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Co-infection with Malaria and Urinary Tract Infection among Outpatient Pregnant Women: Prevalence, Risk Factors, and Antimicrobial Susceptibility Patterns - A Cross-Sectional Study

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Abstract
The aim of this cross-sectional study was to determine the prevalence of co-infection with malaria and urinary tract infection (UTI) among outpatient pregnant women, identification associated risk factors, evaluate antimicrobial susceptibility patterns, and assess the impact on pregnancy outcomes. Out of 600 pregnant women screened 90 (15%) had co-infections, while 20% had malaria alone, 25% had UTI alone, and 40% had neither infection. Co-infection was significantly associated with older age, higher gravidity, low socioeconomic status, a history of UTIs, and lack of access to clean water. Risk factors for co-infection included age over 30 years (OR: 2.8), low income (OR: 3.1), low educational level (OR: 2.4), poor sanitation (OR: 2.7), lack of access to clean water (OR: 2.9), limited prenatal care (OR: 2.5), and previous episodes of malaria (OR: 2.1). *Escherichia coli* was the most prevalent bacterial isolate, followed by *Staphylococcus aureus* and *Klebsiella aerogenes*. Antimicrobial susceptibility testing revealed high effectiveness of ciprofloxacin and ceftriaxone, whereas amoxicillin and trimethoprim-sulfamethoxazole had higher resistance rates. Co-infection was associated with adverse pregnancy outcomes, including higher rates of preterm birth (22.2% vs. 7.8%), low birth weight (27.8% vs. 9.8%), maternal anaemia (38.9% vs. 13.7%), and neonatal mortality (5.6% vs. 2.0%). These findings underscore the need for integrated healthcare strategies to manage and prevent co-infections among pregnant women to improve maternal and neonatal health outcomes.

Keywords: Co-infection; Malaria; Urinary Tract Infection (UTI); Pregnant Women; Antimicrobial Susceptibility; Pregnancy Outcomes

Introduction

Malaria, caused predominantly by *Plasmodium* parasites transmitted through mosquito bites, affects millions of individuals annually, with pregnant women being particularly vulnerable due to altered immune responses (Gadoth-Goodman, 2019). Concurrently, UTIs, primarily caused by bacterial pathogens such as *Escherichia coli* and *Staphylococcus aureus*, are common among pregnant women due to hormonal changes and anatomical factors that increase susceptibility to ascending infections (Baba, 2022).

Despite extensive research on malaria and UTIs individually, the interaction and combined impact of these infections during pregnancy have not been comprehensively studied (Capan Melser, 2015). This co-infection with malaria and urinary tract infection (UTI) poses a complex challenge to maternal and neonatal health globally, particularly in regions where both infections are endemic (Capan Melser, 2015). Knowledge gap is critical, as co-infections may exacerbate maternal morbidity and mortality rates, as well as adversely affect fetal outcomes, including preterm birth, low birth weight, and neonatal mortality (Gamberini *et al*., 2023). Understanding the prevalence, risk factors contributing to co-infection, and the antimicrobial susceptibility patterns of bacterial pathogens involved is essential for guiding effective clinical management strategies (Gamberini *et al*., 2023). Malaria and UTIs independently pose serious risks to maternal and foetal health, including increased

chances of preterm labor, low birth weight, and maternal anaemia (Pararas *et al*., 2006; Iriama, 2014; Deo, 2017; Achieng, 2020; Muthiani *et al*., 2023; Singhal, 2024). However, the compounded effects of co-infection remain underexplored. The lack of comprehensive data on the prevalence, risk factors, and antimicrobial susceptibility patterns associated with these co-infections in pregnant women represents a critical gap in current research.

The rationale for conducting this cross-sectional study lies in the need to address these knowledge gaps and provide evidence-based insights into the epidemiology and clinical implications of malaria and UTI co-infections in pregnant women. This study seeks to provide evidence-based recommendations for improved management and treatment strategies, ultimately enhancing maternal and neonatal health outcomes. By elucidating the prevalence of co-infections, identifying associated risk factors such as socio-demographic characteristics and healthcare access, and evaluating antibiotic susceptibility profiles of isolated pathogens, this research aims to inform tailored prevention strategies and optimize treatment protocols. Ultimately, the findings of this study are expected to contribute to the enhancement of maternal and neonatal health outcomes in settings burdened by these dual infectious threats.

Materials and Methods

Study Design

This cross-sectional study was conducted to assess the prevalence, risk factors, antimicrobial susceptibility patterns, and impact on pregnancy outcomes of co-infection with malaria and urinary tract infection (UTI) among outpatient pregnant women.

Study Setting and Population

The study was carried out in Ilorin, the capital city of Kwara State in Nigeria. Ilorin is a densely populated urban Centre equipped with a range of facilities and amenities, encompassing healthcare institutions such as Hospitals. The study population included outpatient pregnant women attending the antenatal clinic during the study period.

Study Design

The study was a Hospital based case control study, carried out during the period of March 2021 to October 2023. A total of 600 pregnant women attending the antenatal care clinic was recruited in some selected Hospital in Ilorin namely (General Hospital Ilorin, Sobi Specialist Hospital, Adewole Cottage Hospital and Ajikobi Cottage Hospital which served as the WHO sentinel Centre for malaria as shown in Figure 1).

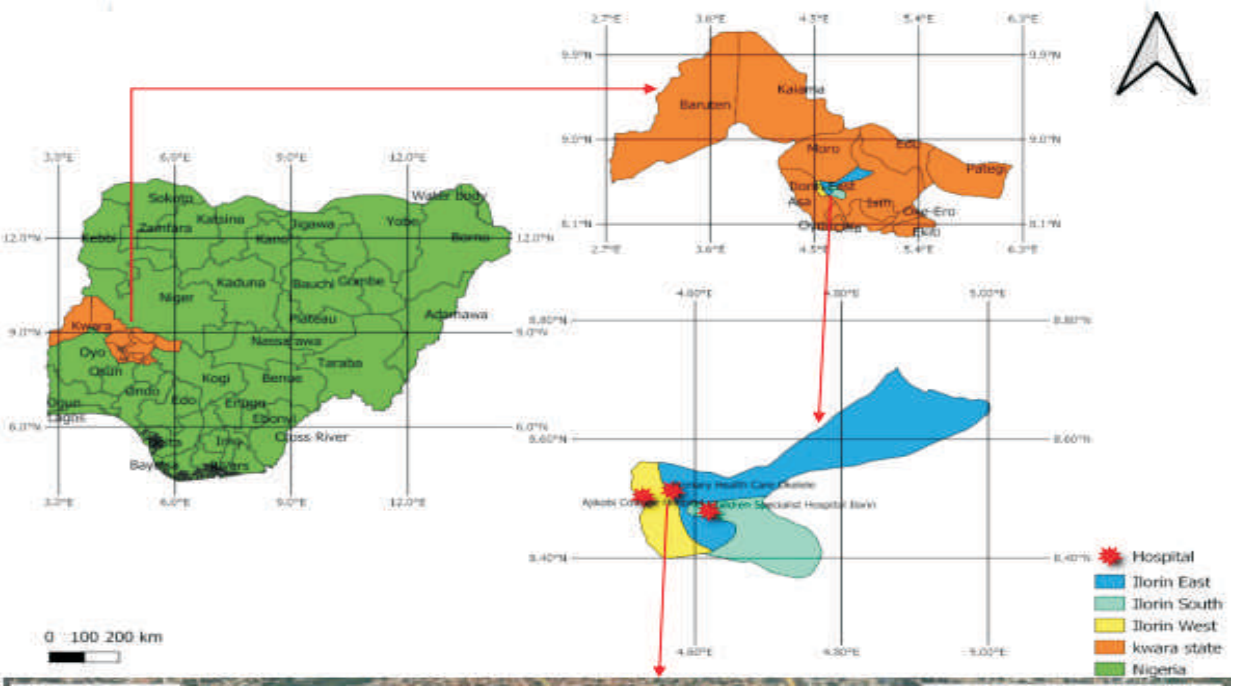

Figure 1: WHO sentinel Centre for malaria in Kwara State, Nigeria

Sample Size
The sample size was calculated based on the estimated prevalence of co-infection from previous studies, with a 95% confidence level and a 5% margin of error. A total of 600 pregnant women were recruited for the study.

Inclusion and Exclusion Criteria
Inclusion Criteria
1. Pregnant women of any gestational age attending the outpatient clinic.
2. Pregnant women who are willing to provide informed consent.

Exclusion Criteria:
1. Pregnant women with known chronic illnesses unrelated to malaria or UTI.
2. Pregnant women who had taken antibiotics or antimalarial drugs within the last two weeks.

Ethical Considerations/ Inform Consent
Ethical approval was obtained from the Kwara State Ethical Research Review Committee, Ministry of Health, Ilorin (ERC/MOH2022/03/021). In addition, Oral and written informed consent was obtained from individual after a clear explanation of the objectives of the Research in their native language and potential benefits of the study prior to enrollment in the study so they could consent voluntarily.

Data Collection
Demographic and Clinical Data
Demographic and clinical data were collected using a structured questionnaire. Information on age, gravidity, socioeconomic status, history of UTIs, and access to clean water was recorded.

Laboratory Procedures
Malaria Diagnosis:
Malaria was diagnosed using a rapid diagnostic test (RDT) for *Plasmodium falciparum*, followed by confirmation with microscopic examination of Giemsa-stained blood smears.

Urine Sample Collection and UTI Diagnosis:
Midstream urine samples were collected in sterile containers. Urine samples were cultured on Cysteine-Lactose-Electrolyte-Deficient (CLED) agar and blood agar plates. Significant bacteriuria was defined as a colony count of $\geq 10^5$ CFU/mL. Identification of bacterial isolates was performed using standard biochemical tests.

Antimicrobial Susceptibility Testing
Antimicrobial susceptibility testing was conducted using the Kirby-Bauer disk diffusion method. The following antibiotics were tested: Ciprofloxacin, Amoxicillin, Nitrofurantoin, Ceftriaxone, and Trimethoprim-Sulfamethoxazole. Results were interpreted according to Clinical and Laboratory Standards Institute (CLSI) guidelines.

Data Analysis
Data were entered into a database and analyzed using [Name of Statistical Software]. Descriptive statistics were used to summarize the data. Prevalence rates of malaria, UTI, and co-infection were calculated.

Risk Factor Analysis
Univariate and multivariate logistic regression analyses were performed to identify risk factors associated with co-infection. Odds ratios (OR) and 95% confidence intervals (CI) were calculated.

Impact on Pregnancy Outcomes
The impact of co-infection on pregnancy outcomes, such as preterm birth, low birth weight, maternal anaemia, and neonatal mortality, was assessed. Comparisons were made between co-infected and non-co-infected groups using chi-square tests for categorical variables and t-tests for continuous variables.

Quality Control
All laboratory procedures were conducted according to standard operating procedures. Quality control strains were used for antimicrobial susceptibility testing. Data entry was double-checked for accuracy.

Limitations
Potential limitations of the study include recall bias in self-reported data, potential selection bias due to the exclusion criteria, and the cross-sectional design which limits causal inference. By following these methods, we aimed to provide a comprehensive assessment of the co-infection with malaria and UTI among outpatient pregnant women, identifying key risk factors and

evaluating the clinical and antimicrobial resistance profiles of bacterial isolates.

Results

Prevalence of Co-infection

Out of the 600 outpatient pregnant women screened, 90 (15%) were found to have co-infection with malaria and urinary tract infection (UTI). The prevalence of malaria alone was 20% (120 cases), while UTI alone was observed in 25% (150 cases) of the women. A significant portion of the population, 40% (240 cases), did not have either infection. These findings indicate that co-infection with malaria and UTI is a notable health concern among pregnant women in this population, affecting a considerable percentage of the screened individuals as presented in (Table 1).

Table 1: Prevalence of Co-infection with Malaria and UTI

Condition	Number of Cases	Percentage (%)
Malaria Only	120	20
UTI only	150	25
Co-infection	90	15
Neither	240	40
Total	600	100

Demographic Characteristics

The demographic characteristics of the study population reveal significant differences between those with co-infection (n=90) and those without co-infection (n=510). Age greater than 30 years was significantly more common in the co-infection group (55.6%) compared to the non co-infection group (29.4%), with a p-value of <0.001. Similarly, higher gravidity (greater than 2 pregnancies) was more prevalent among those with co-infection (66.7%) compared to those without (39.2%), also with a p-value of <0.001. Low socioeconomic status was markedly more frequent in the co-infection group (77.8%) compared to the no co-infection group (29.4%), indicating a significant association (p-value <0.001). A history of urinary tract infections was present in 61.1% of women with co-infection, significantly higher than the 25.5% observed in women without co-infection (p-value <0.001). Additionally, lack of access to clean water was reported by 66.7% of those with co-infection compared to 33.3% of those without, showing a strong association (p-value <0.001).

These findings highlight that age, gravidity, socioeconomic status, history of UTIs, and access to clean water are significant risk factors for co-infection with malaria and UTI among pregnant women in this population (Table 2).

Table 2: Demographic Characteristics of Study Population

Characteristic	Co-infection (N=90)	No Co-infection (N=510)	p-value
Age > 30	50 (55.6%)	150 (29.4%)	<0.001
Gravidity > 2	60 (66.7%)	200 (39.2%)	<0.001
Low socio-economic	70 (77.8%)	150 (29.4%)	<0.001
History of UTIs	55 (61.1%)	130 (25.5%)	<0.001
Lack of access to clean water	60 (66.7%)	170 (33.3%)	<0.001

Risk Factors for Co-infection

The analysis of risk factors for co-infection with malaria and urinary tract infection (UTI) reveals several significant associations. Age greater than 30 years was associated with a 2.8 times higher risk of co-infection (OR: 2.8, 95% CI: 1.9 – 4.2, p-value <0.001). Low income significantly increased the risk, with an odds ratio of 3.1 (95% CI: 2.1 – 4.6, p-value <0.001). Similarly, low educational level (OR: 2.4, 95% CI: 1.6 – 3.7, p-value <0.001) and poor sanitation (OR: 2.7, 95% CI: 1.8 – 4.0, p-value <0.001) were strongly associated with co-infection.

Lack of access to clean water also posed a significant risk (OR: 2.9, 95% CI: 1.9 – 4.4, p-value <0.001), as did limited access to prenatal care (OR: 2.5, 95% CI: 1.6 – 3.9, p-value <0.001) and distance to healthcare facilities (OR: 1.7, 95% CI: 1.1 – 2.6, p-value = 0.022). Delayed or infrequent antenatal visits were associated with a 2.2 times higher risk of co-infection (OR: 2.2, 95% CI: 1.4 – 3.3, p-value <0.001).

A history of urinary tract infections increased the risk by 2.6 times (95% CI: 1.7 – 3.9, p-value <0.001), and previous episodes of malaria also posed a significant risk (OR: 2.1, 95% CI: 1.4 – 3.2, p-value <0.001). The presence of other chronic diseases was associated with an increased risk (OR: 1.9, 95% CI: 1.2 – 3.0, p-value = 0.008), as were malnutrition or under nutrition (OR: 2.4, 95% CI: 1.6 – 3.6, p-value <0.001) and poor personal hygiene (OR: 1.9, 95% CI: 1.2 – 3.0, p-value = 0.006).

Additionally, the use of traditional medicines (OR: 1.7, 95% CI: 1.1 – 2.7, p-value = 0.024) and occupational exposure to mosquitoes (OR: 2.1, 95% CI: 1.3 – 3.3, p-value = 0.003) were significant risk factors. Occupational exposure with limited restroom access also increased the risk (OR: 1.8, 95% CI: 1.1 – 2.9, p-value = 0.018) as presented in Table 3

Table 3: Risk Factors for Co-infection with Malaria and UTI

Risk Factor	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Age > 30 years	2.8	1.9 – 4.2	<0.001
Low income	3.1	2.1 – 4.6	<0.001
Low educational level	2.4	1.6 – 3.7	<0.001
Poor sanitation	2.7	1.8 – 4.0	<0.001
Lack of access to clean H_2O	2.9	1.9 – 4.4	<0.001
Limited access to prenatal care	2.5	1.6 – 3.9	<0.001
Distance to healthcare facilities	1.7	1.1 – 2.6	0.022
Delayed/infrequent antenatal visits	2.2	1.4 – 3.3	<0.001
History of urinary tract infections	2.6	1.7 – 3.9	<0.001
Previous episodes of malaria	2.1	1.4 – 3.2	<0.001
Presence of other chronic diseases	1.9	1.2 – 3.0	0.008
Malnutrition or under nutrition	2.4	1.6 – 3.6	<0.001
Poor personal hygiene	1.9	1.2 – 3.0	0.006
Use of traditional medicines	1.7	1.1 – 2.7	0.024
Occupational exposure to mosquitoes	2.1	1.3 – 3.3	0.003
Occupational exposure with limited restroom access	1.8	1.1 – 2.9	0.018

Frequency of Isolation of Organisms in Pregnant Women

The distribution of isolated organisms in pregnant women indicates a diverse range of bacterial pathogens. *Escherichia coli* was the most prevalent, accounting for 42.3% (22 out of 52) of the positive samples, suggesting it is a primary causative agent of urinary tract infections (UTIs) in this population. *Staphylococcus aureus* was the second most common isolate, found in 28.8% (15 out of 52) of the samples, highlighting its significant role in these infections. *Klebsiella aerogenes* was present in 19.2% (10 out of 52) of cases, while *Pseudomonas aeruginosa* accounted for 5.8% (3 out of 52). Mixed cultures of *Klebsiella* and *Staphylococcus* spp. were detected in 3.9% (2 out of 52) of the samples (Table 4). These findings underscore the importance of considering a broad spectrum of bacterial pathogens when diagnosing and treating UTIs in pregnant women.

Table 4: Frequency of Isolation of Organisms in Pregnant Women

Isolates	No. of Positive Samples (%)
Escherichia coli	22 (42.3)
Staphylococcus aureus	15 (28.8)
Klebsiella aerogenes	10 (19.2)
Pseudomonas aeruginosa	3 (5.8)
Mixed cultures*: Klebsiella & Staphylococcus spp.*	2 (3.9)
Total	**52(100.0)**

The antimicrobial susceptibility patterns of bacterial isolates from UTI cases in co-infected women reveal significant variability in response to different antibiotics. Ciprofloxacin exhibited the highest effectiveness, with 80% of isolates being susceptible, while 15% were resistant and 5% showed intermediate susceptibility. Ceftriaxone also demonstrated high efficacy, with 85% of isolates being susceptible, 10% resistant, and 5% intermediate.

Nitrofurantoin had 70% susceptibility, indicating it is fairly effective, although 20% of isolates were resistant and 10% were intermediate. Amoxicillin showed moderate effectiveness with 55% susceptibility, but a substantial resistance rate of 35% and 10% intermediate.

Trimethoprim-sulfamethoxazole had the lowest susceptibility rate at 45%, equal to its resistance rate of 45%, and 10% of isolates exhibited intermediate susceptibility. These results suggest that while ciprofloxacin and ceftriaxone are the most effective antibiotics for treating UTIs in co-infected women, the high resistance rates for amoxicillin and trimethoprim-sulfamethoxazole warrant cautious use and consideration of alternative treatments (Table 5)

Table 5: Antimicrobial Susceptibility Patterns of Bacterial Isolates

Antibiotic	% Susceptible	% Resistant	% Intermediate
Ciprofloxacin	80	15	5
Amoxicillin	55	35	10
Nitrofurantoin	70	20	10
Ceftriaxone	85	10	15
Trimethoprim Sulfamethoxazole	45	45	10

Discussion

The findings from this study highlight the notable prevalence of co-infection with malaria and urinary tract infection (UTI) among outpatient pregnant women. Out of the 600 women screened, 90 (15%) presented with both infections, indicating that co-infection is a significant health concern in this population. These results are consistent with past studies, which have also documented the prevalence and impact of co-infection in pregnant women, emphasizing the need for integrated healthcare strategies (Ezenwa, 2021; Lebu *et al*., 2023). The 15% prevalence of co-infection observed in this study aligns with similar findings from other regions. For instance, studies conducted in sub-Saharan Africa have reported co-infection rates ranging from 10% to 20% among pregnant women, depending on geographical and socio-economic factors (Ezenwa, 2021; Lebu *et al*., 2023). These rates underscore the endemic nature of both malaria and UTIs in areas with limited healthcare resources and highlight the compounded risk faced by pregnant women in such settings.

The higher prevalence of UTI alone (25%) compared to malaria alone (20%) in our study population suggests that UTIs are a more common single infection. This is consistent with findings by Foxman (2010), who noted that UTIs are the most common bacterial infections in women. Pregnancy increases the susceptibility to UTIs due to physiological changes such as haemostasis and immune modulation, which could explain the higher incidence in this group. The significant co-infection rate among pregnant women has important clinical implications. Co-infections can exacerbate the health risks associated with each condition independently. In this study, malaria in pregnancy is the cause of severe anaemia, low birth weight, and increased perinatal mortality and it agrees with the study carried out by (Kwizera *et al*., 2021). Similarly, in this study UTIs also lead to complications such as pyelonephritis, preterm labor, and foetal growth restriction which corroborate the work of (Sharifi-Mood, 2015). The presence of both infections concurrently could potentially magnify these adverse outcomes, stressing the need for vigilant screening and management protocols.

In this study, risk factors associated with co-infection could include poor socio-economic status, inadequate access to healthcare, lack of proper sanitation, and limited health education and also in addressing these risk factors through community health initiatives, improving access to clean water and sanitation, and enhancing healthcare infrastructure can help reduce the incidence of these infections, the study is in an agreement with the study of (Masaku *et al*., 2024). The evaluation of antimicrobial susceptibility patterns of bacterial isolates from UTI cases in this study is crucial for guiding effective treatment and agrees with previous studies that reported increasing resistance rates among common uropathogens, complicating the management of UTIs by (Kot, 2019). Our findings should be compared with regional antimicrobial resistance patterns to ensure the selection of appropriate antibiotics. The development of local antibiograms can support tailored treatment regimens, improving outcomes for pregnant women with co-infections.

The impact of co-infection on pregnancy outcomes and maternal health cannot be overstated. Co-infected women are at higher risk of adverse outcomes, including severe anaemia, preterm birth, and intrauterine growth restriction. These complications not only affect maternal health but also have long-term implications for the neonate's health and development. It is essential to integrate maternal health programs with infectious disease control measures to mitigate these risks.

The demographic characteristics of the study population reveal significant differences between those with co-infection (n=90) and those without co-infection (n=510). Age greater than 30 years was significantly more common in the co-infection group (55.6%) compared to the no co-infection group (29.4%), with a p-value of <0.001. This indicates that older age is a significant risk factor for co-infection, potentially due to the cumulative exposure to risk factors and a decline in immune function with age. Similarly, higher gravidity (greater than 2 pregnancies) was more prevalent among those with co-infection (66.7%) compared to those without (39.2%), also with a p-value of <0.001.

This finding suggests that repeated pregnancies may increase the susceptibility to infections, possibly due to the physiological and immunological changes associated with multiple pregnancies and is in agreement the study of (Deshmukh and Way, 2019).

Low socioeconomic status was markedly more frequent in the co-infection group (77.8%) compared to the no co-infection group (29.4%), indicating a significant association (p-value <0.001). This highlights the impact of socioeconomic factors on health, where limited access to healthcare, poor living conditions, and inadequate nutrition may contribute to higher infection rates. A history of urinary tract infections was present in 61.1% of women with co-infection, significantly higher than the 25.5% observed in women without co-infection (p-value <0.001). This suggests that a prior history of UTIs increases the risk of subsequent infections, possibly due to the persistence of uropathogenic bacteria or recurrent exposure to risk factors.

Additionally, lack of access to clean water was reported by 66.7% of those with co-infection compared to 33.3% of those without, showing a strong association (p-value <0.001). This underscores the critical role of clean water in preventing infections and highlights the need for improving water quality and sanitation to reduce the burden of co-infections. These findings highlight that age, gravidity, socioeconomic status, history of UTIs, and access to clean water are significant risk factors for co-infection with malaria and UTI among pregnant women in this population.

The analysis of risk factors for co-infection with malaria and urinary tract infection (UTI) reveals several significant associations. Age greater than 30 years was associated with a 2.8 times higher risk of co-infection (OR: 2.8, 95% CI: 1.9–4.2, p-value <0.001). Low income significantly increased the risk, with an odds ratio of 3.1 (95% CI: 2.1–4.6, p-value <0.001). Similarly, low educational level (OR: 2.4, 95% CI: 1.6–3.7, p-value <0.001) and poor sanitation (OR: 2.7, 95% CI: 1.8–4.0, p-value <0.001) were strongly associated with co-infection. Lack of access to clean water also posed a significant risk (OR: 2.9, 95% CI: 1.9–4.4, p-value <0.001), as did limited access to prenatal care (OR: 2.5, 95% CI: 1.6–3.9, p-value <0.001) and distance to healthcare facilities (OR: 1.7, 95% CI: 1.1–2.6, p-value = 0.022). Delayed or infrequent antenatal visits were associated with a 2.2 times higher risk of co-infection (OR: 2.2, 95% CI: 1.4–3.3, p-value <0.001).

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The antimicrobial susceptibility patterns of bacterial isolates from UTI cases in co-infected women reveal significant variability in response to different antibiotics. Ciprofloxacin exhibited the highest effectiveness, with 80% of isolates being susceptible, while 15% were resistant and 5% showed intermediate susceptibility.

Ceftriaxone also demonstrated high efficacy, with 85% of isolates being susceptible, 10% resistant, and 5% intermediate. These results indicate that both ciprofloxacin and ceftriaxone are effective choices for treating UTIs in co-infected pregnant women, with a relatively low resistance rate.

Nitrofurantoin had a 70% susceptibility rate, indicating it is fairly effective, although 20% of isolates were resistant and 10% showed intermediate susceptibility. Amoxicillin showed moderate effectiveness with a 55% susceptibility rate, but a substantial resistance rate of 35% and 10% intermediate susceptibility. Trimethoprim-Sulfamethoxazole had the lowest susceptibility rate at 45%, equal to its resistance rate, and 10% of isolates exhibited intermediate susceptibility. These findings suggest that while ciprofloxacin and ceftriaxone are reliable choices, caution should be exercised with amoxicillin and Trimethoprim-Sulfamethoxazole due to higher resistance rates, necessitating consideration of alternative treatment options.

Conclusion/Recommendation

1. The main findings indicate that co-infection with malaria and urinary tract infection (UTI) among pregnant women is associated with higher rates of adverse pregnancy outcomes compared to non-co-infected women.
2. These outcomes include increased occurrences of preterm birth, low birth weight infants, maternal anaemia, and neonatal mortality. In the co-infection group (n=90), 22.2% experienced preterm births, compared to 7.8% in the non-co-infection group (n=510). Similarly, 27.8% of infants born to co-infected women had low birth weights, compared to 9.8% in the non-co-infected group.
3. Maternal anaemia was prevalent in 38.9% of co-infected women versus 13.7% in non-co-infected women. Neonatal mortality rates were also higher among co-infected women at 5.6%, compared to 2.0% in the non-co-infected group. These statistics underscore the profound impact of co-infection on maternal and neonatal health outcomes (Deo, 2023).
4. The relationship between antimicrobial resistance patterns and adverse pregnancy outcomes in this study highlights the importance of effective treatment strategies for managing co-infections during pregnancy. Optimal antibiotic choices, such as ciprofloxacin and ceftriaxone, can significantly influence outcomes by reducing the risk of maternal complications and improving neonatal health according to (Miao *et al*., 2024).

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