

Urinary Tract Infection: Prevalence, Malaria Co-Infection and Significance for Febrile Under-Fives in Jos North, Nigeria

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ABSTRACT

Background: Urinary tract infections (UTI) are common causes of fever in children frequently misdiagnosed in malaria-endemic, resource-poor regions. **Objectives:** This study assessed the prevalence of UTI, and UTI-malaria co-infection, and associated factors, among febrile children aged 2 to 59 months in Jos North, Plateau state, Nigeria. **Materials and Methods:** This was a cross-sectional study of 247 children presenting with fever to healthcare facilities in Jos north. Participants' data were collected using a semi-structured questionnaire. Diagnosis of UTI was based on urine culture while malaria detection utilized rapid diagnostic tests. **Results:** The prevalence of UTI was 18.2% and the most common pathogens were *Escherichia coli* (62.2%) and *Klebsiella* species (22.2%). UTI-malaria co-infection occurred in 4.5% of the participants, accounting for 24.4% of the UTI cases. Significant associations were found between the occurrence of UTI, female gender and predominant breastfeeding type. UTI occurred more frequently than malaria as an isolated cause of fever (13.8% vs 4.9%). **Conclusion:** This study indicates a substantial burden of UTI among febrile under-five children, which may go unrecognized in favour of malaria diagnosis. Gender differences inform implications for diagnostic focus and healthcare practices. Breastfeeding appeared protective against UTI, and co-infection with malaria highlights the need for comprehensive febrile illness management to prevent potential complications.

Keywords: Fever, Nigeria, Under-five children, Urinary tract infection, UTI-malaria co-infection.

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INTRODUCTION

Febrile illnesses account for the highest mortality rates among admissions to children's emergency rooms in Nigeria and fever remains the most common symptom that prompts parents/care-givers to bring their children to the hospital.[1] The 2018 Nigeria Demographic and Health Survey found that 24% of children younger than five years had fever weeks prior to the survey with regional disparities in the treatment-seeking behaviour of parents/caregivers.[2] The proportion who sought advice or treatment for their febrile children was as high as 82% in the south-south geopolitical zone and as low as 59% in the north-central part of the country.[2] Fever is an adaptive mechanism of the body to a disease condition which can be beneficial through its ability to stimulate the production of leucocytes and hinder the growth of organisms in the blood.[3] There are many causes of fever in children categorized as infective or non-infective.

Urinary tract infection (UTI) is an infective cause of fever and a common cause of morbidity in children of all ages with varying prevalence according to age. Sites of infection range from the kidneys, through the ureters, the bladder down to the urethra. UTI distresses the child, concerns the parents and may cause permanent kidney damage as it is considered a risk factor for the development of renal insufficiency or end-stage renal disease in young children.[4,5] The global paediatric prevalence of UTI ranges from 2–20%.[6] Its prevalence among school-aged children in Bangladesh was 14.7%.[7] It affects up to 2.8% of children in the USA annually with infants presenting with fever having a prevalence of 7%.[4] The prevalence of UTI in under-five children also varies in Nigeria, as low as 4.6% in Jos,[8] 11% in Enugu,[9] and as high as 36.7% in Port Harcourt.[10].

The occurrence of UTI in childhood varies with age, gender and circumcision status. [11] Most UTI occur during the first year of life due to the relatively lower immunity of infants that generally makes them more easily susceptible to infection. The age of onset of childhood UTI has a bimodal distribution with one peak in the first year of life and a second between the ages of 2 and 4 years which corresponds to the age of toilet training in children.[12] Male children are less likely to have a UTI compared to female children because of the longer urethra in males compared to females, however, the presence of the prepuce contributes to the increased occurrence of

UTI in uncircumcised males with a prevalence rate of 20% in infants with fever[5,13]. The symptoms of UTI are often non-specific, mimicking other infectious diseases such as malaria. Fever is perhaps the most common symptom seen in these children while infants usually present with poor feeding and irritability.[5,14,15] Therefore, in Nigeria and other tropical countries where malaria is endemic, UTI may not be diagnosed or even considered as a differential diagnosis and children presenting with fever are treated for malaria,[16] putting such children at risk of complications of untreated UTI such as renal scarring and chronic renal disease that may necessitate frequent hospital admissions, renal dialysis and exert a tremendous toll on the quality of life and finances of the affected child and their family. The exact burden of UTI-malaria coinfection in Nigeria remains uncertain, [17] and there are varying results from previous studies. For example, a prevalence of UTI-malaria co-infection of 9% was reported in Benin city,[17] while 21.4% was previously reported in Jos.[8]

Urinary tract infection is diagnosed using a combination of microscopy, culture and biochemical analysis of a mid-stream, clean-catch urine sample or supra-pubic tap of a full bladder or through catheterization of the urethra. [18] Diagnosis can be challenging as a result of difficulty in collecting mid-stream urine samples in children especially in infants and non-specific symptoms observed in infants and toddlers.

Nigeria's under-five mortality rate of 844 per 1000 live births is the highest in the world. Sadly, the country is not on target to achieving Sustainable Development Goal 3.2.1 which is to reduce under-5 mortalities to at least as low as 25 per 1000 live births by 2030. [19] Achieving this goal would require, among other approaches, addressing major causes of child morbidity and mortality including UTI. Evidence of the prevalence of UTI in childhood and its associated factors will enable clinicians in Nigeria be more proactive in routinely screening every under-five child who presents with fever for UTI and not just focus on malaria as the sole cause of fever in this age group. This study is of critical public health importance given Nigeria's alarmingly high under-five mortality rate and the country's lag in achieving Sustainable Development Goal 3.2.1. In the Jos metropolis, where malaria is endemic and care-seeking for febrile illness has declined significantly, [20] the risk of misdiagnosing or overlooking non-malarial causes of fever such as

UTI is high. The overlapping clinical presentations of UTI and malaria, coupled with limited diagnostic capacity, often results in presumptive malaria treatment and delayed recognition of UTI. These diagnostic gaps have serious implications for child survival, as untreated UTI can lead to renal damage, chronic illness, and increased healthcare burden. By generating evidence on the prevalence of UTI and malaria co-infection in febrile under-five children in Jos, this study provides valuable data to inform clinical decision-making, promote rational antibiotic use, and support the design of context-specific interventions to improve child health outcomes.

This study therefore aimed to determine the prevalence of UTI, its coexistence with malaria and associated factors among febrile children aged 2 to 59 months in Jos north, Nigeria. It seeks to inform evidence-based clinical practices and raise awareness among healthcare providers, encouraging a heightened suspicion of UTI in febrile children presenting to clinics or hospitals. By advocating for the proactive collection of mid-stream urine samples for laboratory analysis, clinicians can enhance their diagnostic accuracy and promptly address UTIs in this vulnerable population. Ultimately, the research aimed to contribute to improved patient care and outcomes by facilitating early detection and intervention for UTIs in young children.

MATERIALS AND METHODS

Study Location

This study was carried out in Jos North, one of the 17 LGAs in Plateau State of Nigeria. The state is located in north-central Nigeria between latitude 8°24'N and longitude 8°32' and 10°38' east, covering an area of 26,899 square kilometres and had an estimated population of 4.9 million people in 2022. It exhibits an endemic and perennial pattern of malaria transmission with 7 to 12 months of suitable climate.[21] Plateau State accounted for 2.0% of Nigeria's 68 million malaria cases in 2021 while care-seeking among children with fever in the State decreased from 78.6% in 2015 to 52.7% in 2021.[20] Jos North is an urban LGA and has 72 healthcare facilities, comprising 33 public (28 primary, 3 secondary and 2 tertiary) and 39 private (28 primary, 9 secondary and 2 tertiary) health care facilities in Jos North LGA.[22]

Study Design and Population

This was an analytical cross-sectional study. We included children aged 2 months to 59 months who presented with a history of fever or axillary

temperature above 37.4°C within two weeks prior to presentation to five selected health care facilities in Jos North from June 2019 to February 2020. Children who had a chronic illness such as sickle cell disease, human immune deficiency virus, any structural abnormality of the urinary system including hypospadias, post-ureteral valve or were on a follow-up visit to the hospital for any illness were excluded from the study.

Sample Size and Sampling Technique

The minimum sample size for the study was 247, calculated using the formula: [23]

$$n = \frac{Z^2(pq)}{d^2}$$

Where z is the standard normal deviate, 1.96 which corresponds to 95% confidence limits, p is the prevalence of fever, 20.17%, among children in Jos North L.G.A.,[24] q is the complement of p and d is the margin of error, 0.05.

We employed a multistage sampling technique to select eligible participants for the study. First, Jos North was selected from Jos metropolis by simple random sampling. Then, five health facilities: four primary health care (PHC) centres and one private hospital (PHC Vanderpuye, PHC Lamingo, PHC Township, PHC Kwanga B and Marysol hospital) were randomly selected from the list of health facilities in Jos North. The sample size was then equally allocated to the health facilities; 49 children recruited from each PHC and 51 from the private hospital. Children who met the eligibility criteria were consecutively sampled until the sample size was achieved.

Study instruments and materials

A proforma was used to document each child's urine and blood laboratory analysis results and a semi-structured questionnaire used to collect data on each child and their caregiver. The questionnaire comprised three sections; section A covered the child's personal data (age, gender, breastfeeding type, duration of fever, type of antipyretic given, use of insecticide-treated nets, and history of any structural and/or functional urogenital anomaly. Section B covered the parent/caregiver's data (age, gender, relationship to the child and occupation) and section C covered the clinical and laboratory assessment of the child (temperature, malaria RDT, urine microscopy and culture results). Pre-testing of the questionnaire yielded a Cronbach alpha of 0.76.

Materials used for laboratory analysis of urine and malaria blood samples obtained from the children include (a) cystine lactose electrolyte deficient (CLED) agar and nutrient (blood) agar for urine cultures done to confirm the diagnosis of urinary tract infection. A colony count of ≥ 105 on CLED signified the presence of a UTI which was then further investigated using urease test, oxidase test, motility and TSI tests to identify the specific organism causing the UTI depending on their colour changes. (b) SD Bioline™ Malaria Antigen *Plasmodium falciparum* (P.f) rapid diagnostic test (RDT) done to identify the presence of *Plasmodium falciparum* antigen indicated by the presence of two-line strips for which one line must be for the control indicator. Other equipment included a microscope, sterile urine sample bottles, sterile pipettes, and free glass slides with cover slips.

Ethical Considerations

Written informed consent was obtained from the parents/caregivers on behalf of the children prior to obtaining their data. They were fully informed of the study procedure, risk and benefits in either English or the local language. Furthermore, they were assured of their voluntary participation, confidentiality of their data and their right to withdraw from the study without incurring any negative consequence. All identifiable information was removed from the data collected and participants were assigned a unique identifier to maintain confidentiality. The collected data was stored securely on a password-protected laptop computer and an encrypted external hard drive, accessible to only authorized personnel. Feedback was given to the attending clinician for every participant who had a positive UTI result for appropriate treatment and/or referral.

Data Collection

Data was collected by the principal researcher and trained research assistants. Nine research assistants were trained for the study: two from each health facility comprising one laboratory technician and one nurse except for one of the PHCs which had only a nurse in the centre. The nurses were trained on proper measurement of children's temperature and how to pass a urine catheter for collecting urine samples in infants while maintaining strict rule of aseptic procedure. Each laboratory technician along with the nurses were trained on how to collect clean mid-stream urine samples in children which they

stepped down to the parents/caregivers. They were also retrained on how to test for malaria using the RDT.

The questionnaire was interviewer-administered to each consenting parent/caregiver by the research assistants. For the urine samples, the parent/caregiver was asked to clean the area around the vulva of a female child from front to back using Savlon® antiseptic liquid while for a male child, the tip of the penis was cleaned with Savlon® prior to urine collection. Ten millilitre mid-stream clean-catch urine or urine catheter samples were collected in sterile urine specimen bottles from each participant, labelled appropriately and sent to the Jos University Teaching Hospital (JUTH) microbiology laboratory for analysis in a cooling pack within one hour of collection. For the blood samples, sterile gauze was used to wipe the left thumb of the children. A new lancet was used to prick the swabbed skin and about five microliters of blood collected using a blood capillary tube; the blood was immediately inserted in the square hole for blood on the properly labelled RDT kit for each participant.

Laboratory Procedures

Each urine sample was evaluated macroscopically for colour, cloudiness, clarity and odour. A sample of urine was placed in a sterile corkscrew container and inoculated on the culture media. Using a sterile wire loop flamed over a Bunsen burner, the urine was touched and streaked on CLED agar and blood agar respectively. Immediately after inoculation, the urine was spun at 1000rpm, the supernatant discarded and the sediment of the spun urine was placed on a glass slide, covered with a cover slip and then viewed at $\times 40$ for pus cells and epithelial cells. Both plates of CLED agar and blood agar were incubated aerobically at 35-37°C over 16 to 18 hours. Thereafter, gram staining was performed on the colonies that grew for organism identification and the colonies were counted on the CLED agar for estimation of significant bacteria indicated as colony count ≥ 105 . Biochemical analysis was also done to speciate the specific organisms that grew in the culture medium. These include the citrate utilization test, indole test, urease test and oxidase test for gram negative organisms while catalase and coagulase tests were performed for gram positive organisms. SD Bioline™ Malaria Antigen P.f RDT was used to detect the presence of the histidine-rich protein II antigen of *Plasmodium falciparum* in the blood samples. Each 5-microliter blood sample was

dropped in the sample port of a RDT kit properly labelled for each participant. Four drops of the buffer solution were then squeezed into the buffer port of the RDT kit and the result was interpreted after 20 minutes.

Data Management

The primary outcome variable for the study was presence of UTI, measured as a dichotomous variable with the categories 'positive' or 'negative'; positive being identification of significant growth of organisms (colony count $\geq 10^5$) isolated on urine culture and negative being, non-significant or no growth of organism seen on culture. The presence of malaria, as determined by RDT, was also measured as a dichotomous variable as either 'positive' or 'negative'. The presence or absence of white blood cells and pus cells on urine microscopy were also determined and measured as dichotomous variables. Sociodemographic covariates included age of child (in months), age of caregiver (in years), sex of child (male/female), relationship of caregiver with child (mother/father/guardian), marital status of the caregiver (married/single/separated/widowed), mother and father's educational level (no formal education/primary/secondary/tertiary), whether the child was breastfed (yes/no), type of breastfeeding given (exclusive/mixed/predominant), whether an antipyretic was given for fever on presentation (yes/no) and the type of antipyretic given. Statistical analysis was done using IBM- Statistical Package for the Social Sciences version 25. Descriptive statistics were used to summarise the participant

characteristics. Frequencies and percentages were used for categorical variables, while mean and standard deviations were reported for continuous variables. Where the parameters were skewed, median and interquartile range was used instead. Pearson chi-square and Fisher's exact tests of significance were used to determine associations between categorical variables. Statistical significance was set at a p value < 0.05 .

RESULTS

Sociodemographic Characteristics of the Study Participants

The sociodemographic data of the 247 children who participated in the study are presented in Table 1. The median age of the children was 36 months (interquartile range of 24 - 48) months. Children aged 36–47 months were predominant (27.5%) while those less than 12 months constituted 7.7% of the study sample. There were more females (53.4%) than males (46.6%). Most of the caregivers who brought their children to the hospital were in the 21–40 years age group (79%) with a mean age of 30.8 ± 8.1 and mothers made up the majority of caregivers (67.2%) who brought their febrile child to the health facility. Majority of the mothers (93.1%) and 89.9% of the fathers had attained secondary level education or higher. Several of the mothers were employed outside the home as civil servants (26.7%), and business/shop owners (49.0%). A large proportion of the fathers (69.1%) were also either civil servants or business owners.

Table 1: Sociodemographic characteristics of 247 febrile children aged 2–59 months in Jos north, Nigeria

Characteristic	Frequency	Percentage
Age of child (months)	<12	7.7
	12 – 23	13.8
	24 – 35	22.3
	36 – 47	27.5
	48 – 59	28.7
	Minimum	4
	Maximum	59
Sex of child	Median [IQR]	36 [24 – 48]
	Male	46.6
	Female	53.4
Age of caregivers (years)	≤ 20	9.7
	21 – 30	39.3
	31 – 40	40.5
	> 40	10.5
	Mean $\pm$ SD	30.8 ± 8.1
Relationship of caregiver with child	Mother	67.2
	Father	8.9
	Guardian	23.9
Marital status of caregiver	Single	6.1
	Married	91.1
		2.8

	Other (separated, widowed)		
Mother's educational level	Primary	17	6.9
	Secondary	119	48.2
	Tertiary	111	44.9
Mother's occupation	Banker	15	6.1
	Civil servant	66	26.7
	Business	121	49.0
	Housewife	32	13.0
	Other (student, farmer)	13	5.2
Father's educational level	Primary	25	10.1
	Secondary	96	38.9
	Tertiary	126	51.0
Father's occupation	Civil servant	112	45.3
	Business	59	23.9
	Farmer	24	9.7
	Artisan	23	9.3
	Banker	15	6.1
	Other (student, clergy, driver, security)	14	5.7

Breastfeeding History and Use of Insecticide Treated Net and Antipyretics

Table 2 shows the participants' breastfeeding history, use of insecticide-treated nets and whether they received antipyretic medication prior to presentation. Majority of the children (79.6%) were exclusively breast-fed and 76.1% slept under insecticide-treated nets at night and 60.3% did not receive any anti-pyretic prior to presentation to the health facility. Those who received an antipyretic were more commonly treated with paracetamol (96.9%). Ibuprofen was given to only three children (3.1%).

Table 2: Breastfeeding history, use of insecticide treatment nets and treatment with antipyretic prior to presentation among 247 febrile children aged 2–59 months in Jos north, Nigeria

Variable		Frequency	Percentage
Was the child breastfed?	Yes	244	98.8
	No	3	1.2
Type of breastfeeding (n = 244)	Exclusive	194	79.6
	Mixed	25	10.2
	Predominant	25	10.2
Use of insecticide-treated nets	Yes	188	76.1
	No	59	23.9
Antipyretic given for fever prior to presentation	Yes	98	39.7
	No	149	60.3
Medication given (n=98)	Paracetamol	95	96.9
	Ibuprofen	3	3.1

Distribution of urine culture and malaria rapid diagnostic test results

Urine culture was positive in 45 children giving a UTI prevalence of 18.2% (Figure 1). Twenty-three children (9.3%) had positive *Plasmodium falciparum* RDTs (Figure 2)

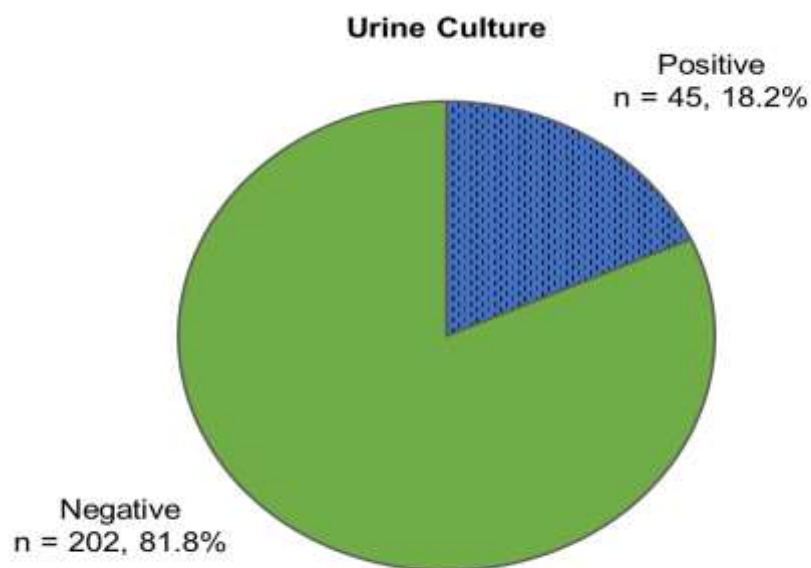


Figure 1: Distribution of Urine Culture Results in 247 Febrile Children Aged 2–59 Months in Jos north, Nigeria.

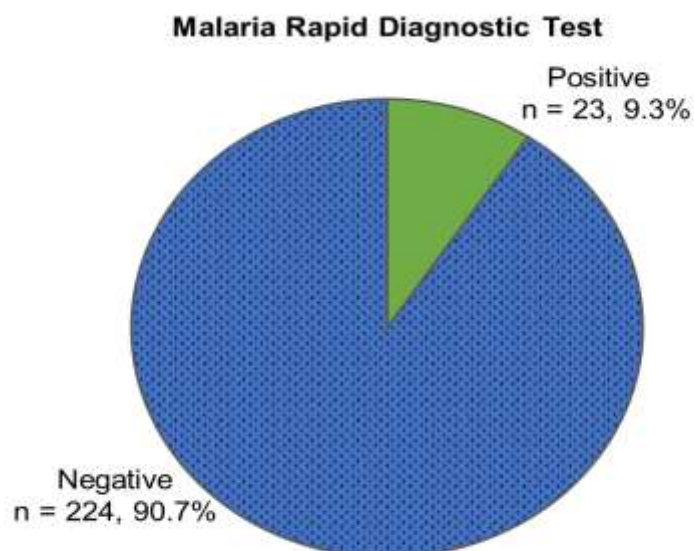


Figure 2: Distribution of Malaria Rapid Diagnostic Test Results in 247 Febrile Children Aged 2–59 Months in Jos north, Nigeria.

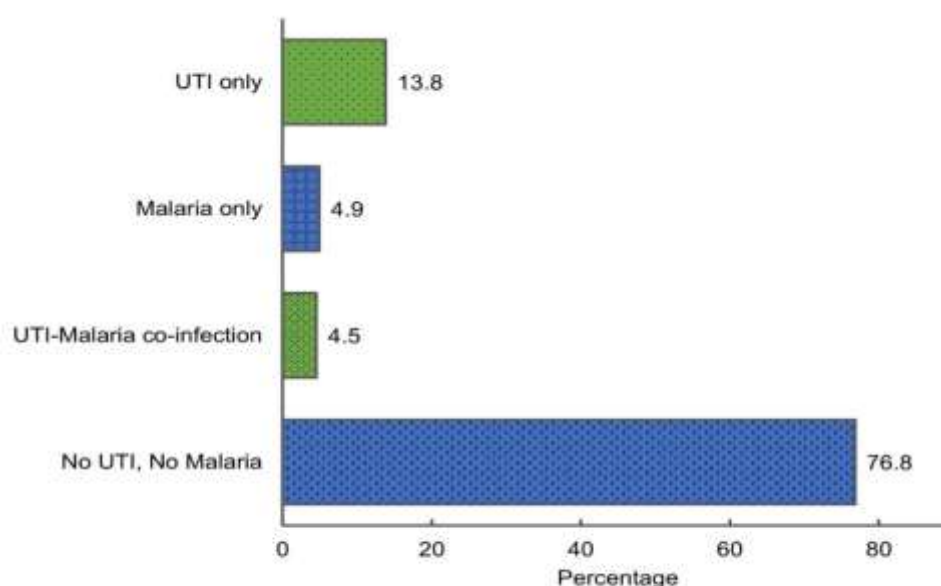
The most frequently isolated pathogen was *Escherichia coli* in 28 samples (62.2%), followed by *Klebsiella spp.* found in 10 samples (22.2%). *Proteus mirabilis* and *Staphylococcus aureus* were each found in three samples (6.7%) respectively and lastly *Acinetobacter spp.* was isolated from only one urine sample (2.2%) (Table 3).

Table 3: Microscopy results and bacteria isolated on culture of 45 positive urine specimens among 247 febrile children aged 2–59 months in Jos metropolis, Nigeria

Variable		Frequency	Percentage
Microscopy result	Normal	22	48.9
	Pus cells	21	46.7
	Pus cells, turbid	2	4.4
Organisms	Escherichia coli	28	62.2
	Klebsiella spp	10	22.2
	Proteus mirabilis	3	6.7
	Staphylococcus aureus	3	6.7
	Acinetobacter spp	1	2.2

Pattern of UTI and Malaria in the Study Population

Figure 3 shows the pattern of UTI and malaria in the study sample. The prevalence of UTI-malaria co-infection overall was 4.5%, accounting for 24.5% of all UTI cases among the participants. Urinary tract infection without malaria was observed in 13.8% of the febrile children while malaria without a UTI was seen in only 4.9%. Majority of the febrile children (76.8%) had no laboratory evidence of either a UTI or malaria.

**Figure 3:** Pattern of urinary tract infection and malaria among 247 febrile children aged 2–59 months in Jos metropolis, Nigeria.

Factors associated with the occurrence of urinary tract infection

Table 4 summarizes the analysis of the relationships between selected factors and the occurrence of UTI in the febrile children. The occurrence of UTI was highest in the 12–23 months age group (32.4%) although the association was not significant ($\chi^2 = 5.895$, $p = 0.207$). Female sex was significantly associated with occurrence of UTI, ($\chi^2 = 6.064$, $p = 0.014$) as well as predominant breast-feeding, ($\chi^2 = 7.958$, $p = 0.019$). The occurrence of UTI was least among children exclusively breastfed (15.5%) compared to those who had mixed feeding (20.0%) and who were predominantly breastfed (40.0%). A higher proportion of females (24.2%) than males (11.3%) had UTI. All other caregiver and parental characteristics were not significantly associated with occurrence of UTI in the study sample.

Table 4: Association between selected factors and occurrence of urinary tract infection in 247 children aged 2–59 months in Jos north, Nigeria

Variable		UTI		χ^2	p-value
		Negative (n = 202)	Positive (n = 45)		
Child's age (months)	<12	16 (84.2)	3 (15.8)	5.895	0.207
	12 – 23	23 (67.6)	11 (32.4)		
	24 – 35	46 (83.6)	9 (16.4)		
	36 – 47	59 (86.8)	9 (13.2)		
	48 – 59	59 (81.7)	13 (18.3)		
Sex	Male	102 (88.7)	13 (11.3)	6.064	0.014*
	Female	100 (75.8)	32 (24.2)		
Was the child breastfed?	Yes	199 (81.6)	45 (18.4)	0.677 ^F	1.000
	No	3 (100.0)	0 (0.0)		
Type of breastfeeding (n = 244)	Exclusive	164 (84.5)	30 (15.5)	7.958 ^F	0.019*
	Mixed	20 (80.0)	5 (20.0)		
	Predominant	15 (60.0)	10 (40.0)		
Age of care giver (years)	≤20	20 (83.3)	4 (16.7)	1.034 ^F	0.792
	21–30	78 (80.4)	19 (19.6)		
	31–40	84 (84.0)	16 (10.0)		
	>40	20 (76.9)	6 (23.1)		
Relationship of caregiver with child	Father	18 (81.8)	4 (18.2)	1.117 ^F	0.606
	Mother	133 (80.1)	33 (19.9)		
	Guardian	51 (86.4)	8 (13.6)		
Marital status of caregiver	Single	13 (86.7)	2 (13.3)	0.186 ^F	1.000
	Married	183 (81.3)	42 (18.7)		
	Separated/widowed	6 (85.7)	1 (14.3)		
Mother's educational level	Primary	14 (76.5)	4 (23.5)	0.905 ^F	0.657
	Secondary	96 (80.7)	23 (19.3)		
	Tertiary	93 (83.8)	18 (16.2)		
Mother's occupation	Civil servant	55 (83.3)	11 (16.7)	8.213 ^F	0.110
	Business	99 (81.8)	22 (18.2)		
	Housewife	23 (71.9)	9 (28.1)		
	Banker	15 (100.0)	0 (0.0)		
	Other (student, farmer)	10 (76.9)	3 (23.1)		
Father's educational level	Primary	17 (68.0)	8 (32.0)	3.880 ^F	0.151
	Secondary	82 (85.4)	14 (14.6)		
	Tertiary	103 (81.7)	23 (18.3)		
Father's occupation	Civil servant	89 (79.5)	23 (20.5)	6.911 ^F	0.272
	Business	54 (91.5)	5 (8.5)		
	Farmer	18 (75.0)	6 (25.0)		
	Artisan	18 (78.3)	5 (21.7)		
	Banker	13 (86.7)	2 (13.3)		
	Other (student, clergy, driver, security)	10 (71.4)	4 (28.6)		

UTI, urinary tract infection; χ^2 , Chi-square statistic; F, Fisher's Exact test; *statistically significant

Factors associated with occurrence of UTI-malaria co-infection

The results of the analysis of the relationship between selected factors and the occurrence of UTI-malaria co-infection in the children are presented in Table 5. Only those children who were brought to the hospital by their mothers had significant association with the occurrence of UTI-malaria co-infection ($F = 8.991$, $p = 0.018$).

Table 5: Association between selected factors and occurrence of UTI-Malaria co-infection in children aged 2–59 months in Jos north, Nigeria.

Factor		UTI-malaria co-infection		χ^2	p-value
		Negative (n = 202)	Positive (n = 45)		
Child's age (months)	<12	19 (100.0)	0 (0.0)	1.016 ^F	0.945
	12 – 23	32 (94.1)	2 (5.9)		
	24 – 35	52 (94.5)	3 (5.5)		
	36 – 47	65 (95.6)	3 (4.4)		
	48 – 59	68 (95.8)	3 (4.2)		
Sex	Male	111 (96.5)	4 (3.5)	0.481	0.488
	Female	125 (94.7)	7 (5.3)		
Class	None	47 (97.9)	1 (2.1)	3.606 ^F	0.462
	Creche	13 (100.0)	0 (0.0)		
	Play class	44 (91.7)	4 (8.3)		
	Nursery	129 (95.6)	6 (4.4)		
	Primary	3 (100.0)	0 (0.0)		
Was the child breastfed?	Yes	233 (95.5)	11 (4.5)	0.142 ^F	1.000
	No	3 (100.0)	0 (0.0)		
Type of breastfeeding (n = 244)	Exclusive	185 (95.4)	9 (4.6)	1.634 ^F	0.369*
	Mixed	25 (100.0)	0 (0.0)		
	Predominant	23 (92.0)	2 (8.0)		
Age of care giver (years)	≤20	23 (95.8)	4 (4.2)	1.331 ^F	0.740
	21–30	93 (95.9)	4 (4.1)		
	31–40	94 (94.0)	6 (6.0)		
	>40	26 (100.0)	0 (0.0)		
Relationship of caregiver with child	Father	22 (100.0)	0 (0.0)	8.991 ^F	0.018*
	Mother	155 (93.4)	11 (6.6)		
	Guardian	59 (100.0)	0 (0.0)		
Marital status of caregiver	Single	215 (95.6)	10 (4.4)	4.128 ^F	0.293
	Married	15 (100.0)	0 (0.0)		
	Separated/widowed	6 (85.7)	1 (14.3)		
Mother's educational level	Primary	18 (100.0)	0 (0.0)	1.735 ^F	0.617
	Secondary	113 (95.0)	6 (5.0)		
	Tertiary	105 (95.5)	5 (4.5)		
Mother's occupation	Civil servant	64 (97.0)	2 (3.0)	9.134 ^F	0.058
	Business	118 (97.5)	3 (2.5)		
	Housewife	27 (84.4)	5 (15.6)		
	Banker	15 (100.0)	0 (0.0)		
	Other (student, farmer)	12 (92.3)	1 (7.7)		
Father's educational level	Primary	2 (8.0)	23 (92.0)	0.694 ^F	0.661
	Secondary	4 (4.2)	92 (95.8)		
	Tertiary	5 (4.0)	121 (96.0)		
Father's occupation	Civil servant	5 (4.5)	107 (95.5)	8.265 ^F	0.169
	Business	0 (0.0)	59 (100.0)		
	Farmer	2 (8.3)	22 (91.7)		
	Artisan	1 (4.3)	22 (95.7)		
	Banker	1 (6.7)	14 (93.3)		
	Other (student, clergy, driver, security)	2 (14.3)	12 (85.7)		

UTI, urinary tract infection; χ^2 , Chi-square statistic; F, Fisher's Exact test; *statistically significant.

DISCUSSION

The prevalence of UTI, 18.2%, observed in this study falls within the global prevalence range of 2%-20%.[6] and is comparable to that seen among school aged children in Bangladesh with prevalence of 14%.[7] In contrast, a higher prevalence of 24.1% was found among hospitalized children in Ile-Ife, southwest Nigeria.[25] This higher prevalence may be because the study sample consisted of severely ill children who were at higher risk of overwhelming infection either from the nosocomial exposure or reduced immunity. The prevalence of UTI in this present study should be of concern, not only because of the morbidity associated with this condition, but also the economic burden it places on families and the health sector in general.

We found that UTI was most frequent in the 12–23 months age group. Our findings agree with a previous study in Iran,[26] and a meta-analysis that demonstrated a higher prevalence of UTI in febrile children older than 12 months.[27] In contrast, the results of a study conducted at Enugu, Nigeria, showed the prevalence, 21.1%, was highest among children aged 2–12 months.[9] As previously mentioned, research has shown that UTI in children under the age of 5 years has a bimodal age of onset with one peak in the first year of life and the second peak between the ages of 2 and 4 years, found to occur at the time of toilet training of children.[12] This second peak was observed in our study.

Females in our study had a significantly higher prevalence of UTI than their male counterparts, agreeing with findings observed in Akwa Ibom, Borno and Enugu States, Nigeria,[6,9,28] and is attributed to the anatomical differences in males and females where the longer male urethra gives them an advantage over females, reducing the risk of males contracting UTIs.[5] The age of the child, however, modulates the effect of the child's sex on the occurrence of UTI. Most cases of UTI in male under-five children occur in the first year of life compared to the first three years in females. In Nigeria, the male to female ratio of UTI is 2.8-5.4: 1 for children younger than 12 months but beyond the age of one year, the ratio changes to 1: 10. [15]

Our study demonstrated the crucial role exclusive breastfeeding plays in promoting the health of under-five children, as the prevalence of UTI was lowest in those children who were exclusively breastfed. Previous studies have established the role of breastfeeding in providing both short-term and long-term protection against urinary tract infection long after weaning. [29,30] Exclusive breastfeeding provides children with essential nutrients and antibodies that strengthen their immune systems and protect them from infectious diseases which are leading causes of death in this age group.[31]

The most common bacterial pathogens in the urine sample of our study participants were *E. coli* (62.2%) and *Klebsiella sp.* (22.2%) similar to the previous research done in Jos University Teaching Hospital and Japan.[8,32] Contrary to our research, *Staphylococcus aureus* and *Klebsiella species* were the leading cause of urinary tract infection in Abakaliki and Awka.[33,34] This difference can be explained by the geographical variation in pathogens causing urinary tract infections in various regions. *Proteus mirabilis* and *Staphylococcus aureus* were also isolated from urine cultures in our study, similar to other studies done in Jos.[8]

UTI-malaria co-infection was found in 4.5% of the study participants and 24.5% of those diagnosed with a UTI, similar to 21.4% observed by Ocheke et al.[8] Interestingly, our study demonstrated that the combined proportion of children who had malaria alone and UTI-malaria co-infection (9.4%) was still lower than the prevalence of UTI (18.3%) observed. These findings imply that UTI may be a more common cause of fever than malaria in our study population, and point to the risk posed to a febrile child if their clinician does not obtain a urine culture to diagnose and confirm their UTI and identify the causative organism(s). Undiagnosed UTIs can progress to severe kidney disease if left untreated.[17] On the other hand, by prescribing antibiotics for a 'possible' UTI without a confirmed diagnosis and knowledge of the sensitivity profile of the causative organisms contributes to the development of antibiotic-resistant bacteria, making infections harder to treat.[35] Ineffective antibiotics due to resistant causative organisms result in the

infection not being adequately treated, leading to prolonged illness, increased risk of complications and potential long-term consequences as well as increased healthcare costs due to prolonged hospital stays, additional diagnostic tests, and the need for second-line antibiotics.[36,37] Furthermore, unnecessary antibiotic use can result in adverse effects such as allergic reactions, diarrhoea, and *Clostridioides difficile* infections.[38]

The lower prevalence of malaria compared to UTI found in the study sample further points to an overreliance on presumptive malaria treatment for febrile children by clinicians. Microscopy remains the gold standard for parasitological confirmation of malaria and in resource-poor populations, RDT is a diagnostic alternative.[39,40] Unfortunately, malaria diagnosis and treatment have been trivialized in Nigeria, and more often than not, febrile children are presumed to have malaria and treated as so without laboratory confirmation.[39] This approach may lead to unnecessary use of antimalarial medications in febrile children who do not have malaria.[9] A study in Sokoto State, involving a sample of 800 febrile children presumed to have malaria, found that only 56% were confirmed and while 44% were misdiagnosed and treated for malaria.[41] Presumptive malaria treatment of febrile illnesses can lead to misdiagnosis, overdiagnosis and overtreatment with antimalarial medication.[39] With majority (76.8%) of our study sample of febrile children having no evidence of a UTI or malaria, it indicates that other potential life-threatening causes of fever, such as pneumonia and meningitis, that require different treatment approaches, may go undiagnosed.[39,42] The failure to diagnose and treat underlying infections correctly can lead to prolonged illness, complications, and even death in children.[17]

This study has some limitations that may influence the interpretation of the findings. First, this was a hospital-based cross-sectional study which could affect the generalisability of the study results. Furthermore, the study sample was selected from the north-central region of Nigeria, thus the prevalence of UTI and UTI-malaria co-infection may not reflect

that of the entire country. This study also limited by its reliance on RDT for malaria diagnosis without using malaria blood film microscopy and parasite counts to confirm the absence of malaria and may have accounted for the low prevalence of malaria in our study. Malaria RDT test can be less reliable for detecting malaria in patients with low-density parasitaemia, especially in low-transmission settings. However, this was not a problem in this study since the study area has an endemic and perennial malaria transmission pattern.[20] Our findings provide evidence of UTI prevalent in febrile under-five children, and underscore the need for a higher index of suspicion among clinicians and pro-active screening for UTI in febrile under-five children who present to the health facility.

CONCLUSION

This study aimed to determine the prevalence of UTI, its coexistence with malaria and associated factors among febrile children aged 2 to 59 months in Jos north, Nigeria. UTI is prevalent (18.2%) among febrile children aged 2 to 59 months in Jos north, Nigeria. We identified a peak occurrence of UTI in the 12–23 months age group. Females had a significantly higher UTI prevalence, attributed to anatomical differences, emphasizing the need for gender-specific preventive strategies. Exclusive breastfeeding emerged as a protective factor, underscoring its role in early childhood health promotion. *Escherichia coli* and *Klebsiella spp.* were the predominant bacterial isolates, highlighting the need for antibiotic stewardship in managing paediatric infections. Furthermore, the finding of UTI-malaria co-infection underscores the diagnostic complexity of febrile illnesses in children under the age of five years, and calls for comprehensive diagnostic protocols that consider multiple aetiologies to guide appropriate and timely treatment, mitigate the risk of long-term complications such as renal damage, and improve survival and health outcomes in children under five years of age.

This paper recommends that clinicians maintain a high index of suspicion for UTI in febrile children,

especially females and those within the first two years of life. Routine urine testing should be integrated into the diagnostic algorithm for febrile illness in endemic settings. Exclusive breastfeeding should be promoted not only for its nutritional benefits but also as a non-pharmacologic preventive strategy against UTIs.

It is also imperative that health authorities invest in the training of healthcare workers on early recognition and management of UTIs in children. National and regional guidelines should incorporate co-infection screening protocols, especially in malaria-endemic areas like Nigeria. Public health policies should also prioritize community-based education on breastfeeding and hygiene, and enhance laboratory infrastructure to support timely and accurate diagnosis of paediatric infections.

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Author contributions

CCO: Conceptualization; Investigation; Data curation; Writing – review and editing;

NNE: Methodology; Formal analysis; Visualization; Writing – Original draft preparation; Writing – review and editing;

CCI: Conceptualization; Supervision; Methodology; Writing – review and editing;

IHO: Data curation; Writing – review and editing; NKS – Investigation; Formal analysis; Writing – review and editing. All authors were involved in the writing and revision of the manuscript. The authors read, approved the final manuscript and agree to be accountable for all aspects of the work.

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