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Antimicrobial Resistance Patterns and Immunological Electrolyte Profiling Among Pregnant Women with Urinary Tract Infections in Selected Local Government Areas of Taraba State, Nigeria

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ABSTRACT

Research has shown that UTIs are the most common human diseases across all age groups, including those who have been hospitalized and those who have not. The hormonal and physiological changes that occur during pregnancy make UTIs more common, as they provide an ideal environment for the growth of microbes. A mother and her unborn child are in grave danger if these infections are left untreated. A further complication of treatment is the rising antibiotic resistance among uropathogens. Taraba State's pregnant population may benefit from understanding the immune response patterns and effective therapy by evaluating electrolyte changes and antimicrobial susceptibility in infected individuals. The purpose of this study is to identify antibiotic susceptibility and antimicrobial activity against pathogens in pregnant women's urine and to profile the immune response to certain electrolytes in infected individuals in the study areas. As part of the research, 282 urine samples were obtained using conventional microbiological methods. Of the 282 samples that were analyzed, 103 showed symptoms while 179 showed no symptoms at all. In the case of *Escherichia coli*, the investigation revealed seven (7) distinct isolates, accounting for 8.7 percent of the total. There were seven (7) isolates of various bacteria, including nine (87.7%), one (1) of *Staphylococcus aureus*, one (1) of coagulase, and one (1) of a mysterious enzyme. Results for symptomatic patients showed negative staphylococci 4(3.9), *Klebsiella pneumonia* 0(0.0), *Citrobacter* species 3(2.9), proteus species 3(2.9), and *Streptococcus* species 1(1.0). No other bacteria were found. For patients without symptoms, the following bacteria and viruses were detected*: Escherichia coli* 17(8.6), *Staphylococcus aureus* 7(3.6), CONs 4(2.0), *Klebsiella pneumonia* 4 (2.0), *Citrobacter* species 0(0.0), *Proteus* species 3(1.5), and *Streptococcus* species 0(0.0). The most common infection among pregnant women was *Escherichia coli*, with 26 cases in symptomatic women and 8.7 cases in asymptomatic women. The least common type of bacteria was determined to be *Streptococcus,* with only one case (0.3%) among pregnant women experiencing symptoms and none among those without any symptoms. Ampicillin produced a perfect resistance against all strains of Proteus, *Klebsiella pneumonia*, and *Streptococcus* when tested against the antibiogram of urine samples taken from pregnant women experiencing symptoms and those without any symptoms. Various species of *Proteus*, *Klebsiella pneumonia*, and *Citrobacter,* among others. Among the bacteria tested, 3.8% were resistant to ciprofloxacin, 25% to CONs, 0% to *Streptococcus spp*., and 0% to all other bacteria. Cotrimoxazole was the antimicrobial agent against which *Klebsiella pneumoniae* displayed the lowest level of resistance. Ceftriaxone was the antibiotic with which *Proteus* isolates were most resistant (83.33%), while ciprofloxacin and norfloxacin showed no resistance at all. Furthermore, the majority of *Citrobacte*r isolates showed resistance to Ampicillin (66.67%), Gentamicin (66.67%), and ceftriaxone (66.67%). In terms of immunological studies, the results for IL-10 electrolyte profiles in seropositive individuals are as follows: 64.98 ±11.38 for weakly positive, 76 ±20.3 for moderately positive, and 235.5±22.83 for strongly positive. In comparison, for TNF alpha, the results for seropositive individuals are as follows: 24 ±2.81 for weakly positive, 32.5±2.18 for moderately positive, and 73.5 ±22.83 for strongly positive. Salt had the highest level of elevation among the other electrolytes tested, which included protein (43±2.25), urea (1.29±0.17), creatinine (1.36±0.05), potassium (4.12±0.2), and sodium (131±2.25). Comparing infected and control subjects reveals notable variations in serum electrolyte levels and infection intensity. It is possible to use these electrolytes as a biomarker for UTI when they are elevated or depressed. As a result, these electrolytes may be a key immunological marker in the immunopathology of UTI, according to the results of the immunological studies.

Keywords: *Urinary Tract Infections (UTIs), Uropathogens, Antimicrobial susceptibility, Pregnant women, Antibiotics, Urine, Pathogens, Immunology.*

Introduction

The unique anatomy and physiology of the female urinary tract makes her more susceptible to urinary tract infections (UTIs), which rank high among the most prevalent bacterial infections globally [1]. An increased risk of urinary tract infections (UTIs) is a common medical consequence of pregnancy due to hormonal changes, ureteral dilatation, and urine stasis. Significant hazards, including pyelonephritis, premature labor, low birth weight, and increased maternal and neonatal morbidity, can be attributed to these infections [2]. The significance of early discovery and proper diagnosis in pregnant women cannot be emphasized enough, since problems can be prevented with rapid and adequate antibiotic therapy. But underdiagnosis or empirical treatment, which would not work against resistant strains, is common in underdeveloped areas like Nigeria due to a lack of healthcare facilities and medical professionals [3, 4].

Problems in treating UTIs have only become worse with the worldwide increase in antibiotic resistance (AMR). The rise of multidrug-resistant bacteria and viruses is directly attributable to the careless and improper administration of antibiotics, including self-medication, partial dosages, and access to drugs without a prescription [5, 6]. Inadequate monitoring systems, a lack of antibiotic stewardship, and ineffective infection control procedures all contribute to Accra's disaster. More and more frequent uropathogens, including *E. coli, Klebsiella pneumoniae*, *Proteus mirabilis*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Enterococcus faecalis*, are developing resistance to antibiotics that are commonly used, such as ampicillin, cotrimoxazole, but also amoxicillin-clavulanic acid [7]. In light of these tendencies, it is critical to conduct regular investigations to identify patterns of bacterial isolate susceptibility; this will help doctors choose appropriate medications and create treatment protocols tailored to specific regions [8, 9]. Antimicrobial susceptibility testing (AST), especially when conducted using the Kirby-Bauer disc diffusion technique, is still an important tool for finding the best antibiotics and avoiding the overuse of broad-spectrum medications [10].

Infections not only affect microbiome evaluation, but also known to trigger immunological and physiological reactions that might disrupt the body's biochemical equilibrium, especially electrolyte concentrations [11]. Essential for cellular homeostasis, fluid balance, nerve transmission, and muscular function are electrolytes such sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), and chloride (Cl).

Damage to electrolyte homeostasis can occur as a result of infection-related processes like inflammation, fever, and renal failure, which can impede recovery [12]. With their kidneys and immune systems already dealing with heightened physiological stress, pregnant women are more vulnerable to these effects. Knowledge of electrolyte changes during infection can shed light on the severity of the disease, the role of the kidneys, and the immune system's overall response. Medical professionals can track the effects of infection and the body's compensatory processes during pregnancy by profiling these electrolytes in infected patients, which has diagnostic and prognostic significance [13].

The northern Nigerian state of Taraba provides a one-of-a-kind setting for this research because of its extensive use of empirical treatment, strong prevalence of infectious diseases, and inadequate healthcare infrastructure. Many hospitals and clinics don't have the resources they need to properly monitor antibiotic resistance and prevent the overuse of antibiotics. Additionally, there is a lack of information regarding the physiological alterations linked with urinary tract infections and the microbiological etiology of these infections in pregnant women in the area. So, the purpose of this research is to examine the immunological profiling of certain electrolytes in infected people in Taraba State and to find out which antibiotics work best against the bacteria and viruses found in pregnant women's urine. The study seeks to create data that will promote rational antibiotic usage, assist optimal clinical care, and boost infection control efforts by integrating microbiological and biochemical analysis. In the end, the results will aid in reducing the rising problem of antibiotic resistance in the area and will lead to better effects on maternal health.

Materials and Method

Selected Materials, Equipment, and Reagents Used

For the purpose of this study, the following materials, equipment, and reagents were used: petri dish, wire loop, sterile urine containers, nose mask, weigh balance, hand gloves, disinfectant, cotton wool, masking tape, padlock, normal saline, distilled water, standard cultures of selected organisms, lab coat, IMVIC test kit, sensitivity disc, ELISA kit, autoclave, nutrient agar, incubator, ampicillin (AMP, 30 µg), norfloxacin (NOR, 10 µg), gentamicin (GM, 10 µg), ceftriaxone (CRO, 10 µg), ciprofloxacin (CPR, 5 µg), nitrofurantoin (NIT, 300 µg), cotrimoxazole (SXT, 1.25 µg), among others.

Study Area

Wukari and Jalingo Metropolis in Taraba State, Northeast Nigeria, were the sites of the research. The Wukari Local Government Area is located in Taraba State, and the administrative seat of that area is Wukari. The coordinates of Wukari are 7°55'42" N and 9°47'59" E. Wukari is 4,308 km2 in size. Both Federal University Wukari and Kwararafa University call Wukari home. The Wukari people mostly use Jukun as their language of communication. In spite of this, the majority of the population is bilingual (in Hausa, Fulani, Kutep, and Tiv). However, Jalingo serves as the capital of Taraba State and is also the administrative headquarters of the Jalingo Local Government Area. The coordinates of Jalingo are 8°54'42" N and 11°47'59" E. Its total area is 191,000,000 km^2.

Study Population

The population of this study included pregnant women attending antenatal care (ANC) at General Hospital Wukari, a private Hospital and Federal Medical Center, Jalingo.

Study Design

The research in this study was cross-sectional in nature. Pregnant women had their urine collected. Participants' age, income, religion, gestational stage, pregnancy category, raw meat consumption habit, education level, water source, and history of UTI were among the demographic data collected using a structured questionnaire.

Sample Size Determination

The needed sample size for this research was calculated using $N = Z^2 (P \times q)/d2$. P represents prevalence of 18.8% from previous similar study. N is the required sample size, Z is the score for 95% confidence interval (1.96), d represent the acceptable error (5%), and q is derived from 1-P = 1–0.188 = 0.812. A total of 234 sample size was obtained using the above formula adopted but was raised to 300 to augment for fall-out of responses.

Ethical Consideration

Ethical clearance was gotten from the Ministry of Health Taraba State, Nigeria. The nature and scope of the research was made explicit to the volunteered participants and community members. Written consent was obtained from the 350 pregnant individuals included in the study.

Exclusion Criteria

Pregnant and non-pregnant individuals who have been on any form of antibiotics for 14 days before sample collection were not considered for this research.

Sampling Method

A comprehensive list of pregnant women was obtained from Hospital's administration and subjected to simple random sampling technique. The sample size was unevenly assigned as follows: General Hospital Wukari (n=220), Private Hospital (n=30) and Federal Medical Center, Jalingo (n=50).

Sample Collection

Isolation and Identification of Uropathogens

Pregnant women had 15 milliliters of urine collected midstream, which was then frozen at 2-8 degrees Celsius and sent straight to the lab. Urine samples were spun in a centrifuge at 1500 RPM for 5 minutes in the lab.

A drop of sediment was placed on a grease-free slide, covered, and examined under a microscope with a high-power objective lens (40X) after five minutes of centrifugation of the urine. The following media were inoculated with 0.001 ml of urine: Blood agar, Cysteine lactose electrolyte deficient medium, and MacConkey agar, in accordance with the standard microbiological protocol outlined by Imarenezor et al. (2017). The number of colonies that could be seen was determined after 24 hours of incubation at 37 °C. A considerable bacterial colony count of ≥105 cfu/ml was used to confirm cases of UTI.

Antimicrobial Susceptibility Testing (AST) of Uropathogens

Agar disk diffusion technique using commercially obtained disks containing antibiotics was used in determining the antimicrobial susceptibility of isolates. The antibiotics used in this study were: Augmentin (AMC, 30 μg), Norfloxacin (NOR, 10 μg), Ampicillin (AMP, 30 μg), Ciprofloxacin (CPR, 5 μg), Erythromycin (E, 15 μg), Gentamicin (GM, 10 μg), Nitrofurantoin (NIT, 300 μg), Cotrimoxazole (SXT, 1.25 μg) and Ceftriaxone (CRO, 10 μg).

Determination of Protein Concentration and Electrolytes Levels in Patients with Urinary Tract Infections

Determination of Protein Concentration

Protein concentration in the serum of participants and control (non-pregnant women) was determined by Biuret's method. This was done using 0.5ml reagent and 0.1ml serum samples of individuals positive for pregnancy and negative (control) for non- pregnant participants.

Determination of Creatinine, Urea, Sodium and Potassium Levels

Creatinine, urea, sodium and potassium levels in serum of participants and control (non-pregnant women) was determined using the alkaline picrate slot methods. This was done using 0.5ml reagent and 0.1ml serum samples of individuals positive for pregnancy and negative (control) for non- pregnant (Imarenezor *et al*, 2017).

Interleukin Assay

Sera were obtained from pregnant women and then assayed for TNF-α and IL-10 using standard enzyme linked Immunosorbent assay (ELISA) with strict adherence to the manufacturer's instruction (Abcam Plc, United Kingdom). Control taken for interleukin evaluation included 11 individuals who did not have UTI and other aforementioned diseases.

Statistical Analysis

Data obtained from this study were organized using Microsoft applications and analyzed using STATA. Data was summarized using descriptive statistics. Prevalence and differences in the positive and negative results were determined using Chi-square test. The prevalence of UTI was calculated. Likelihood estimation technique was used to determine odds ratios and predictors of UTI among participants. Independent variables such as education level, income, age, settlement, consumption or raw milk and meat heat, hygiene, and previous UTI history were subjected to multivariable logistic regression to get adjusted odds ratios as variables were non-collinear with univariable logistic regression analysis with P-values ≤0.25 in. Finally, P-value of <0.05 was considered statistically significant.

Results

Biochemical Identification of Bacterial Uropathogens from Symptomatic and Asymptomatic UTI Among Pregnant Women

Three hundred pregnant women attended the antenatal clinic (ANC) at General hospital Wukari, a private clinic, and the Federal Medical Centre Jalingo to have urine samples taken for this study. Bacterial uropathogens from pregnant women with and without symptoms of UTI are biochemically identified in Table 1. The majority of the tested isolates, with the exception of *Streptococcus spp*., tested positive for catalase. The catalase test came back negative. These were gram-negative bacilli and gram-positive cocci, according to the gram reaction. Additionally, the likely species found in the samples were Klebsiella pneumoniae, Escherichia coli, Staphylococcus aureus, CONs, citrobacter spp., and Streptococcus spp. The indole test was positive for *Escherichia coli* and negative for *Proteus spp*., *Klebsiella pneumoniae*, and *Citrobacter spp*.

Table 1. Biochemical identification of bacterial uropathogens from symptomatic and asymptomatic UTI among pregnant women

S/No.	Gram Rxn	Biochemical tests								Probable organism
		CAT	COAG	IND	CIT	H_2S	TSI RXN	MAN	HEM	
1.	Gram-negative bacilli	+	NA	+	-	-	Acid slant/acid butt with gas production	NA	NA	*Escherichia coli*
2.	Gram-positive cocci	+	+	NA	NA	NA	NA	+	+	*Staphylococcus aureus*
3.	Gram-positive cocci	+	-	NA	NA	NA	NA	-	-	CoNS
4.	Gram-negative bacilli	+	NA	-	+	+	Alkaline slant/acid butt with gas production	NA	NA	*Proteus* Spp.
5.	Gram-negative bacilli	+	NA	-	+	-	Acid slant/acid butt with gas production	NA	NA	*Klebsiella pneumoniae*
6.	Gram-negative bacilli	+	NA	-	+	+	Acid slant/acid butt with gas production	NA	NA	*Citrobacter* Spp.
7.	Gram-positive cocci	-	NA	NA	NA	NA	NA	-	+	*Streptococcus* Spp.

CAT: Catalase; **COAG**: Coagulase; **IND**: Indole; **CIT**: Citrate; **TSI**: Triple sugar iron; **RXN**: Reaction; **MAN**: Mannitol fermentation; **HEM**: Hemolysis; **NA**: Not applicable; **H_2S**: Hydrogen sulfide; **CoNS**: Coagulase-negative Staphylococci

Prevalence of UTI in Symptomatic and Asymptomatic Pregnant Women

Table 2 displays the overall UTI prevalence among both symptomatic and asymptomatic pregnant women. A total of 179 samples were found to be asymptomatic, whereas 103 samples exhibited symptoms. With 9(8.7%) and 17(8.6%) isolates for symptomatic and asymptomatic pregnant women, respectively, *Escherichia coli* was the most common of the seven (7) isolates obtained. With a prevalence of 1% in pregnant women exhibiting UTI symptoms and 0% in those without symptoms, *Streptococcus spp*. was determined to be the least common isolate. *Staphylococcus aureus* was one of the other species identified in this investigation; its incidence was 1.1% in symptomatic pregnant women and 3.6% in asymptomatic ones. There were 4 (3.9%) CONs for pregnant women experiencing symptoms and 4 (2%), respectively, for pregnant women without symptoms. In the case of asymptomatic pregnant women, 3 (2.9%) *Proteus spp*. were detected, while in the case of symptomatic women, 3 (1.5%) were found. Pregnant women experiencing symptoms had 0(0%) *Klebsiella pneumoniae* infections, while those without symptoms had 4(2%). For pregnant women experiencing symptoms, the number of *Citrobacter spp*. was 3 (2.9%), while for those without symptoms, it was 0 (0%).

Table 2. Prevalence of UTI in symptomatic and asymptomatic pregnant women

Isolated Bacteria	Prevalence		Total Positive N (%)
	Symptomatic (103)	Asymptomatic (197)	
	Number positive (%)	Number positive (%)	
E. coli	9 (8.7)	17 (8.6)	26 (8.7)
S. aureus	1 (1.0)	7 (3.6)	8 (2.7)
CoNS	4 (3.9)	4 (2.0)	8 (2.7)
Proteus Spp.	3 (2.9)	3 (1.5)	6 (2.0)
Klebsiella pneumoniae.	0 (0.0)	4 (2.0)	4 (1.4)
Citrobacter Spp.	3 (2.9)	0 (0.0)	3 (1.0)
Streptococcus Spp.	1 (1.0)	0 (0.0)	1 (0.3)
Total	21 (20.4)	35 (17.8)	56 (18.7)

Socio-Demographic Characteristics of Study Participants

The results for the study's demographic variables are shown in table 3. Participant age, gestational age, pregnancy category, employment status, residential area, education level, monthly income, consumption of raw meat, vegetables, and milk, water source, and history of urinary tract infections (UTIs) were among the socio-demographic variables collected in this study. A total of 81.3% of the 300 individuals tested came back negative when tested with bacterial culture, while 18.7% showed positive results. The age group of 35–44 years included 31% of positive participants and 69% of negative subjects, correspondingly, when broken down by age category.

The highest percentage of negative participants was found in the 15–24 age group (82%), followed by the 25–34 age group (19% positive and 81% negative). In the second trimester, 23% of the cases evaluated fell into the "gestation stage" group, with 120 subjects coming back negative on the bacterial culture test. 33% of pregnant women who were tested during the third trimester came up negative.

Pregnant women living in periurban areas had the greatest rate of bacterial culture positive results (35%). The rate of subjects who tested negative to bacterial culture was higher among pregnant women living in metropolitan areas. Among the pregnant women who were part of the study, those who were unemployed had a higher rate of positive bacterial culture results (20%) compared to those who were working (83%). The study looked at pregnant women with varying levels of education. The highest percentage of pregnant individuals who tested positive to bacterial culture was among the illiterate (20%), whereas the highest percentage of pregnant subjects who tested negative to bacterial culture was among the university-class pregnant subjects (0%).

Participants who relied on spring water as their primary water supply during their pregnancy had the greatest rate of participants who tested positive to bacterial culture (32%). Among pregnant women, the percentage who tested negative to bacterial culture was highest among those who drank water from sources other than springs and taps (91%).

The percentage of pregnant women who tested positive to bacterial culture was 18% lower in the raw milk group compared to the non-raw milk group (19%). Nonetheless, the disparity in worth was insignificant.

Table 3. Socio-demographic characteristics of study participants

Socio-demographic variables	Bacterial Culture (%)		Total	X²	p-value
	Positive= 56 (18.7)	Negative= 244 (81.3)			
Age in years					
15-24	27 (18)	126 (82)	153	1.359	0.51
25-34	25 (19)	109 (81)	134		
35-44	4 (31)	9 (69)	13		
Gestation stage					
Second trimester	23 (16)	120 (84)	143	1.201	0.27
Third trimester	33 (21)	124 (79)	157		
Pregnancy category					
Primiparous	25 (18)	113 (82)	138	0.051	0.82
Multiparous	31 (19)	131 (81)	162		
Employment					
Employed	17 (17)	86 (83)	103	0.483	0.49
Unemployed	39 (20)	158 (80)	197		
Residency					
Urban	37 (17)	187 (83)	224	5.096	0.08
Rural	10 (20)	40 (80)	50		
Periurban	9 (35)	17 (65)	26		
Education					
Illiterate	10 (20)	41 (80)	51	0.170	0.98
Primary school	20 (19)	85 (81)	105		
Secondary school	13 (19)	55 (81)	68		
University	13 (17)	63 (83)	76		
Income/month					
<500	32 (19)	85 (81)	117	14.079	0.007
501-1000	18 (25)	77 (75)	95		
1001-1500	3 (8)	36 (92)	39		
1501-2000	1 (9)	22 (91)	23		
>2001	2 (15)	24 (85)	26		
Eat raw meat					
Yes	28 (24)	87 (76)	115	3.965	0.046
No	28 (15)	157 (85)	185		
Drink raw milk					
Yes	14 (18)	63 ()82	77	0.016	0.90
No	42 (19)	181 (81)	223		
Eat raw vegetable					
Yes	19 (24)	61 (76)	80	1.857	0.17
No	37 (17)	183 (83)	220		
Water source					
Others	2 (9)	20 (91)	22	3.418	0.18
Spring water	6 (32)	13 (68)	19		
Tap water	48 (19)	211 (81)	259		
UTI history					
Yes	18 (27)	48 (73)	66	4.128	0.04
No	38 (16)	196 (84)	234		

Antimicrobial Resistance Pattern of Gram-Negative and Gram-Positive Bacteria Isolated from Asymptomatic and Symptomatic Pregnant Women

Table 4 displays the pattern of resistance of the bacteria that were identified from pregnant women who experienced symptoms and those who did not. *Proteus species*, *Klebsiella pneumonia*, and *Streptococcus species* exhibited complete resistance to ampicillin when tested with other urinary tract isolates. In terms of ciprofloxacin resistance, the following bacteria and viruses fared poorly: *Escherichia coli*, *Proteus spp*., *Klebsiella pneumonia*, *Citrobacter spp*., S. aureus, CONs, and *Streptococcus spp*. It was shown that *Klebsiella pneumoniae* was the most susceptible to contrimoxazole. In terms of antibiotic resistance, *Proteus spp*. exhibited 83.33 percent ceftriaxone resistance and 0 percent ciprofloxacin and 0 percent norfloxacin resistance. Ampicillin (66.67%), Gentamicin (66.67%), and ceftriaxone (66.67%) were the antibiotics against which *Citrobacter spp*. demonstrated the greatest resistance.

Table 4. Antimicrobial resistance pattern of Gram-negative and Gram-positive bacteria isolated from asymptomatic and symptomatic pregnant women

Antimicrobial agents	Number of resistant urinary isolates (%)						
	Gram-Negative Isolates				Gram-Positive Isolates		
	E. coli (n=26)	*Proteus* Spp. (n=6)	*Klebsiella pneumoniae* (n=4)	*Citrobacter* Spp. (n=3)	*S. aureus* (n=8)	CoNS (n=8)	*Streptococcus* Spp. (n=1)
Ampicillin	16 (61.54)	6 (100)	4 (100)	2 (66.67)	6 (75.0)	6 (75.0)	1 (100)
Ciprofloxacin	1 (3.85)	0 (0.0)	1 (25.0)	0 (0.0)	0 (0.0)	4 (50.0)	0 (0.0)
Norfloxacin	1 (3.85)	0 (0.0)	1 (25.0)	0 (0.0)	2 (25.0)	1 (12.5)	0 (0.0)
Gentamicin	16 (61.54)	4 (66.67)	3 (75.0)	2 (66.67)	2 (25.0)	1 (12.5)	1 (100)
Ceftriaxone	10 (38.46)	5 (83.33)	3 (75.0)	2 (66.67)	5 (62.5)	2 (25.0)	0 (0.0)
Augmentin	1 (3.85)	1 (16.67)	1 (25.0)	1 (33.33)	2 (25.0)	0 (0.0)	0 (0.0)
Nitrofurantoin	6 (23.08)	-	-	1 (33.33)	2 (25.0)	0 (0.0)	1 (100)
Cotrimoxazole	4 (15.38)	2 (33.33)	0 (0.0)	1 (33.33)	1 (12.5)	1 (12.5)	1 (100)

Immune Response Patterns of Pregnant Subjects

Based on the concentration of IL-10, Table 5 shows the results of IL-10 concentration across different groups of volunteers who tested positive for the virus. Nine participants tested got a weakly positive result with an average value of 64.98±11.38 out of the three groups of infection levels. Twelve participants scored moderately positive, with an average of 76±20.3, and fourteen participants scored highly positive, with an average of 235.5±22.83. In comparison to the three groups of infection, the control group of 15 participants, who tested negative for infection, had a lower mean value of 73.59±6.85.

Table 6 shows the levels of IL-10 in the serum and cerebrospinal fluid (CSF) of pregnant subjects with UTIs in the early and late stages. At the early stage, the mean levels of serum IL-10 and cerebrospinal fluid IL-10 in pg/ml were 146.66±2.11 and 65.67±1.07, respectively. A mean of 378.2±2.23 pg/ml for serum IL-10 and 128.61±1.27 pg/ml for cerebrospinal fluid IL-10 were recorded at the late stage, respectively.

Table 7 displays the results of TNF-∘ concentrations among different groups of seropositive individuals. The results showed that out of all the samples tested, 9 people tested weakly positive, 12 subjects tested moderately positive, and 14 subjects tested extremely positive for the virus. Fifteen individuals who tested negative for infection served as controls. There was a statistically significant difference between the means of all the infection level categories. The control group had a mean value of 14.41±0.41, while the participants with weak positivity, moderate positivity, and very positive positivity all had values that were higher than that.

Table 8 displays the results of the TNF-∘ concentration in the serum and cerebrospinal fluid of pregnant subjects with early and late stages of UTI. Compared to the mean serum TNF-∘ concentration of 81.6±1.52 pg/mL, the early stage concentration of 43.09±2.08 pg/mL was considerably lower. At the early stage, the average concentration of CSF TNF-∘ in parts per million was 25.53±1.52. When the stage was advanced, the concentration of CSF TNF-∘ (pg/mL) was 25.85±0.1. In both the early and late stages, the mean concentration of CSF TNF-∘ (pg/mL) does not alter significantly.

Table 5 displays the different types of volunteers who tested positive for the virus. Nine participants tested got a weakly positive result with an average value of 64.98±11.38 out of the three groups of infection levels. Twelve participants scored moderately positive, with an average of 76±20.3, and fourteen participants scored highly positive, with an average of 235.5±22.83. In comparison to the three groups of infection, the control group of 15 participants, who tested negative for infection, had a lower mean value of 73.59±6.85. Table 6 shows the levels of IL-10 in the serum and cerebrospinal fluid (CSF) of pregnant subjects with UTIs in the early and late stages. At the early stage, the mean levels of serum IL-10 and cerebrospinal fluid IL-10 in pg/ml were 146.66±2.11 and 65.67±1.07, respectively. A mean of 378.2±2.23 pg/ml for serum IL-10 and 128.61±1.27 pg/ml for cerebrospinal fluid IL-10 were recorded at the late stage, respectively.

Table 7 displays the results of TNF-∘ concentrations among different groups of seropositive individuals. The results showed that out of all the samples tested, 9 people tested weakly positive, 12 subjects tested moderately positive, and 14 subjects tested extremely positive for the virus. Fifteen individuals who tested negative for infection served as controls. There was a statistically significant difference between the means of all the infection level categories. The control group had a mean value of 14.41±0.41, while the participants with weak positivity, moderate positivity, and very positive positivity all had values that were higher than that.

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Table 5. IL-10 Concentrations among categories of seropositive volunteers

Level of infection	Weakly positive (n=9)	Moderately positive (n=12)	Strongly positive (n=14)	Control (n=15)
Mean	64 .98 ±11.38	76 ±20.3	235.5±22.83	73.59±6.85
X^2	1.01	0.078	355.78	
F-value	294.43			

Table 6. IL-10 concentrations in serum and CSF of UTI early and late stages

Stages of UTI	Early stage (n=12)	Late stage (n=4)	Mean difference
Mean Serum IL-10 (pg/mL)	146.66±2.11	378.2±2.23	t-value = 188.26 95% CI: 229.55-234.85
Mean CSF IL-10 (pg/mL)	65.67±1.07	128.61±1.27	t-value= 97.69 95% CI: 61.55-64.32,

Table 7. TNF-α concentrations among categories of seropositive individuals

Level of infection	Weakly positive (n=9)	Moderately positive (n=12)	Strongly positive (n=14)	Control (n=15)
Mean	24 ±2.81	32.5±2.18	73.5 ±22.83	14.41±0.41
X^2	6.37	22.79	35.57	
F-value	39.73			

Table 8. TNF-α concentrations in serum and CSF of UTI early and late stages

Stages of UTI	Early stage (n=12)	Late stage (n=4)	Mean difference
Mean Serum TNF-α (pg/mL)	43.09±2.08	81.6±1.52	t-value= 33.85 95% CI: 36.07-40.95
Mean CSF TNF-α (pg/mL)	25.53±1.53	25.85±0.1	t-value= 0.408 95% CI: 61.55-64.32

In Table 9, we can see the average protein, sodium, potassium, creatinine, and urea profiles of pregnant women with heavy and light infections, respectively. Under the category of light infection, thirty-six (36) pregnant women were examined. The average levels of urea, creatinine, protein, sodium, and potassium in milligrams per deciliter were respectively measured as 9.9±0.17, 1.34±0.05, 41±2.25, 131±1.41, and 3.81±0.2. When it came to the category of high infection, 29 pregnant women were checked. In milligrams per deciliter, the average levels of urea, creatinine, protein, sodium, and potassium were 7.9±0.15, 1.28±0.04, 34±2.05, 134±2.05, and 3.87±0.17, respectively.

Pregnant women who did not have any infections had their mean values for five (5) parameters shown in Table 10. These parameters are urea, creatinine, protein, sodium, and potassium. The control group had a mean urea value of 2.3±0.42, while the infected group had a lower value of 1.29±0.17. A slightly higher mean value of 1.36±0.05 was obtained for creatinine compared to the control. The control had a mean protein value of 67±1.41, while the experimental group had a lower value of 43±2.25. The control group had a sodium mean value of 137±1.4, while the infected group had 131±2.25, a little lower. Infected pregnant women had a slightly higher mean potassium levels (4.12±0.2) compared to the control group (4.11±0.19).

Presented in table 11 are the results for serum urea (Mmol/L), creatinine (Mmol/L), and protein levels (Mg/dL) of pregnant women with light and heavy UTI infections, as well as control persons who did not have an infection. In comparison to persons with mild and heavy infection, the control group had lower mean values of urea, creatinine, and protein, which were 4.98±0.32, 110.66±4.77, and 14.66±1.42 correspondingly.

Pregnant women with a heavy illness had the highest mean urea value (5.56±0.04), while the control group had the lowest (4.98±0.32). In pregnant women with heavy infection, the mean creatinine value was 125.62±12.86, while in healthy persons, it was 110.66±4.77, the lowest. People with severe infections had the greatest mean protein values (27.94±3.07), whereas the control group had the lowest (14.66±1.42).

Serum electrolyte results (sodium (Mmlo/L) and potassium (Mmol/L)) in pregnant women with UTIs (mild and high infection) are displayed in Table 12. The control individuals with heavy infection had the greatest mean potassium value (4.05±0.69), while pregnant women with mild infection had the lowest (4.00±0.06). However, there was no significant difference in the mean potassium value among these groups. Infected people had the lowest mean sodium value (Mmol/L), while weakly infected pregnant women had the greatest mean sodium value (130.66±1.04). Sodium levels were not significantly different between pregnant women with severe infections and those without infections (control individuals).

The results of serum urea, creatinine, protein, sodium, and potassium levels, as well as the severity of infection relative to age in both the infected and control persons, are displayed in Table 13. In terms of the number of sick people tested, the mean urea value was 6.44±0.36 for those aged 11–15 and 5.22±0.88 for those aged 26–30. The people with the highest serum urea levels were those between the ages of 21 and 25 (5.05±0.33), while those between the ages of 26 and 30 had the lowest levels (4.78±0.36).

Infected people with serum creatinine levels that were highest were those between the ages of 11 and 15 (126.88±12.24), while those between the ages of 26 and 30 had the lowest levels (118.68±4.80). The control group with the highest serum creatinine mean value (109.21±3.55) was comprised of persons aged 26–30. Infected persons between the ages of 26 and 30 had the highest serum protein mean value (29.42±1.64), while those between the ages of 16 and 20 had the lowest (19.64±3.91). Among those aged 11–15, serum protein levels were lowest (13.04±1.13) and highest (19.11±0.69).

In Table 9, we can see the average protein, sodium, potassium, creatinine, and urea profiles of pregnant women with heavy and light infections, respectively. Under the category of light infection, thirty-six (36) pregnant women were examined. The average levels of urea, creatinine, protein, sodium, and potassium in milligrams per deciliter were respectively measured as 9.9±0.17, 1.34±0.05, 41±2.25, 131±1.41, and 3.81±0.2. When it came to the category of high infection, 29 pregnant women were checked. In milligrams per deciliter, the average levels of urea, creatinine, protein, sodium, and potassium were 7.9±0.15, 1.28±0.04, 34±2.05, 134±2.05, and 3.87±0.17, respectively.

Pregnant women who did not have any infections had their mean values for five (5) parameters shown in Table 10. These parameters are urea, creatinine, protein, sodium, and potassium. The control group had a mean urea value of 2.3±0.42, while the infected group had a lower value of 1.29±0.17. A slightly higher mean value of 1.36±0.05 was obtained for creatinine compared to the control. The control had a mean protein value of 67±1.41, while the experimental group had a lower value of 43±2.25. The control group had a sodium mean value of 137±1.4, while the infected group had 131±2.25, a little lower. Infected pregnant women had a slightly higher mean potassium levels (4.12±0.2) compared to the control group (4.11±0.19).

Presented in table 11 are the results for serum urea (Mmol/L), creatinine (Mmol/L), and protein levels (Mg/dL) of pregnant women with light and heavy UTI infections, as well as control persons who did not have an infection. In comparison to persons with mild and heavy infection, the control group had lower mean values of urea, creatinine, and protein, which were 4.98±0.32, 110.66±4.77, and 14.66±1.42 correspondingly.

Pregnant women with a heavy illness had the highest mean urea value (5.56±0.04), while the control group had the lowest (4.98±0.32). In pregnant women with heavy infection, the mean creatinine value was 125.62±12.86, while in healthy persons, it was 110.66±4.77, the lowest. People with severe infections had the greatest mean protein values (27.94±3.07), whereas the control group had the lowest (14.66±1.42).

Serum electrolyte results (sodium (Mmlo/L) and potassium (Mmol/L)) in pregnant women with UTIs (mild and high infection) are displayed in Table 12. The control individuals with heavy infection had the greatest mean potassium value (4.05±0.69), while pregnant women with mild infection had the lowest (4.00±0.06). However, there was no significant difference in the mean potassium value among these groups. Infected people had the lowest mean sodium value (Mmol/L), while weakly infected pregnant women had the greatest mean sodium value (130.66±1.04). Sodium levels were not significantly different between pregnant women with severe infections and those without infections (control individuals).

The results of serum urea, creatinine, protein, sodium, and potassium levels, as well as the severity of infection relative to age in both the infected and control persons, are displayed in Table 13. In terms of the number of sick people tested, the mean urea value was 6.44±0.36 for those aged 11–15 and 5.22±0.88 for those aged 26–30. The people with the highest serum urea levels were those between the ages of 21 and 25 (5.05±0.33), while those between the ages of 26 and 30 had the lowest levels (4.78±0.36).

Infected people with serum creatinine levels that were highest were those between the ages of 11 and 15 (126.88±12.24), while those between the ages of 26 and 30 had the lowest levels (118.68±4.80). The control group with the highest serum creatinine mean value (109.21±3.55) was comprised of persons aged 26–30. Infected persons between the ages of 26 and 30 had the highest serum protein mean value (29.42±1.64), while those between the ages of 16 and 20 had the lowest (19.64±3.91). Among those aged 11–15, serum protein levels were lowest (13.04±1.13) and highest (19.11±0.69).

Table 9. Prevalence of UTI and mean profile urea, creatinine, protein, sodium and potassium concentration among infected pregnant women

Intensity of infection	Number examined	Mean urea (mg/dl)	Mean creatinine (mg/dl)	Mean protein (mg/dl)	Mean sodium (mg/dl)	Mean potassium (mg/dl)
Light	36	9.9±0.17	1.34±0.05	41±2.25	131±1.41	3.81±0.2
Heavy	29	7.9±0.15	1.28±0.04	34±2.05	134±2.05	3.87±0.17

Table 10. Urea, Creatinine, Protein, Sodium and potassium concentration of infected pregnant women

Parameters	Infected N=130	Control N=50	X2
Urea	1.29±0.17	2.3±0.42	0.79
Creatinine	1.36±0.05	1.1±0.44	0.049
Protein	43±2.25	67±1.41	13.39
Sodium	131±2.25	137±1.41	0.27
Potassium	4.12±0.2	4.11±0.19	0.00024

Table 11. Serum urea, creatinine, and protein concentration and intensity UTI of pregnant women and control individuals

Intensity of infection	No of infected	Urea Mmol/l	Creatinine Mmol/l	Protein Mg/dl
Light infection	75	5.01±0.86	115.44±7.66	19.48±2.13
Heavy infection	55	5.56±0.04	125.62±12.86	27.94±3.07
Infected individuals	130	5.56±0.88	120.76±10.40	25.46±3.01
Control individuals	50	4.98±0.32	110.66±4.77	14.66±1.42

**Means values are significantly different (P<0.05) compared with the control*

Table 12. Serum sodium, and potassium concentration and intensity UTI of pregnant women and control individuals

Intensity of infection/10ml	No of infected	Sodium (Mmol/l)	Potassium (Mmol/l)
Light infection	75	130.66±1.04	4.00±0.06
Heavy infection	55	130.54±0.24	4.01±0.12
Infected individuals	130	129.86±2.08	4.01±0.80
Control individuals	50	130.06±0.95	4.05±0.69

Table 13. Serum urea, creatinine, protein, sodium and potassium concentration and intensity of infection according to the age of the infected and control individuals

Individual	Age	Number examined	Urea (Mmol/l)	Protein (Mmol/l)	creatinin (Mmol/l)	Sodium (Mmol/l)	Potassium (Mmol/l)
Infected	11-15	19	6.44±0.36	126.88±12.24	28.07±2.66	124.80±1.06	4.12±1.06
	16-20	62	5.27±0.91	123.76±4.32	19.64±3.91	126.76±3.94	4.11±0.06
	21-25	26	6.34±0.32	121.34±4.22	21.22±2.98	131.32±2.56	4.18±1.55
	26-30	23	5.22±0.88	118.68±4.80	29.42±1.64	128.44±2.98	3.98±1.44
Control	11-15	14	4.96±0.31	110.67±2.81	13.04±1.13	125.40±1.01	3.69±0.07
	16-20	11	5.01±0.44	111.45±3.71	15.84±0.59	129.64±0.71	4.16±0.81
	21-25	17	5.05±0.33	111.44±4.12	17.33±1.42	132.43±1.44	3.98±1.10
	26-30	8	4.78±0.36	109.21±3.55	19.11±0.69	127.60±0.98	4.05±1.22

**Mean values are significantly different (P<0.05) compared with the control subjects*

Discussion

Colonization of the urinary system by microbes can lead to UTIs [4]. While some people with UTIs show symptoms that progress to more serious problems, some people with pathogenic germs in their lower urinary tracts may show no symptoms at all. In most cases, the host's competitive defensive mechanisms will clear the lower urinary tract of any harmful microbes that have colonized the bladder. Pregnant women are at increased risk for UTIs and other issues because their immune systems aren't working properly, which allows these germs to survive in the urinary tract and evade the host's defenses [5,6].

In South West Nigeria, *Escherichia coli* is one of the most commonly isolated bacteria in UTI cases [7]. The current study's findings align with that of [8] since *E. coli* was primarily detected in clinical samples taken from pregnant women experiencing symptoms or not. In addition, women have a higher prevalence of Escherichia coli. The larger prevalence of *E. coli* induced UTIs in women compared to men is due to the near proximity of the female urethra to the anus, where *E. coli* typically colonizes, as mentioned earlier in the literature review chapter. Because of this, the bacteria can more easily go to the bladder and start colonizing other areas of the urinary system. Another factor that might lead to a UTI is the improper way the genitalia are cleaned after urine. If you wipe from the anus to the vagina in the opposite direction of how you would normally do it, you may be encouraging *E. coli* to move more easily from the anus to the urethra. Crucially, *E. coli* colonization of the urinary tracts may be accelerated by highly penetrative sexual practices. Some medical experts have speculated that E. coli can ascend to the urinary tract as a pregnant woman's bladder moves to accommodate the expanding fetus. The high incidence rates of pyelonephritis, early birth, and low birth weight resulting from maternal morbidity have been frequently related to untreated, symptomless UTIs, according to [9]. Samples obtained for this investigation revealed the presence of uropathogens other than *E. coli*, including Staphylococcus aureus, Pseudomonas aeruginosa, *Klebsiella spp*., and *Streptococcus spp*. These results are in line with those of the study that identified various bacteria, including *E. coli*, Staphylococcus aureus, Pseudomonas aeruginosa, Klebsiella spp., and Streptococcus spp. [10].

There are a number of known variables that increase the likelihood of uropathogens being present in the urine system throughout pregnancy. Among these factors are the following: age, stage of gestation, history of urinary tract infections (UTIs), socioeconomic status, educational level, eating habits, location, and water source [11, 12]. This study's results have clarified that a person's socioeconomic position is a factor in the prevalence of UTIs associated with pregnancy. Pregnant women with monthly incomes between 501 and 100 and those with incomes less than 500 were each diagnosed with a UTI at a rate of 32% and 57%, respectively. Consistent with previous research, this study shows that pregnant women with lower income levels are more likely to have UTIs than those with higher income levels [13]. There was a correlation between poor financial status and high UTI frequency in [14] as well. There is a strong correlation between the host immune system's ability to fight off infections and the inability of pregnant women to afford healthy eating habits, especially when their monthly income is low.

The prevalence of UTIs is strongly correlated with a poor medical history in this study. In terms of UTI prevalence and previous medical history, the results of this study are consistent with those of [15] regarding UTI in Pakistan. Pregnant women's risk of UTI was significantly correlated with their region of domicile.

The most common type of urinary tract infection (UTI) was found in pregnant women living in rural areas. These expecting mothers are more likely to try to cure themselves for a urinary tract infection (UTI) without first seeing a doctor. Due to the greater distance between their homes and healthcare facilities, pregnant women in this area may be more reluctant to seek medical attention until their babies are born. The results of this study demonstrated that pregnant women with a university degree had the lowest rate of positive UTI patients when stratified by education level. This might be because this group of pregnant women is well-versed in UTIs and knows how to treat and avoid them. In their study, [16] found that lower rates of UTIs were associated with higher levels of education among women.

The elderly are more likely to have uropathogens, or bacteria and viruses that cause urinary tract infections, than any other age group [17]. Because of aging, the likelihood of getting a urinary tract infection (UTI) increase. A person's resistance to common infections declines with age. This claim is supported by the results of this study. Compared to the 15–24 age group (18%) and the 25–34 age group (19%), the 35–44 age group had a higher UTI prevalence of 31%.

This current study investigated the mechanism involves in pro and anti-inflammatory cytokine responses to urinary tract infected pregnant subjects at the beginning and advanced stage of the infection. The anti-inflammatory cytokine response in UTI positive pregnant subjects (at early and late stages) and negative UTI pregnant subjects was determined by measurement of concentrations of tumor necrosis factor alpha (TNF-∝) and interleukin (IL-10) concentration in sera of pregnant subjects.

Cytokines are important proteins coordinating inflammatory processes. Tumor necrosis factor alpha (TNF- a) and interleukin 1 (IL-1) are recognized as the most effective pro-inflammatory cytokines [18]. Multiple hosts' internal mechanisms are responsible for moderating the production and/ or activity of TNF and/ or IL-10 [19]. Serum TNF-∝ and IL-10 were higher in positive UTI pregnant subjects at late stage compared to positive UTI pregnant subjects at the early stage. Serum TNF-∝ and IL-10 were also seen to increase progressively from weakly positive UTI pregnant subjects to moderately positive pregnant subjects to strong positive pregnant subjects. Pro-inflammatory cytokine production resulting from infection of the urinary tract mainly occurs internally, at the spot in which the infection was initiated [20]. In examining cytokine production resulting from acute UTI, it was observed that there was increase in the concentrations of IL-10 in serum and urine. However, higher concentration of IL-10 was discovered in urine than in serum. The IL-10 increase in serum is in tandem with the findings of this study.

Many studies on the analysis of biochemical profile of UTI focuses on proteins and other biochemical parameters like serum urea, serum creatinine, and potassium, among others. Alterations in the concentration of proteins in blood results from numerous clinical symptoms related with pathophysiological procedures and integration of acute phase proteins [21]. The synthesis of acute-phase proteins results from infection, inflammation, tissue damage and stress. Cytokines are released from the macrophages and monocytes in place of inflammation as a result of the acute-phase responses [22]. One of the several effects of cytokine is the intense change in the liver protein synthesis. For example, *Staphylococcus aureus* induced infection, surges the concentration of albumin which is an acute-plasma proteins [23].

This study specifies a high value of serum protein in positive UTI pregnant women compared to the control subjects (negative UTI pregnant women). Also, comparing serum protein levels in pregnant subjects with heavy infection and those with light infection, it was observed that serum protein levels were higher in pregnant subjects with heavy infection. The increase observed in serum protein may also occur from the decrease in amino acids reabsorption or increased catabolism of amino acids [12].

Conclusion

This study provides valuable insight into the prevalence, bacterial etiology, antimicrobial susceptibility patterns, and immunological response associated with urinary tract infections (UTIs) among pregnant women in Taraba State. The findings revealed that UTIs remain a significant health concern among both symptomatic and asymptomatic pregnant women, with *Escherichia coli* emerging as the most prevalent uropathogen. Its high occurrence aligns with global reports that identify *E. coli* as the predominant cause of UTIs due to its virulence factors and ability to adhere to uroepithelial cells. The detection of other isolates such as *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Proteus* species, *Citrobacter* species, and *Streptococcus* species demonstrates the polymicrobial nature of urinary infections in this population.

The antimicrobial susceptibility testing revealed concerning levels of resistance among isolates, particularly against ampicillin, ceftriaxone, and gentamicin. Notably, *Proteus* and *Citrobacter* species showed high resistance rates, indicating potential multidrug resistance. Conversely, ciprofloxacin and norfloxacin demonstrated higher effectiveness against most isolates, suggesting that these antibiotics may still serve as suitable empirical options for UTI management in this setting. However, the observed pattern of resistance underscores the urgent need for periodic surveillance, rational antibiotic use, and implementation of antimicrobial stewardship programs to prevent further resistance escalation.

The varying resistance levels among bacterial isolates also highlight the necessity for culture-based diagnosis rather than empirical treatment, especially in pregnant women, where antibiotic safety and efficacy are paramount.

The immunological and electrolyte profiling provided an additional dimension to understanding the pathophysiology of UTIs during pregnancy. Elevated levels of cytokines such as IL-10 and TNF-α among seropositive individuals reflect the activation of inflammatory and immune pathways in response to infection. The differential cytokine expression suggests varying immune intensities depending on infection severity. Furthermore, alterations in serum electrolytes such as sodium, potassium, urea, and creatinine levels indicate renal involvement and systemic response to infection. Sodium, which was most elevated, and other altered electrolytes may serve as potential biomarkers for UTI progression and immune status monitoring.

Conclusively, this study establishes that UTIs in pregnant women of Taraba State are predominantly caused by *E. coli* and are increasingly resistant to conventional antibiotics. The findings emphasize the need for continuous microbial surveillance, prudent antibiotic prescription, and integrated monitoring of electrolyte and immunological changes. These parameters could serve as diagnostic and prognostic indicators, improving infection management and maternal health outcomes in the region.

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Conflict of Interest

The authors declared that there are no conflicts of interest.

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