in Douala, Cameroon. The findings demonstrated that malaria and typhoid fever remain important contributors to febrile illness in the study setting, with malaria–typhoid co-infection representing a considerable proportion of cases. The observed co-infection prevalence of 15.5% confirms that dual infection remains a significant public health concern in urban Cameroon. Similar prevalence rates have been reported in previous studies conducted in Cameroon and other sub-Saharan African countries [7,11,12].

The predominance of malaria mono-infection observed in this study is consistent with the epidemiological profile of malaria in Cameroon, where malaria remains one of the leading causes of morbidity and outpatient consultations [1,2]. Environmental conditions in Douala, including stagnant water, poor drainage systems, overcrowding, and rapid urbanization, may contribute to sustained malaria transmission [3]. However, the prevalence observed in this study was slightly lower than reports from some rural settings in Cameroon, where malaria prevalence exceeded 40% among febrile patients [2]. This difference may be attributed to variations in ecological conditions, vector density, and healthcare-seeking behavior between urban and rural populations.

The prevalence of typhoid fever mono-infection observed in this study also confirms that typhoid fever remains endemic in the study setting. Similar findings have been reported in studies conducted in urban African settings where unsafe water supply, poor sanitation, and inadequate food hygiene practices contribute substantially to disease transmission [4,5]. Previous studies conducted in Cameroon have also highlighted the association between typhoid fever and poor environmental sanitation [6]. Nevertheless, some studies using blood culture techniques have reported lower prevalence rates than studies relying on serological diagnostic methods, suggesting possible overestimation associated with less specific laboratory tests [10].

The study identified several important environmental and behavioral factors associated with malaria–typhoid co-infection. Participants who did not regularly use bed nets had significantly increased odds of co-infection. This finding supports WHO recommendations emphasizing LLIN utilization as one of the most effective malaria prevention strategies [1]. Similar associations between poor bed net use and malaria infection have been widely reported in Cameroon and other African countries [3].

An unsafe water source was identified as a strong predictor of co-infection, with affected participants being approximately three times more likely to develop malaria–typhoid co-infection compared to those using safe water sources. This finding agrees with previous studies demonstrating that unsafe drinking water significantly increases the risk of enteric infections, including typhoid fever [4,5]. Poor food hygiene also emerged as the strongest predictor of co-infection in this study. Similar findings have been reported in studies conducted in Nigeria and Ghana, where poor food handling practices and contaminated food sources significantly contributed to typhoid transmission [5].

Exposure to stagnant water was significantly associated with co-infection in the present study. This finding is biologically plausible because stagnant water promotes mosquito breeding and also reflects poor environmental sanitation conditions favorable for enteric disease transmission. Similar observations have been documented in urban malaria studies conducted in Douala and other rapidly urbanizing African cities [3].

An important finding of this study was the increased severity of clinical manifestations among co-infected participants. High fever, diarrhea, vomiting, abdominal pain, and headache were significantly more common among co-infected patients than among mono-infected individuals. These findings support previous reports suggesting that malaria may increase susceptibility to bacterial infections and worsen clinical outcomes through immune dysregulation [15,16]. Similar observations have also been reported among febrile patients in Cameroon [11].

The findings of this study have important public health implications. The substantial burden of co-infection and the significant role of environmental and behavioral risk factors demonstrate the need for integrated approaches to febrile illness management. Empirical treatment of febrile illnesses with simultaneous administration of antimalarial and antibiotic therapies remains common in many low-resource settings and may contribute to antimicrobial resistance and inappropriate drug use [9]. Strengthening laboratory diagnostic capacity, improving environmental sanitation, promoting food hygiene, increasing access to safe water, and reinforcing malaria prevention measures could substantially reduce the burden of malaria–typhoid co-infection in urban Cameroon.

Overall, the findings contribute important context-specific evidence regarding malaria–typhoid co-infection among febrile patients in Douala and highlight the need for integrated disease prevention and control strategies targeting both environmental and behavioral determinants of infection.

Generalizability of Findings

Although the present study provides valuable evidence regarding malaria–typhoid co-infection among febrile patients attending the Camrail Medical Center, the findings should be interpreted within the context of its single-center design. Because the study was conducted in one urban healthcare facility, the results may not be fully generalizable to all populations in Douala or other regions of Cameroon. Nevertheless, the Camrail Medical Center serves a diverse patient population and shares many epidemiological characteristics with similar urban healthcare settings across sub-Saharan Africa. Therefore, the findings remain highly relevant for comparable settings facing challenges related to malaria transmission, sanitation, and management of febrile illnesses.

Potential Influence of Seasonal Factors

The study period may also have influenced the observed infection patterns. Malaria transmission in Douala is known to increase during periods of heavy rainfall due to increased mosquito breeding sites, while typhoid fever incidence may rise during periods characterized by flooding, contamination of water sources, and deterioration of sanitation conditions. Consequently, seasonal environmental factors may have contributed to the occurrence of both mono-infections and co-infections observed in this study. Future longitudinal studies spanning multiple seasons would provide a more comprehensive understanding of seasonal variations in malaria–typhoid co-infection.

Age and Gender Considerations

The age-stratified analysis suggested a higher proportion of malaria–typhoid co-infection among younger participants (≤25 years), which may reflect greater exposure to environmental risk factors and behavioral practices facilitating disease transmission. Although the association was not statistically significant, this finding aligns with previous reports indicating that younger populations frequently experience a higher burden of infectious diseases in endemic settings. Similarly, gender-based analysis demonstrated no significant differences in infection patterns between males and females, suggesting comparable exposure to the major environmental and behavioral determinants identified in this study.

Study Limitations

This study has some limitations. First, the single-center design may limit the generalizability of the findings to other regions of Cameroon. Second, the cross-sectional design does not permit causal inference. Third, although age-stratified and gender-based analyses were performed, the sample size within some infection categories was relatively small and may have limited the statistical power to detect significant subgroup differences. Future multicenter studies involving larger populations and multiple transmission seasons are recommended to further explore demographic and temporal variations in malaria–typhoid co-infection patterns.

Conclusion

Malaria and typhoid fever remain important causes of febrile illness among patients attending the Camrail Medical Center in Douala, Cameroon. The study revealed a considerable prevalence of malaria–typhoid co-infection, highlighting the continuing public health burden posed by these infections in urban settings characterized by poor sanitation and persistent malaria transmission. Malaria mono-infection remained the most common diagnosis, although a substantial proportion of patients presented with dual infection.

The findings identified several significant predictors of malaria–typhoid co-infection, including unsafe water sources, poor food hygiene practices, non-use of bed nets, and exposure to stagnant water. These results emphasize the important role of environmental and behavioral factors in sustaining the transmission of both malaria and typhoid fever. In addition, co-infected participants experienced more severe clinical manifestations such as high fever, vomiting, diarrhea, abdominal pain, and headache, suggesting that co-infection may worsen disease severity and complicate clinical management.

The study highlights the need for integrated approaches to febrile illness management in endemic settings. Strengthening laboratory diagnostic capacity, improving access to safe drinking water, promoting food hygiene, reinforcing environmental sanitation measures, and increasing utilization of malaria preventive interventions such as long-lasting insecticide-treated nets are essential for reducing the burden of co-infection. Furthermore, rational use of antimicrobials and evidence-based treatment strategies should be encouraged to limit inappropriate drug use and reduce the risk of antimicrobial resistance.

Overall, the findings provide important context-specific evidence that may support clinicians, public health authorities, and policymakers in developing integrated strategies for the prevention and control of malaria–typhoid co-infection in Cameroon and similar endemic settings.

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Data Availability Statement: The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Author Contributions

Jolle Belle Alice participated in study conception, data collection, data analysis, and manuscript drafting. Fankep Dihewou Alphonse Bertin contributed to study design, data interpretation, and manuscript revision. Mohnchimbare Christina Mbongueh contributed to methodological design, statistical analysis, and critical revision of the manuscript. Kamga Fouamno Henri Lucien supervised the study, contributed to scientific review, interpretation of findings, and final approval of the manuscript. All authors read and approved the final manuscript.

References

1. World Health Organization. World malaria report 2024 [Internet]. Geneva: World Health Organization; 2024 [cited Year Month Day]. Available from: https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2024
2. World Health Organization Regional Office for Africa. Cameroon malaria country profile [Internet]. Brazzaville: WHO Regional Office for Africa; 2024 [cited Year Month Day]. Available from: https://www.afro.who.int/countries/cameroon
3. Antonio-Nkondjio C, Ndo C, Njiokou F, Bigoga JD, Awono-Ambene P, Etang J, et al. Review of malaria transmission dynamics and vector control in urban settings of Cameroon. Parasit Vectors. 2019;12(1):1-15. Available from: https://doi.org/10.1186/s13071-019-3404-7
4. Kim JH, Mogasale V, Im J, Ramani E, Marks F. Updated estimates of typhoid fever burden in sub-Saharan Africa. Clin Infect Dis. 2022;75(Suppl 1). Available from: https://doi.org/10.1186/s13071-019-3404-7
5. Marks F, von Kalckreuth V, Aaby P, Adu-Sarkodie Y, El Tayeb MA, Ali M, et al. Incidence of invasive Salmonella disease in sub-Saharan Africa. Clin Infect Dis. 2017;65(Suppl 1). Available from: https://doi.org/10.1093/cid/cix393
6. Akoachere JFTK, Tanih NF, Ndip LM, Ndip RN. Phenotypic characterization of Salmonella Typhi in Cameroon and associated environmental risk factors. BMC Infect Dis. 2019;19(1):1-9. Available from: https://doi.org/10.1093/cid/cix393
7. Uneke CJ. Concurrent malaria and typhoid fever in the tropics: the diagnostic challenges and public health implications. J Vector Borne Dis. 2008;45(2):133-142. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2743161/
8. D'Acremont V, Kilowoko M, Kyungu E, Philipina S, Sangu W, Kahama-Maro J, et al. Beyond malaria: causes of fever in outpatient Tanzanian children. N Engl J Med. 2014;370(9):809-817. Available from: https://doi.org/10.1056/NEJMoa1214482
9. Anjorin AA, Abioye AI, Adegoke AA, Adeyemi OO. Febrile illness management and antimicrobial misuse in sub-Saharan Africa. Trop Med Infect Dis. 2023;8(2):85-96. Available from: https://doi.org/10.3390/tropicalmed8020085
10. Olopoenia LA, King AL. Widal agglutination test—100 years later: still plagued by controversy. Postgrad Med J. 2000;76(892):80-84. Available from: https://doi.org/10.1136/pmj.76.892.80
11. Sohanang Nodem M, Tchouangueu TF, Ndzi ES. Prevalence and determinants of malaria-typhoid co-infection among febrile patients in Adamawa Region, Cameroon. BMC Infect Dis. 2023;23(1):633-642. Available from: https://doi.org/10.1186/s12879-023-08533-4
12. Netongo PM, Tchoutang AM, Eric MB, Tepa A, Nzuno MC, Kamdem SD. Malaria and typhoid fever coinfection among febrile patients attending a health facility in Yaoundé, Cameroon: a cross-sectional study. J Parasitol Res. 2025;2025:9977704. Available from: https://doi.org/10.1155/japr/9977704
13. Kothari CR. Research methodology: methods and techniques. 2nd ed. New Delhi: New Age International Publishers; 2004. Available from: https://arunodayauniversity.ac.in/wp-content/uploads/2025/01/Research-Methodology-Methods-and-Techniques-Kothari.pdf
14. World Health Organization. Guidelines for the treatment of malaria. 3rd ed. Geneva: World Health Organization; 2015. Available from: https://www.who.int/publications/i/item/9789241549127
15. Cunnington AJ, de Souza JB, Walther M, Riley EM. Malaria impairs resistance to Salmonella through heme- and heme oxygenase-dependent dysfunctional granulocyte mobilization. Nat Med. 2012;18(1):120-127. Available from: https://doi.org/10.1038/nm.2601
16. Scott JAG, Berkley JA, Mwangi I, Ochola L, Uyoga S, Macharia A, et al. Relation between falciparum malaria and bacteremia in Kenyan children. Lancet. 2011;378(9799):1316-1323. Available from: https://doi.org/10.1016/S0140-6736(11)60888-X