Science World Journal Vol. 21(No 1) 2026
www.scienceworldjournal.org
ISSN: 1597-6343 (Online), ISSN: 2756-391X (Print)
Published by Faculty of Science, Kaduna State University
https://dx.doi.org/10.4314/swj.v21i1.49

OCCURRENCE AND ANTIBIOTIC SUSCEPTIBILITY PATTERN OF BACTERIAL PATHOGENS IN URINE SAMPLES OF FEMALE STUDENTS AT KADUNA STATE UNIVERSITY HOSTEL

*Fatima Mohammed Musa, Surayya Ladan Shuraihu, Zainab Farouk Borgu, Aisha Aliyu

Department of Microbiology, Faculty of Life Sciences, Kaduna State University, Kaduna, Nigeria

*Corresponding Author Email Address: fatima.mohammed@kasu.edu.ng

ABSTRACT
Urinary tract infections (UTIs) are among the most common bacterial infections affecting women worldwide, particularly females living in communal settings such as university hostels. Overcrowding, poor sanitation, and limited hygiene practices increase the risk of infection and facilitate the spread of uropathogens. This study aimed to determine the occurrence of urinary tract infections and the antibiotic susceptibility pattern of bacterial pathogens isolated from urine samples of female students residing in the Kaduna State University hostel. Understanding the bacterial profile and antibiotic resistance patterns of uropathogens is essential for effective treatment and control. A total of 40 midstream early-morning urine samples were aseptically collected from female hostel students. Samples were cultured on Cystine Lactose Electrolyte Deficient (CLED) agar and MacConkey agar. Isolates were identified using standard microbiological techniques, including colony morphology, Gram staining, and biochemical tests. Antibiotic susceptibility testing was performed using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar, and results were interpreted according to Clinical and Laboratory Standards Institute (CLSI) guidelines. Out of the 40 urine samples analyzed, 32 (80.0%) showed significant bacterial growth. The predominant isolate was *Escherichia coli*, with a frequency of 13 (40.6%), followed by Proteus mirabilis, 9 (28.1%), Pseudomonas aeruginosa, 6 (18.8%), and Staphylococcus aureus, 4 (12.5%). Antibiotic susceptibility testing revealed varying resistance patterns among the isolates, with high resistance to commonly used antibiotics and moderate susceptibility to fluoroquinolones. The high occurrence of uropathogenic bacteria and the observed antibiotic resistance patterns highlight the public health significance of UTIs among female students in hostel environments. Routine surveillance, improved hygiene practices, and rational antibiotic use are strongly recommended to reduce the burden of UTIs and prevent the emergence of multidrug-resistant strains.

Keywords: Urinary tract infection, Uropathogens, Antibiotic susceptibility, Female students, Kaduna State University.

INTRODUCTION
Urinary tract infections (UTIs) are among the most common bacterial infections affecting humans worldwide and constitute a major public health concern. They occur when pathogenic microorganisms invade and multiply within any part of the urinary tract, including the urethra, bladder, ureters, and kidneys (Flores-Mireles *et al*., 2015). UTIs account for over 150 million cases annually and represent a significant burden on healthcare systems globally (Mancuso *et al*., 2023). Women are disproportionately affected by UTIs due to anatomical and physiological factors such as a shorter urethra, proximity of the urethral opening to the anus, hormonal influences, and sexual activity (Ahmed & Bello, 2020; Mancuso *et al*., 2023). Studies indicate that approximately 50–60% of women experience at least one episode of UTI during their lifetime, with many suffering recurrent infections (Flores-Mireles *et al*., 2015). Young women living in communal environments, particularly university hostels, are at increased risk owing to shared sanitary facilities, overcrowding, poor hygiene practices, and limited awareness of preventive measures (Ahmed & Bello, 2020). In developing countries, factors such as inadequate sanitation, limited access to clean water, and inappropriate antibiotic use further exacerbate the prevalence and recurrence of UTIs (Tariq *et al*., 2021). Communal hostel environments provide favourable conditions for the transmission of uropathogens, thereby increasing susceptibility among female students (Mancuso *et al*., 2023). The continuous circulation of pathogenic organisms in such settings contributes to the persistence and spread of infections. The most frequently isolated uropathogen is *Escherichia coli*, responsible for approximately 70–90% of uncomplicated UTIs, owing to its virulence factors such as adhesins, biofilm formation, and immune evasion mechanisms (Flores-Mireles *et al*., 2015). Other important bacterial agents include *Proteus mirabilis*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Staphylococcus saprophyticus*, and *Staphylococcus aureus* (Tariq *et al*., 2021; Mancuso *et al*., 2023). These organisms possess various pathogenic mechanisms that facilitate colonization, persistence, and tissue invasion within the urinary tract. The increasing emergence of antimicrobial resistance among uropathogens has become a critical challenge in the management of UTIs. Widespread misuse of antibiotics, self-medication, and non-adherence to prescribed regimens contribute significantly to this growing problem (Ahmed & Bello, 2020). Resistance to commonly prescribed antibiotics, including amoxicillin, augmentin, and fluoroquinolones, has been widely reported, leading to therapeutic failures and increased healthcare costs (Tariq *et al*., 2021).

Despite the high prevalence and clinical significance of urinary tract infections, continuous surveillance of the bacterial aetiology and antibiotic susceptibility patterns among female university students remains essential for effective disease management and infection control. Such studies provide updated epidemiological data that guide empirical treatment, promote rational antibiotic use, and support public health interventions. Therefore, this study was undertaken to determine the occurrence and antibiotic susceptibility pattern of bacterial pathogens isolated from urine samples of female students residing in the Kaduna State University hostel.

https://dx.doi.org/10.4314/swj.v21i1.49

MATERIALS AND METHODS

Study Area

This study was conducted at Kaduna State University, Kaduna, Nigeria. The institution is located in the North-Western region of Nigeria and comprises students from diverse socio-economic and cultural backgrounds. Urine samples were obtained from female students residing in the university hostels, which provide communal living conditions and shared sanitary facilities that may influence the occurrence and transmission of urinary tract infections.

Sample Size Determination

The required sample size was calculated using Cochran's formula (Cochran, 1977)

$n=Z^2 \times P(1-P)/d^2$

Where:

Z= 1.96 (for 95% confidence level)

P= 0.146 (prevalence = 14.6% as reported by Alfa, Theresa and Umar 2022)

d= 0.05 (desired margin of error = 5%)

Calculation:

$n= (1.96)^2 \times 0.146 \times (1 - 0.146)/ (0.05)^2$

$n= 3.8416 \times 1.461 \times 0.854/ 0.0025$

$n= 0.479/0.0025$

$n= 191.6 \approx 192$

However, due to financial constraints, only 40 urine samples were collected and analysed in this study.

Collection of Samples

A total of 40 early morning midstream urine samples were collected from female hostel students at Kaduna State University. Participants were properly instructed on the correct method of urine collection to minimize contamination. Each participant was provided with a sterile, wide-mouthed universal container, and approximately 10-20 mL of midstream urine was collected aseptically. The samples were appropriately labelled and transported immediately to the microbiology laboratory for analysis.

LABORATORY ANALYSIS

Preparation of Culture Media

Cystine Lactose Electrolyte Deficient (CLED) agar and MacConkey agar were prepared according to the manufacturer's instructions. The required quantities of the dehydrated media were weighed, dissolved in distilled water, and sterilized by autoclaving at 121°C for 15 minutes. The media were allowed to cool to about 50°C before being aseptically poured into sterile Petri dishes and left to solidify.

Culture of Urine Samples

Using a sterile wire loop, urine samples were inoculated onto CLED and MacConkey agar plates by the streak plate technique under aseptic conditions. The inoculated plates were incubated aerobically at 37°C for 24 hours. After incubation, plates were examined for bacterial growth and colony morphology, including size, shape, colour, and elevation (Cheesbrough, 2006).

Subculture of Isolates

Distinct colonies were subcultured onto fresh CLED agar plates to obtain pure isolates. The plates were incubated at 37°C for 24 hours to ensure culture purity before further identification tests were carried out.

Gram Staining and Microscopy

Smears of pure bacterial isolates were prepared on clean glass slides, air-dried, heat-fixed, and stained with the Gram stain. The stained slides were examined microscopically under oil immersion (×100 objective lens) to determine the Gram reaction, morphology, and cellular arrangement of the isolates (Cheesbrough, 2006).

Biochemical Characterization of Isolates

The bacterial isolates were further identified using standard biochemical tests, including the indole test, methyl red (MR), Voges-Proskauer (VP), citrate utilisation test, triple sugar iron (TSI) agar test, and catalase test. These tests were performed according to standard microbiological procedures. The results were interpreted using established biochemical identification criteria for bacterial pathogens (Cheesbrough, 2006).

Antibiotic Susceptibility Testing

Antibiotic susceptibility testing was carried out using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar. Pure isolates were emulsified in sterile normal saline, and the turbidity was adjusted to match the 0.5 McFarland standard. The standardized inoculum was evenly spread onto the surface of Mueller-Hinton agar plates using sterile swab sticks. Antibiotic discs were aseptically placed onto the inoculated plates using sterile forceps and gently pressed to ensure proper contact. The plates were incubated aerobically at 37°C for 24 hours.

After incubation, the diameters of zones of inhibition were measured in millimetres using a transparent ruler. The results were interpreted as sensitive, intermediate, or resistant according to the Clinical and Laboratory Standards Institute (CLSI, 2024) guidelines.

RESULTS

A total of 40 urine samples were collected from female hostel students of Kaduna State University and analyzed for the presence of bacterial pathogens. Of these, 32 samples (80%) showed significant bacterial growth, while 8 samples (20%) showed no growth. Four bacterial species were isolated and identified, namely *Escherichia coli*, *Proteus mirabilis*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus*.

The colonial morphology and Gram reaction of the bacterial isolates are presented in Table 1. On MacConkey agar, *Escherichia coli* produced pink colonies, indicating lactose fermentation, whereas Proteus mirabilis and Pseudomonas aeruginosa produced pale or colourless colonies, indicating non-lactose fermentation. On CLED agar, *E. coli* appeared as yellow colonies, *Proteus mirabilis* produced bluish-green colonies, and *Pseudomonas aeruginosa* showed greenish colonies. *Staphylococcus aureus* formed golden-yellow colonies on CLED agar. Gram staining revealed that *E. coli*, *Proteus mirabilis*, and *Pseudomonas aeruginosa* were Gram-negative bacilli, while *Staphylococcus aureus* appeared as Gram-positive cocci arranged in clusters.

The biochemical characteristics of the bacterial isolates are presented in Table 2. *Escherichia coli* showed positive reactions to indole and methyl red tests, while being negative for Voges–Proskauer and citrate tests. It produced an acid slant/acid butt (A/A) with gas production and no hydrogen sulfide (H_2S) on TSI agar, and was catalase-positive. *Proteus mirabilis* was indole negative, methyl red positive, Voges–Proskauer negative, and citrate negative, with alkaline slant/acid butt (K/A), gas production, and H_2S production on TSI agar, and was catalase positive. *Pseudomonas aeruginosa* was indole-, methyl red-, and Voges–Proskauer-negative but citrate-positive, showing an alkaline slant/alkaline butt (K/K) with no gas or H_2S production on TSI agar, and was catalase-positive. *Staphylococcus aureus* was indole and methyl red negative but Voges–Proskauer positive, citrate negative, produced acid slant/acid butt (A/A) with no gas or H_2S, and was catalase positive.

The frequency distribution of bacterial species isolated from urine samples of female hostel students is presented in Table 3. Among the 32 positive samples, *Escherichia coli* had the highest frequency, with 13 isolates (40.6%), followed by Proteus mirabilis, with 9 isolates (28.1%), Pseudomonas aeruginosa, with 6 isolates (18.8%), and Staphylococcus aureus, with 4 isolates (12.5%). This indicates that *E. coli* was the predominant uropathogen isolated in this study.

The antibiotic resistance profile of the bacterial isolates is presented in Table 4. The isolates exhibited varying degrees of resistance, intermediate response, and susceptibility to the tested antibiotics. *Escherichia coli* showed high resistance to most antibiotics, including amoxicillin, augmentin, ciprofloxacin, tarivid, pefloxacin, sparfloxacin, cefozamine, but remained sensitive to azithromycin and gentamicin, with intermediate response to levofloxacin. *Proteus mirabilis* demonstrated high resistance to nearly all antibiotics tested, showing intermediate susceptibility only to levofloxacin, indicating multidrug resistance. *Pseudomonas aeruginosa* exhibited moderate susceptibility, showing sensitivity to azithromycin, augmentin, gentamicin, ciprofloxacin, and tarivid, and resistance to pefloxacin, sparfloxacin, and cefozamine, with an intermediate response to levofloxacin. *Staphylococcus aureus* showed high susceptibility to azithromycin, amoxicillin, gentamicin, ciprofloxacin, levofloxacin, and rocephin; moderate susceptibility to pefloxacin, ampiclox, and erythromycin; and resistance to zinnacef.

Table 1: Colonial Morphology and Gram Reaction of Bacterial Isolates

Isolates	CLED Agar	MacConkey Agar	Gram Reaction	Probable Bacteria
1	Opaque yellow colonies with a slightly deeper yellow center	Pink to deep red colonies, slightly surrounded by a pinkish halo	Gram-negative, rod-shaped,	*Escherichia coli*
2	Light Green colonies with typical matte surface	Translucent colonies, slightly green	Gram-negative, rod-shaped,	*Proteus mirabilis*
3	Deep yellow colonies, uniform in colour on yellow medium	No growth	Gram-positive, cocci-shaped in clusters	*Staphylococcus aureus*
4	Blue to greenish colonies with a fishy smell	Colourless to pale yellow colonies	Gram-negative, rod-shaped,	*Pseudomonas aeruginosa*

Table 2: Biochemical Characteristics of Bacterial Isolates

Probable Bacteria	Indole	MR	VP	Citrate	TSI	Catalase
Escherichia coli	+	+	-	-	A/A,Gas +, H2S -	+
Proteus mirabilis	-	+	-	-	K/A, Gas +, H2S +	+
Pseudomonas aeruginosa	-	-	-	+	K/K, Gas -, H2S -	+
Staphylococcus aureus	-	-	+	-	A/A, Gas -, H2S -	+

Keys: - Negative + Positive
MR = Methyl Red
VP = Voges-Proskauer
TSI = Triple Sugar Iron

Table 3: Frequency of Occurrence of the Bacterial Species Isolated From Urine Samples of Female Students at Kaduna State University Hostel

Organism	Frequency	Percentage (%)
Escherichia coli	13	40.6
Proteus mirabilis	9	28.1
Pseudomonas aeruginosa	6	18.8
Staphylococcus aureus	4	12.5
Total	**32**	**100**

Table 4: Antibiotic Resistance Profile of the Bacterial Species Isolated From Urine Samples of Female Students at Kaduna State University Hostel

S/N	Probable Bacteria	AZ (12ug)	AM (30ug)	AU (10ug)	CN (30ug)	CPX (30ug)	LEV (20ug)	OFX (10ug)	PEF (30ug)	SP (10ug)	CF (10ug)	Z (20ug)	R (25ug)	APX (30ug)	E (10ug)
1	*Escheria coli*	S	R	R	S	R	I	R	R	R	R	-	-	-	-
2	*Proteus mirabilis*	R	R	R	R	R	I	R	R	R	R	-	-	-	-
3	*Pseudooas aerugenosa*	S	R	S	S	S	I	S	R	R	R	-	-	-	-
4	*Staphylococcus aureua*	S	S	-	S	S	S	-	I	-	-	R	S	I	I

Keys: S = Sensitive, I = Intermediate, R = Resistant (Interpretation based on CLSI 2024 guidelines)

Azithromycin (AZ)	≥21mm(S)	16-20mm(I)	≤15mm(R)
Amoxicillin (AM)	≥20mm(S)	17-19mm(I)	≤16mm(R)
Augmentin (AU)	≥18mm(S)	14-17mm(I)	≤13mm(R)
Gentamycin (CN)	≥15mm(S)	13-14mm(I)	≤12mm(R)
Ciprofloxacin (CPX)	≥21mm(S)	16-20mm(I)	≤15mm(R)
Levofloxacin (LEV)	≥21mm(S)	17-20mm(I)	≤16mm(R)
Tarivid (OFX)	≥21mm(S)	16-20mm(I)	≤15mm(R)
Perfloxacin (PEF)	≥21mm(S)	16-20mm(I)	≤15mm(R)
Sparfloxacin (SP)	≥22mm(S)	17-21mm(I)	≤16mm(R)
Cefotaxim (CF)	≥22mm(S)	19-21mm(I)	≤18mm(R)
Zinnacef (Z)	≥22mm(S)	19-21mm(I)	≤18mm(R)
Rocephin (r)	≥23mm(S)	20-22mm(I)	≤19mm(R)
Ampicolx (APX)	≥20mm(S)	17-19mm(I)	≤16mm(R)
Erythromycin (E)	≥23mm(S)	14-22mm(I)	≤13mm(R)

DISCUSSION

This study investigated the occurrence and antibiotic resistance profile of bacterial pathogens isolated from urine samples of female students residing in Kaduna State University hostels. The findings revealed a high prevalence of urinary tract infection (80%), highlighting UTIs as a major public health concern among young women in communal living environments. Similar high prevalence rates among female students have been reported by Alfa, Theresa and Umar (2022), who attributed this trend to overcrowding, poor sanitary facilities, delayed urination, and inadequate hygiene practices in hostel settings.

Among the bacterial isolates, *Escherichia coli* was the most predominant pathogen (40.6%). This agrees with findings from Alfa, Theresa, and Umar (2022) and other studies, which consistently report *E. coli* as the leading cause of community-acquired UTIs. The dominance of *E. coli* is attributed to its abundance in the gastrointestinal tract, the proximity of the female urethra to the anus, and its virulence factors, such as adhesins and fimbriae, which enhance its ability to colonise uroepithelial cells (Flores-Mireles *et al.*, 2015; Mancuso *et al.*, 2023). *Proteus mirabilis* was the second most frequently isolated organism (28.1%), comparable to the findings of Alfa, Theresa, and Umar (2022). The high occurrence of *Proteus* species may be linked to poor sanitation and environmental contamination, particularly in communal hostel settings. *Proteus* produces urease, an enzyme that hydrolyzes urea to ammonia, thereby increasing urine pH and creating an alkaline environment that supports bacterial survival and persistence (Flores-Mireles *et al.*, 2015).

Pseudomonas aeruginosa accounted for 18.8% of the isolates. This organism is known to thrive in moist environments and contaminated water sources, making it common in settings with poor hygiene practices, damp clothing, and unsanitary bathrooms, which are frequent challenges in student hostels (Tariq *et al.*, 2021; Mancuso *et al.*, 2023). *Staphylococcus aureus*, representing 12.5% of isolates, is part of the normal flora of the skin and mucous membranes. Its isolation may be attributed to skin contamination, improper sample collection techniques, inadequate genital hygiene, or sexual activity, which can facilitate bacterial entry into the urinary tract (Ahmed & Bello, 2020).

The antibiotic susceptibility pattern of bacterial isolates in this study revealed varying levels of resistance, intermediate susceptibility, and sensitivity across the tested antibiotics, highlighting the

https://dx.doi.org/10.4314/swj.v21i1.49

growing challenge of antimicrobial resistance among uropathogens. *Escherichia coli* demonstrated high resistance to amoxicillin, augmentin, ciprofloxacin, ofloxacin, perfloxacin, sparfloxacin, and cefozamine, while showing sensitivity to azithromycin and gentamicin, and intermediate susceptibility to levofloxacin. This resistance pattern may be attributed to the widespread misuse and over-the-counter availability of antibiotics, leading to selective pressure and emergence of resistant strains (Eze & Obi, 2021). The preserved sensitivity to gentamicin suggests that aminoglycosides remain effective options in the treatment of UTIs caused by *E. coli*. *Proteus mirabilis* exhibited extensive multidrug resistance, showing resistance to nearly all tested antibiotics except levofloxacin, to which it showed intermediate susceptibility. This high resistance profile may be linked to intrinsic resistance mechanisms, enzyme production, and prolonged exposure to commonly prescribed antibiotics (Tariq *et al*., 2021). The multidrug-resistant nature of *Proteus mirabilis* presents significant therapeutic challenges, particularly in complicated urinary tract infections.

Pseudomonas aeruginosa showed sensitivity to azithromycin, augmentin, gentamicin, ciprofloxacin, and ofloxacin, intermediate susceptibility to levofloxacin, and resistance to amoxicillin, perfloxacin, sparfloxacin, and cefozamine. The resistance to β-lactam antibiotics and some fluoroquinolones reflects the organism's inherent low membrane permeability and active efflux systems, which limit antibiotic effectiveness (Tariq *et al*., 2021). However, its sensitivity to gentamicin and selected fluoroquinolones indicates that these drugs remain viable therapeutic options.

Staphylococcus aureus isolates were largely sensitive to azithromycin, amoxicillin, gentamicin, ciprofloxacin, levofloxacin, and rocephin, while showing intermediate susceptibility to perfloxacin, ampiclox, and erythromycin, and resistance to zinnasef. The relatively high susceptibility observed may indicate a lower prevalence of multidrug-resistant strains within the study population. Similar susceptibility patterns have been reported among *Staphylococcus aureus* isolates in community-acquired UTIs (Eze & Obi, 2021).

Overall, the antibiotic resistance pattern observed in this study underscores the growing public health concern of antimicrobial resistance, particularly among Gram-negative uropathogens. These findings highlight the urgent need for routine antimicrobial susceptibility testing, rational antibiotic prescription, public health education, and strict regulation of antibiotic sales to reduce misuse and curb the spread of resistant strains.

Conclusion

This study investigated the prevalence, bacterial aetiology, and antimicrobial susceptibility patterns of urinary tract infections (UTIs) among female students of Kaduna State University. The findings revealed a notable incidence of UTIs, underscoring the ongoing public health relevance of this infection among young adult females, particularly in university settings. The predominant bacterial isolates identified in this study were *Escherichia coli*, *Staphylococcus aureus*, *Proteus mirabilis*, and *Pseudomonas aeruginosa*. Among these, *E. coli* was the most frequently isolated organism, consistent with existing literature and confirming its role as the primary causative agent of UTIs. The presence of other uropathogens further emphasizes the diversity of bacterial agents responsible for UTIs in this population. Antibiotic susceptibility testing demonstrated varying degrees of sensitivity and resistance among the isolated organisms. While some antibiotics were effective, resistance was observed to commonly used antimicrobial agents. This pattern raises concerns about the increasing problem of antimicrobial resistance and underscores the need for routine culture and sensitivity testing prior to antibiotic prescription. Empirical treatment without laboratory guidance may contribute to treatment failure and further promote resistance.

Overall, the findings of this study highlight the importance of continuous surveillance of uropathogens and their antibiotic susceptibility patterns. There is a need for improved awareness of personal hygiene, proper health-seeking behaviour, and the rational use of antibiotics among female students. These measures will contribute significantly to the prevention, effective management, and reduction of complications associated with urinary tract infections.

REFERENCES

Alfa, S., Theresa, A. A. & Umar, Z. (2022). *Prevalence of urinary tract infections among students residence in Nicon Hostel, Federal Polytechnic Bida, Niger State, Nigeria. BIOMED Natural and Applied Science,* 2(3), 1–9. https://doi.org/10.53858/bnas02030109

Ahmed, R.& Bello, H. (2020). Awareness and prevention of urinary tract infections among students. *Journal of Public Health Education*, 12(3), 215–221.

Eze, N. & Obi, C. (2021). Misuse of antibiotics in rural Nigeria. *Journal of Pharmaceutical Studies*, 19(4), 203–211.

Flores-Mireles, A. L., Walker, J. N., Caparon, M., & Hultgren, S. J. (2015). Urinary tract infections: Epidemiology, mechanisms of infection and treatment options. *Nature Reviews Microbiology*, 13(5), 269–284.

Mancuso, C. A., Tan, T. L. & Osei, A. (2023). Environmental factors associated with UTIs. *African Journal of Infectious Diseases*, 17(1), 92–98.

Tariq, M., Idris, A. & Yusuf, A. (2021). Patterns of antibiotic resistance among uropathogens. *International Journal of Microbiology and Infectious Diseases*, 25(2), 78–85.

Gupta, K., Hooton, T. M., Naber, K. G., Wullt, B., Colgan, R., Miller, L. G., & Soper, D. E. (2011). International clinical practice guidelines for the treatment of acute uncomplicated cystitis and pyelonephritis in women. *Clinical Infectious Diseases*, 52(5), e103–e120. https://doi.org/10.1093/cid/ciq257

Akande, M. & Balogun, R. (2021). Clinical evaluation and treatment of urinary infections. *West African Medical Journal*, 27(2), 75–84.

Bakare, F. & Lawal, M. (2021). Knowledge, attitudes and practices of students on UTI prevention. *Public Health in Nigeria,* 10(4), 89–95.

Tan, Y. & Musa, F. (2020). Behaviour and lifestyle are correlated with UTIs. *African Public Health Research*, 9(2), 45–58.

Clinical and Laboratory Standards Institute (CLSI). Performance Standards for Antimicrobial Susceptibility Testing. *CLSI Supplement M100,* 34th ed. CLSI; 2024.

Garnett, A., & Fields, M. (2020). Women's health and hygiene. *Journal of Medical Education and Practice*, 17(2), 140–148.

Cochran, W. G. (1977). *Sampling Techniques*. 3rd ed. New York: John Wiley & Sons.

Cheesbrough, M. (2006). *District Laboratory Practice in Tropical Countries*, Part 2. 2nd ed. Cambridge: Cambridge University Press.