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Occurrence and antimicrobial resistance patterns of bacterial and fungal pathogens from patients with urinary tract infections in Ojo, Lagos Nigeria

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Abstract

Urinary tract infections (UTIs) is a common bacterial and fungal infection affecting millions of people globally. The aim of this study was to investigate the distribution and antimicrobial susceptibility patterns of bacteria and fungi from patients with UTI.

Urine samples were collected aseptically from patients with symptoms of UTI in sterile universal containers from five hospitals in a period of three months. A total of 200 urine samples from 75 males and 125 females were analyzed and subjected to culture, biochemical identification and antimicrobial susceptibility testing using the Kirby-Bauer technique. Fungal isolates were identified based on cultural characteristics, lactophenol cotton blue stain, chlamydospore formation, and colony colour on CHROM agar Candida medium.

Most samples were positive for one microorganism each and a few had two isolates, thus giving a frequency of 210 microbial isolates. The most commonly isolated bacteria were *Escherichia coli,* 71(34%), followed by *Staphylococcus aureus,* 63(30%), *Enterobacter* spp., 32(15.2%), *Klebsiella* spp., 17(8.1%), *Proteus mirabillis,* 15(7.1%) and *Candida albicans* 12(5.7%), being the only fungus isolated. Antimicrobial susceptibility testing showed that *Escherichia coli* showed 57.7% susceptibility to streptomycin. *Klebsiella* spp. were 70.5% susceptible to septrin, but with susceptibility as low as 47.1% to chloramphenicol. *Enterobacter* spp. showed 71.9% susceptibility to septrin, 68.8% to gentamycin, 59.4% to streptomycin and chloramphenicol, 53.1%. *Proteus* spp showed 53.5%, and 66.7% to pefloxacin, septrin and streptomycin respectively. *Staphylococcus aureus* showed susceptibility of 56(88.9%), 55(87.3%), and 47 (74.6%) to gentamicin, ciprofloxacin. and pefloxacin respectively. *Candida albicans* was highly susceptible to nystatin, fluconazole and miconazole by 7(58.3%) but was highly resistant to ketoconazole, 41.7%.

The findings of this study provide valuable information on the distribution of bacterial and fungal agents that are common etiology of UTIs, and likely antimicrobial drugs for the treatment of UTIs.

Keywords: Urinary Tract Infections; Resistance; Bacteria; Fungi; Antibiotic; Antifungal

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1 Introduction

Urinary tract infection (UTI) is a common bacterial and fungal infection that affects individuals of all ages and genders worldwide. It is a significant public health concern due to its high prevalence, morbidity, and mortality rates. Nigeria, like other developing countries, has a high burden of UTI, with a prevalence rate of up to 50% in some communities. The emergence of drug-resistant strains of bacteria and fungi has further complicated the management of UTIs in Nigeria [1]. The prevalence and antimicrobial susceptibility patterns of bacteria and fungi from patients with UTI in Nigeria have been the subject of several studies.

The distribution of UTIs in the population is affected by factors such as age, sex, catheterization, hospitalization and prolonged use of antimicrobials depending on the environment of the people. Bacteria represent the main cause of UTIs, although viruses, fungi and parasites may be involved in the development of this infection [2]. Gram-negative bacterial pathogens are responsible for up to 90% of UTI cases, while Gram-positive bacteria are responsible for the other 10%. The examination of the patient's clinical symptoms of UTIs are based on the anatomical district, the microorganisms, severity of the infection and the patient's immune system [3][4].

There is a worldwide setback in the management of many bacterial and fungal infections due to antimicrobial resistance. It is estimated that globally, 26% of deaths are due to infectious diseases such as UTIs of which 98% occur in low-income countries [5]. Unfortunately, Nigeria is among the low-income countries thus bears the impact and burden of urinary tract infections. In Nigeria, limited studies are available regarding the prevalence and antimicrobial susceptibility patterns of bacterial and fungal etiology of UTIs. The extensive and inappropriate use of antimicrobial agents have invariably resulted in the development of antibiotic resistance which, in recent years, has become a major problem worldwide [6].

Antibiotics resistance is on the increase are because of their frequent and indiscriminate use in medical treatments. The emergence of resistant and multidrug resistant uropathogens coupled with the decline in the number of new antibiotics available for the treatment of UTIs had resulted in a major healthcare challenge [7]. A study conducted with 12,458 urine samples in Nigeria, reported the prevalence of nosocomial and community-acquired UTIs were 9.3% and 12.3% respectively, with the. Prevalence in females and males were 14.6% and 7.4% respectively [8]. Nigerians are at risk of developing an epidemic of bacterial resistance due to self-prescription and default on medication. Patients who suspect that they have UTI often get over-the-counter drugs without laboratory tests, which inadvertently leads to antibiotic resistance which is currently a threat.

The study investigates the prevalence and antimicrobial susceptibility patterns of bacteria and fungi from patients with UTI within Lagos. This study has provided insights into the epidemiology and microbiology of UTI in Nigeria and has helped to guide the selection of appropriate antimicrobial therapy [9].

2 Materials and methods

2.1 Description of the study area

Urine samples were collected from three different hospitals and two different laboratories within and around Alimosho Local Government Area and its environment. Alimosho lies on the Latitude 6°36'N and Longitude 3°17'E with an estimated total population of 11,456,783. The samples were collected from the following areas: Alimosho General Hospital, Igando (40), LASU Health Center (40), Pons Medical Diagnostic Center (40), Juta Laboratory and Blue-Sky Hospital (80). The different areas where the samples were collected ensure absolute randomization.

2.2 Collection of Samples

A total of 200 samples of urine from hospital patients were collected and 50 samples from apparently healthy individuals as control. The samples were collected from both male and female patients of all ages aseptically in a labeled sterile universal container and were transported to the laboratory for microbiological analysis within 2 hours. Demographic information relating to sex, age, sexual exposure, educational status, marital status, etc., was collected from patients and control using a well-structured questionnaire.

2.3 Identification of Bacterial isolates

Colonies on selective media which included blood agar, MacConkey agar, Mannitol salt agar, Sabouraud dextrose agar and ChroM Candida agar were inoculated with a loopful of urine samples, inoculated into buffered peptone water, which was incubated at 37 °C for 24 hours. Bacteria were identified and characterized using morphology, Gram staining reaction and biochemical tests, such as catalase, coagulase, indole, urease, oxidase, citrate utilization, methyl red and Voges Proskauer tests were carried out according to [10].

2.4 Antimicrobial Susceptibility Testing

Sensitivity test was performed following modified Kirby-Bauer disc diffusion method as recommended by National Committee for Clinical Laboratory Standards [10]. An 18-24 hour old culture of pure bacterial isolates was inoculated onto Mueller Hinton agar after standardization with MacFarland's standard Discs containing the following antibacterial agents and concentrations were used: Septrin (30μg), Chloramphenicol (30μg), Ciprofloxacin (30μg), Amoxacillin (30μg), Augmentin (10μg), Pefloxacin (10μg), Gentamycin (30μg), against Gram negative bacteria and Pefloxacin (10μg), Gentamycin (10μg), Ampiclox (30μg), Zinnacef (20μg), Amolxacillin (30μg), against Gram positive bacteria. The plates were incubated at 37 °C for 24 hours after which the zones of inhibition were measured in millimeters. Using the interpretative chart derived from the zones of inhibition of standard organisms according to the Clinical Laboratory Science Institute [10]. The zone size of each antimicrobial agent was interpreted.

2.5 Mycological Analysis

2.5.1 Identification of fungal isolates

Germ tube test

The suspension of pure Candida isolate was made by inoculating a test tube containing 0.5 ml of human serum with a loopful of the organism. It was then incubated in a water bath for 2-4 hours at 37°C. A wet preparation was made by transferring an aliquot of the suspension onto a clean glass slide and covered with a coverslip. This was examined using magnification of x10 and x40 objective lenses respectively. The presence of elongated daughter cells from the mother cells without constriction at the origin of mother cells was noted as pseudohyphae, both were positive indications for *Candida albicans* [10][11].

Chlamydospore formation test

Test colonies were stabbed-inoculated on cornmeal agar plate by slide culture technique and were incubated for 72 hours at 25°C. Chlamydospore formation was demonstrated by staining with lactophenol cotton blue. Yeast isolates found to be positive for chlamydospore formation were further confirmed as *Candida albicans* while those showing negative results were recorded as non- albicans *Candida* spp. [11].

2.5.2 Preparation of Standardised Inoculum

The CLSI guidelines were used to prepare $BaSO_4$ turbidity standard (0.5 McFarlands standard). Briefly, 99.5 ml of solution A (1% v/v H_2SO_4) was added to 0.5 ml of solution B (1.17% w/v $BaCl_2.2H_2O$) with constant stirring. Using matched curvette with a 1.0 cm path, the OD (625nm) was measured on the spectrophotometer. The 0.5 McFarland standard was distributed into a disposable screw-capped universal bottle. From potatoe dextrose agar (PDA) plate, a discrete colony of test organisms was suspended in sterile distilled water and agitated briefly to homogenize. The yeast density which gave an OD (625 nm) equivalent to that of 0.5 McFarland standard was referred to as the standardization inoculum [12].

2.5.3 Antifungal Susceptibility Test

The antifungal susceptibility test was carried out using discs each containing 30μg of nystatin, fluconazole, amphotericin B, ketoconazole and miconazole was based on the CLSI disc diffusion method [10]. Mueller Hinton glucose methylene blue agar surface was inoculated by using a sterile swab dipped into a standard Candida cell suspension which was allowed to dry. The antifungal disc was dispensed on the inoculated plates and the sensitivity plates were measured and interpreted according to the CLSI interpretative break point after 18-24 hours of incubation.

3 Results

The demographic data of the subjects showed that majority of the participants were females (62.5%) and male (37.5%). Considering the specific age groups of the patients sampled; a higher prevalence rate of 130(65%) was observed in patients within the age group of 19-39 years while a lower occurrence rate (14.5%) was observed in the age group of people less or equal to 18 years, 110(55%) married and 118(59%) people who stopped their education at the secondary level (Table 1). The antibiotic resistance patterns of the bacteria are shown in Figures 2 to 6, while the antimicrobial resistance pattern is shown in Figure 7.

E. coli showed high resistance to the antibiotics tested with 94.3% to amoxicillin, pefloxacin (88.7%), and augmentin (83.2%), and was only susceptible to streptomycin (Figure 2). Figure 3 shows the resistance patterns of Enterobacter spp. with 100% resistance to ciprofloxacin and amoxicillin, 81.3% to pefloxacin and was least resistant to chloramphenicol (53.1%) (Figure 3). Klebsiella spp. showed 100% amoxicillin, streptomycin (94.2%), ciprofloxacin and augmentin, (76.5%), but least resistant to streptomycin (59.4%) (Figure 4). The antimicrobial resistance pattern of Proteus mirabilis showed 100% resistance to amoxicillin, augmentin (80%), gentamicin (73.3%), but least resistant to pefloxacin (Figure 5). S. aureus which was the only Gram positive bacterium recovered showed 96.5% resistance to zinnacef, amoxicillin (90.5%), and ampiclox (85.7%) but susceptible to rocephin (Figure 6). *Candida albicans* showed a high resistance to ketocanozole, but susceptible to miconazole, fluconazole and Nystatin (Figure 7).

Table 1 Demographic Characteristics of Subjects in Ojo, Lagos

Variables	Number	Percentages (%)
SEX		
Male	75	37.5
Female	125	62.5
AGE CATEGORIES		
Less or equal to 18 years	29	14.5
19 to 39	130	65
40 to 59	41	20.5
EDUCATIONAL STATUS		
Secondary	118	59
Tertiary	82	41
MARITAL STATUS		
Single	110	55
Married	83	41.5
Widowed	7	305

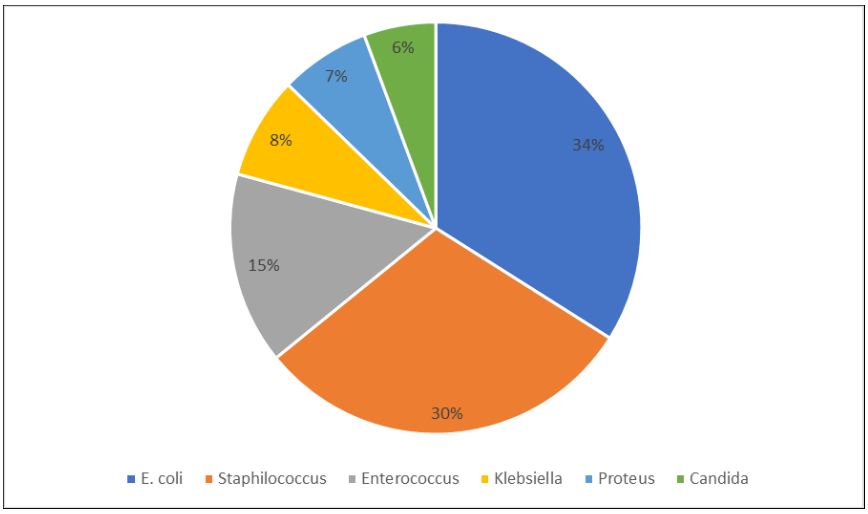


Figure 1 Distribution and pattern of isolates from patients

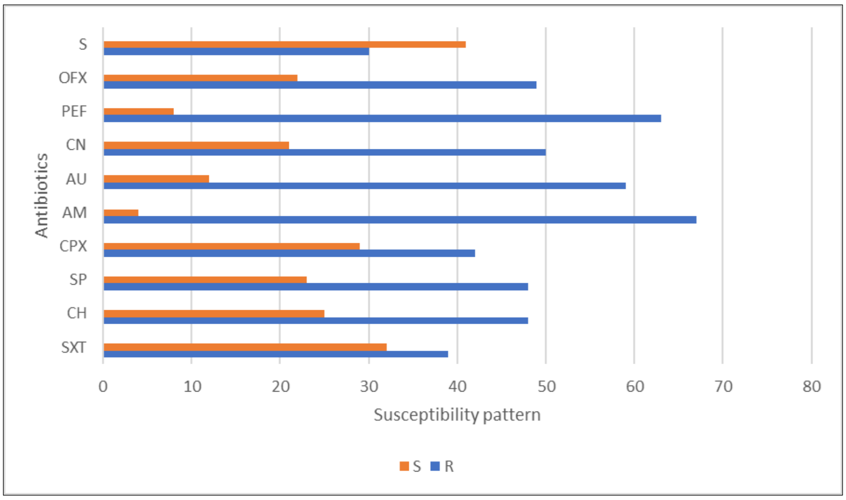


Figure 2 Antibiotic susceptibility pattern of *Escherichia coli*

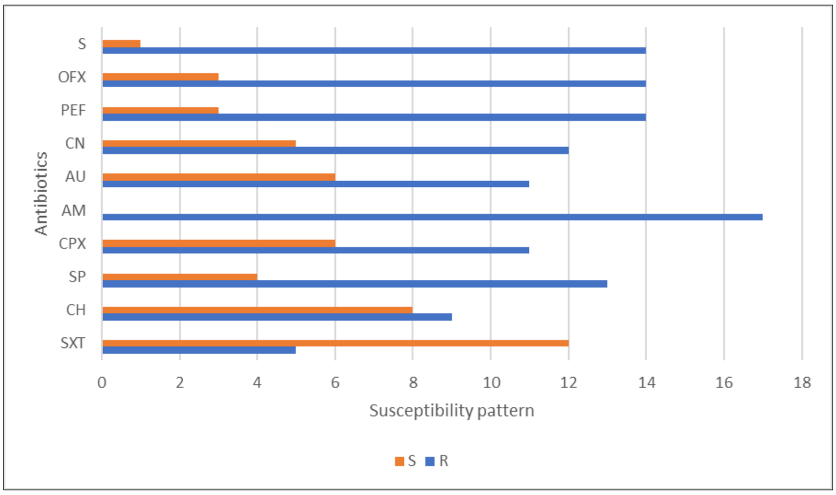


Figure 3 Antibiotic susceptibility pattern of *Klebsiella* spp

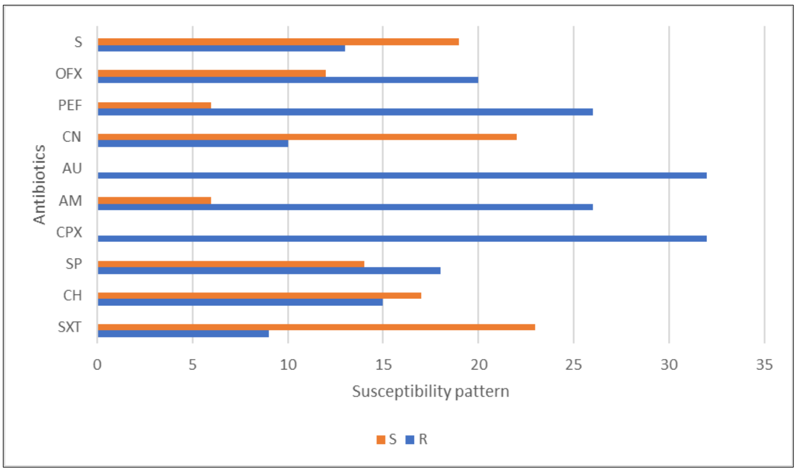


Figure 4 Antibiotic susceptibility pattern of *Enterobacter* spp

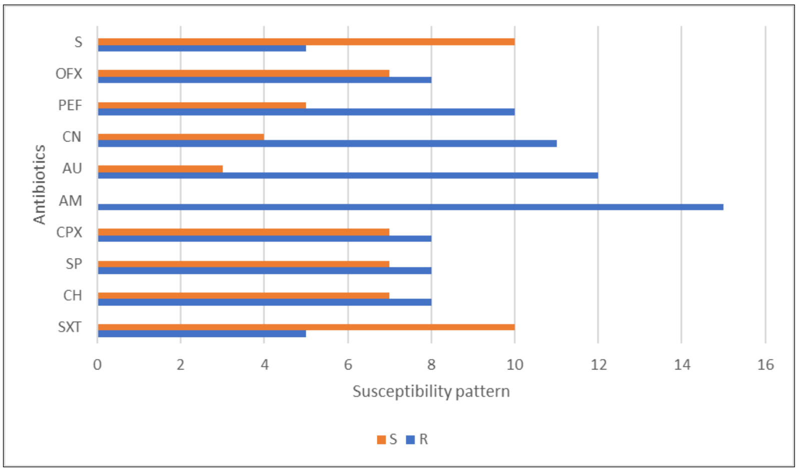


Figure 5 Antibiotic susceptibility pattern of *Proteus mirabillis*

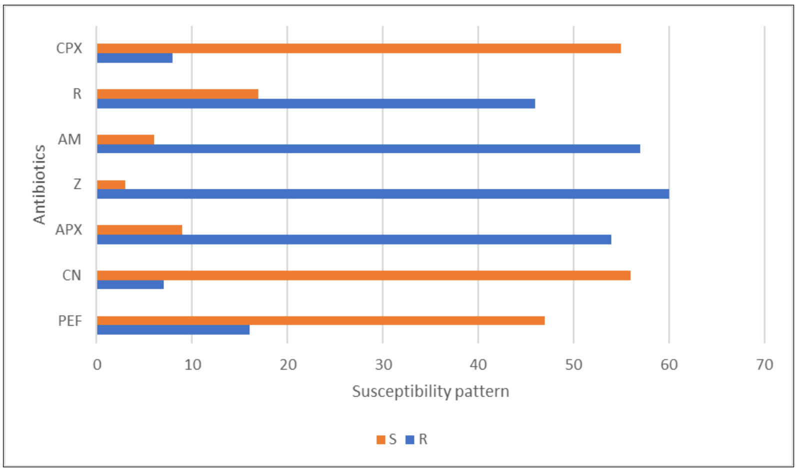
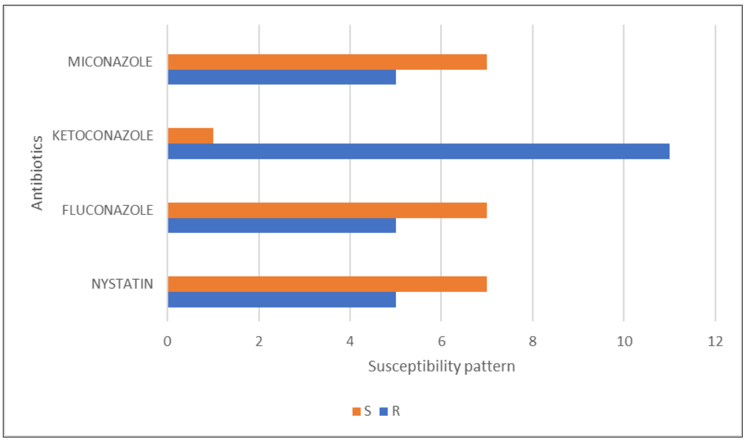


Figure 6 Antibiotic susceptibility pattern of *Staphylococcus aureus*



KEY: SXT - SEPTRIN, CH - CHLORAMPHENICOL, SP - SPARFLOXACIN, CPX - CIPROFLOXACIN, AM - AMOXACILLIN, AU - AUGMENTIN, CN - GENTAMYCIN, PEF - PEFLOXACIN, OFX - OFLOXACIN, S - STREPTOMYCIN, APX - AMPICLOX, Z - ZINNACEF, R - ROCEPHIN. S = Susceptibility, R=Resistance.

Figure 7 Antifungal susceptibility pattern of *Candida albicans*

4 Discussion

Due to the high incidence of infection in the community and hospital environment, urinary tract infections have placed a huge burden on the health system [13]. Effective treatment of patients with bacterial urinary tract infections is usually based on the identification of the pathogens and selection of effective antibiotics through continuous monitoring of the antimicrobial susceptibility pattern of urinary tract pathogens in specific areas [14].

In this study, there was high prevalence of significant uropathogenic microorganisms in 200 samples among the UTI patients. All samples revealed significant growth for various species of bacteria while a few revealed significant growth of bacteria and fungi at once. The most commonly encountered agents from urinary tract infections vary; as almost all of them have a single type of microorganism. The Gram negative bacteria constituted the largest group with a prevalence of 135(67.5%) followed by Gram positive bacteria which constituted 65(32.5%) and the least by yeast 12(6%). The high prevalence of uropathogens may be due to factors like pregnancy, lower socio-economic status, and lack of personal hygiene which are common among Nigeria young men and women living in the urban centers.

The high prevalence of UTI among female participants may be due to females having a shorter and wider urethra which is proximate to the anus, lack of prostatic fluid which acts as an antimicrobial agent and having moist and warm urethra which could be supportive for the original growth of bacteria and fungi compared to males [15]. The locations of the urethra and vagina openings are far less effective in the prevention of bacterial and fungal entry. This may account for the low incidence of UTIs among men in this study. An unhygienic manner of wiping the anus from back to front helps in inoculating the vulva and vagina with fecal pathogens. Pregnancy and sexual intercourse have been emphasized by [16] to increase the risk of UTIs as bacteria are pushed into the vagina during sex.

Escherichia coli was the most predominant causative agent of UTI accounting for 34%. This agrees with other studies by [17] at the Ahmadu Bello University Nigeria and another report by [1] in southwest Nigeria. The high incidence of *Escherichia coli* could be attributed to the fact that they are commensals of the bowels and that infections are mostly by fecal contamination due to poor hygiene and the presence of unique structures which promote colonization of the host epithelial cells within the urinary tract and prevent bacteria from urinary washing [18].

Staphylococcus aureus was recorded as the second prevalent isolated organism and the only Gram positive microorganism isolated. This disagrees with previous report by [19] on uropathogens showing *Staphylococcus aureus* as the most frequently isolated organism in patients with UTI. This may be due to differences in locations where studies were carried out and methods used by the researchers. This finding however agrees with the report on symptomatic urinary tract infection among students of Mekelle University, Northern Ethiopia [20].

Enterobacter spp. were recorded as a prevalent uropathogen in this study. The bacteria use adhesins to bind to host cells. The presence of a lipopolysaccharide (LPS) capsule can initiate a cascade of inflammation in the host cell and may further lead to sepsis. Enterobacter UTI can present dysuria, frequency, or urgency in urination [21]. The other isolates identified were in line with previous studies where Klebsiella, Proteus and Enterobacter were isolated from high school college students by [22][23].

UTIs caused by *Klebsiella* can range from mild to severe and can lead to complications if not properly managed. In severe cases, *Klebsiella* UTIs can progress to pyelonephritis (kidney infection) and bloodstream infections, which can be life-threatening, especially in immunocompromised individuals [24]. *Proteus* species, particularly *Proteus mirabilis*, are another common cause of UTIs. They are known for their ability to form urinary tract stones (crystals) and cause recurrent infections. *Proteus* UTIs are often associated with symptoms like frequent and painful urination. Additionally, the formation of urinary stones can lead to blockages, increasing the risk of kidney damage. *Proteus* UTIs can also be recurrent and challenging to treat due to the formation of biofilms by the bacteria [25]. *Candida albicans* is a common fungus found in various parts of the human body including the urinary tract and can cause infection, though, it is not a common pathogen for UTIs. Its presence in the UTI may suggest an underlying issue, such as a compromised immune system, urinary catheter use or an imbalance in the normal microbial flora.

Antimicrobial resistance is a major clinical problem in treating infections caused by different bacterial and fungal pathogens and has increased over the years. In this study. Multidrug resistance was observed in 75.4% of the isolated bacterial uropathogens. The reason for this is due to increasing irrational use of antibiotics, the transmission of resistant genes between people and people or/and animals to people and the consumption of animal products that are treated with antibiotics. Self-medication and non-compliance with medication and sales of substandard drugs may account for the rise in antibiotic resistance observed in this study. The sale of antimicrobial medications remains unregulated in Africa and is aggravated by the penetration of fake and adulterated drugs with little or no active ingredients are readily available in pharmacies and on the streets. In addition, some practitioners often prescribe antimicrobial medications based on only clinical presentations, these factors pose a serious public health threat, thus responsible for more antimicrobial drugs being rendered ineffective in treating microbial infections.

5 Conclusion

The high prevalence of multidrug-resistant bacteria and fungi in patients with UTIs in the study area is a cause for concern. The findings underscore the need for appropriate antibiotic stewardship and infection control measures to prevent the spread of resistant strains. Further studies are needed to identify the risk factors associated with the emergence and spread of antibiotic-resistant UTI pathogens in Nigeria.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

The authors declare no conflict of interest.

Statement of ethical approval

The research adheres to informed and written consent according to the Declaration of Helsinki 1964 and 1986.

Statement of informed consent

Written Informed consent was obtained from all individual participants included in the study (inclusion criteria) consisting of individuals aged less than 18 years and older than 59 years and people without formal education. Those who fall between the inclusion criteria but refused to participate in the study were excluded.

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