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RESEARCH ARTICLE

URINARY TRACT INFECTIONS PREVALENCE AMONG CANCER PATIENTS UNDERGOING CHEMOTHERAPY AND RADIOTHERAPY AT THE NATIONAL ONCOLOGY CENTRE IN SANA'A, YEMEN

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Abstract

Background and aims: Among the most prevalent bacterial infections are UTIs, especially in cancer patients with compromised immune systems. The patients' vulnerability to infection and antibiotic resistance frequently worsen these infections, making empirical treatment challenging. In order to improve the empirical treatment of UTIs with antibiotics, the study is carried out to determine the antibiotic resistance pattern of UTI bacteria among cancer patients at the National Oncology Centre.
Methods: An ongoing prospective follow-up research was conducted at the National Oncology Centre in the city of Sana'a, Yemen, from October to December 2025, involving 290 cancer patients (157 females and 133 males) aged 2 to 76, with a mean age of 32.7 years. Data on clinical, demographic, and factors influencing urinary tract infections (UTIs) were collected, followed by midstream urine samples to culture potential UTI pathogens on blood and MacConkey agar.
Results: The largest group of cancer patients is aged 26-35 years (24.1%), with a majority female representation (54.1%). Breast cancer is the most prevalent, constituting 26.9% of cases, followed by Hodgkin's lymphoma and other types at 10.7% each, with leukemia and head and neck cancer at 10%. Pathogenic strains like *Escherichia coli* and *S. saprophyticus* were the dominant causes of UTI. Antibiotic susceptibility, revealing *E. coli* shows 100% resistance to cefixime, while imipenem and meropenem maintain high sensitivity at 68.4%. *S. saprophyticus* has high sensitivity to vancomycin (95.7%) and linezolid but significant resistance to cefixime (78.3%) and augmentin (56.5%).
Conclusions: The results highlight two primary health concerns: a high prevalence of cancer among young adults (particularly females with breast cancer) and a widespread crisis of beta-lactam antibiotic resistance in UTI-causing bacteria. Overall, significant resistance to beta-lactam antibiotics was noted among isolates.
Keywords: Antimicrobial resistance, cancers, *E. coli*, *S. saprophyticus*, uro-pathogens.

INTRODUCTION

A class of disorders known as cancer is defined by aberrant cell proliferation that has the potential to spread to other body parts. Millions of new cases are diagnosed each year, making it one of the top causes of mortality globally. The World Health Organisation (WHO) estimates that there were roughly 19.3 million new cases of cancer in 2020, indicating a notable rise in the disease's prevalence[1]. The most prevalent cancers are lung cancer (about 2.5 million cases, 12.4%), colorectal cancer (about 1.9 million cases, 9.6%), stomach cancer (about 970,000 cases, 4.9%)[2-4], and breast cancer (about 2.3 million cases, 11.6%), which is the most common cancer among women globally. About 1.5 million cases (7.3%) of prostate cancer[2].

In Yemen, the most common cancers are breast cancer (31.1%), colorectal cancer (7.7%), and stomach cancer (5.0%). Other cancers, including blood cancers like leukemia, exist but are less prevalent in terms of incidence. An aging population, urbanization, and

lifestyle changes may contribute to the rising cancer rates[5,6]. Treatment modalities include surgery, which is the main curative option for localized tumors. Radiotherapy is used alone or with other treatments; advanced techniques reduce side effects. Chemotherapy is a systemic treatment; toxicity may occur, including myelosuppression and nausea. Drugs that target particular molecular alterations in cancer cells are known as targeted treatment. Immunotherapy works well for a variety of solid tumours and boosts the immune system. Hormone therapy for malignancies that are sensitive to hormones, such as prostate and breast. Palliative care improves quality of life and manages side effects[7-9].

The health of cancer patients is affected by several factors, including the type of treatment used. Chemotherapy and radiation therapy are among the common methods for treating cancer; however, they have significant side effects on the immune system[6-8]. Chemotherapy, for instance, aims to kill cancer cells but can also affect healthy cells, leading to weakened immunity and an increased risk of infections. In this context, UTI is one of the most common types of infections among cancer patients undergoing chemotherapy or radiation therapy, as these infections can be more severe and sometimes life-threatening due to compromised immunity[9].

The study was carried out to determine the antibiotic resistance pattern in UTI bacterial causes among cancer patients at the National Oncology Centre in Sana'a, Yemen.

SUBJECTS AND METHODS

An active prospective follow-up research was the methodology used. Every patient who gave their permission to take part and was seen at the National Oncology Centre in Sana'a City, Yemen, throughout the course of three months, beginning in October 2025 and ending in December 2025 (as permitted by the National Oncology Centre). 290 people with a cancer diagnosis were included in the study for its duration. Between the ages of 2 and 76, there are 157 females and 133 men, with a mean age of 32.7±16.5 years. For every cancer patient, clinical, demographic, and UTI-influencing data were gathered.

A midstream urine sample was then collected. The cultures were checked for important possible UTI bacterial pathogens after the samples were aerobically cultivated in blood agar and MacConkey agar. Potential bacterial pathogens were isolated and identified using standard laboratory procedures, and the disc diffusion method for microbial sensitivity testing was described by the Clinical and Laboratory Standards Institute (CLSI)[10].

Susceptibility testing

In compliance with National Committee for Clinical Laboratory Standards (NCCLS) approvals, the isolates were tested for antibiotic susceptibility using Muller-Hinton medium and the disc diffusion method[10]. Tests were conducted on augmentin, norfloxacin, imipenem-pipracillin/tazobenem, meropenem, gentamicin, linezolid, ciprofloxacin, levofloxacin, cefotaxime, ceftriaxone, cefixime, teicoplanin, and amoxicillin.

Ethical consideration: Patients provided informed consent, and the study was authorised by the Sana'a University Faculty of Medicine and Health Sciences Ethics Committee (document number: 2025-10, dated January 25, 2025).

Data analysis: After the results were totalled, standard descriptive statistics were used. While categorical data are shown as counts and percentages, numerical variables are summarised using mean values.

Table 1: Distribution of cancer patients by gender and age undergoing chemotherapy and radiotherapy.

Characters	Males, N (%)	Females, N (%)	Total, N (%)
Age groups (years)			
Less than 16 years	32 (24.1)	26 (16.6)	58 (20)
16-25 years	17 (12.8)	21 (13.4)	38 (13.1)
26 -35 years	20 (15)	50 (31.8)	70 (24.1)
36-45 years	20 (15)	38 (24.2)	58 (20)
More than 46 years	44 (33.1)	22 (14)	66 (22.8)
Total	133 (45.9)	157 (54.1)	290 (100)
Mean	33.4 years	32.1 years	32.7 years
SD	18.4 years	14.9 years	16.5 years
Median	34.5 years	33 years	34.5 years
Mod\]e	12 years	35 years	35 years
Range	3 - 66 years	2 - 76 years	2 - 76 years

RESULTS

Table 1 shows the distribution of 290 cancer patients for different age groups, where the highest percentage was observed in the age group 26-35 years (24.1%); in contrast, a lower percentage was seen in the age group 16-25 (13.1%). Regarding the gender, the highest percentage was seen in females (54.1%) rather than in males (45.9%). Table 2 provides a simplified analysis of the cancer patients undergoing chemotherapy and radiotherapy at the National Cancer Centre in Sana'a city, based on the schedule provided. Total cases: 290 cancer cases were analyzed. The most common cancer Breast cancer is the most common type among analyzed cases, accounting for 78 (26.9%). Other notable cancers, Hodgkin's lymphoma and the “others” class, come second, each with 10.7% (31 cases). Leukemia and head and neck cancer are 10% each (29 cases each). It was noted that the very pathogenic bacteria isolates were from the urine of cancer patients undergoing chemotherapy and radiotherapy at the National Oncology Centre in Sana'a city.

Table 2: Types of cancers among cancer cases undergoing chemotherapy and radiotherapy.

Cancers	Number (%)
Hodgkin lymphoma	31 (10.7)
NP tongue cancer	15 (5.2)
Breast cancer	78 (26.9)
Leukemia	29 (10)
Non-Hodgkin's Lymphoma (NHL):	20 (6.9)
Colorectal cancer	23 (7.9)
Head and neck cancers: Including nasopharyngeal carcinoma	29 (10)
Gastric and esophageal cancers	17 (5.9)
Brain and CNS tumors	17 (5.9)
Others	31 (10.7)

They were *E. coli*, *P. aeruginosa*, *E. faecalis*, and *S. saprophyticus*. Their frequency and percentage were 19 (6.6%), 3 (1.03%), 3 (1.03%), and 23 (7.9%), respectively (Table 3). Table 4 illustrates the antibiotic susceptibility patterns of *E. coli* isolates causing UTIs among cancer patients. The findings reveal high levels of resistance to several antibiotics. The high rate of resistance was observed with cefixime (100%), followed by Augmentin (94.7%), amoxicillin (68.4%), cefotaxime (63.2%), and ceftriaxone (57.9%). Moderate resistance rates were also reported for norfloxacin and ciprofloxacin (52.6%).

Table 3: Bacterial pathogens isolated from urine samples of cancers PATIENTS undergoing chemotherapy and radiotherapy.

Name of pathogens	Frequency (%)
E. coli	19 (6.6)
P. aeruginosa	3 (1.03)
E. faecalis	3 (1.03)
S. saprophyticus	23 (7.9)
Total isolates	48/290 (16.6)

On the other hand, some antibiotics demonstrated relatively good effectiveness. Imipenem and meropenem showed the highest sensitivity rates (68.4%), followed by linezolid (63.2%) and gentamicin (57.9%). Teicoplanin exhibited complete sensitivity (100%) with no detected resistance.

Table 5 shows the susceptibility pattern of *S. saprophyticus* isolated from UTIs among cancer patients. High sensitivity was observed for vancomycin and linezolid (95.7% each), followed by nitrofurantoin (91.3%) and trimethoprim sulfamethoxazole (87%). Moderate sensitivity was reported in small proportions across most antibiotics. In contrast, high resistance rates were observed for cefixime (78.3%), augmentin (56.5%), ceftriaxone (52.2%), and cefotaxime (47.8%). Ciprofloxacin and piperacillin/tazobactam also showed notable resistance levels (39.1% and 43.5%, respectively). Overall, the isolates demonstrated high susceptibility to vancomycin, linezolid, and nitrofurantoin, while resistance was more prominent against several beta-lactam antibiotics.

DISCUSSION

The current study found that the 26–35 age group had the highest incidence of cancer (24.1%), while females had the highest incidence (54.1%) compared to males (45.9%). These results are comparable to those before described in Yemen, where female cancer patients are predominately female due to the high incidence of breast cancer, with women accounting for approximately 53% to 54% of cancer cases. Cancer is the second leading cause of death worldwide and causes about 9.6 million deaths per year[1-3]. Males are more likely than females to develop childhood malignancies in Yemen, and the prevalence of adult cancer peaks in women between the ages of 30 and 59, whereas the incidence in men is higher than in women over 60[4-6]. In Yemen, the incidence rate of cancer is roughly 89.2 per 100,000 for females (53–54%) and 77.8 per 100,000 for males (46–47%) across all age categories[7]. With 78 cases (26.9%), breast cancer was the most prevalent type of cancer in the current study.

Table 4: Antibiotics sensitivity for UTI isolated *E. coli* (n=19) among cases of cancers undergoing chemotherapy and radiotherapy.

Antibiotics	Sensitive N, (%)	Moderate, N (%)	Resistant, N (%)
Augmentin	1 (5.3)	0 (0.0)	18 (94.7)
Norfloxacin	7 (36.8)	2 (10.6)	10 (52.6)
Imipenem	13(68.4)	2 (10.6)	4 (21.1)
Piprecillin/tazobenem	6 (31.6)	3 (15.8)	10 (52.6)
Meropenem	13 (68.4)	0 (0.0)	6 (31.6)
Gentamicin	11 (57.9)	1 (5.3)	7 (36.8)
Linezolide	12 (63.2)	0 (0.0)	7 (36.8)
Ciprofloxacin	7 (36.8)	2 (10.6)	10 (52.6)
Levofloxacin	7 (36.8)	3 (15.8)	9 (47.4)
Cefotaxim	3 (15.8)	4 (21.1)	12 (63.2)
Ceftriaxone	4 (21.1)	4 (21.1)	11 (57.9)
Cefixime	0 (0.0)	0 (0.0)	19 (100)
Teicoplanin	19 (100)	0 (0.0)	0 (0.0)
Amoxacillin	2 (10.6)	4 (21.1)	13 (68.4)

Table 5: Antibiotic susceptibility of *S. saprophyticus* bacteria isolated from urinary tract infections (n=23) among cancer patients undergoing chemotherapy and radiotherapy.

Antibiotics	Sensitive, N (%)	Moderate, N (%)	Resistant, N (%)
Nitrofurantoin	21(91.3)	2 (8.7)	0 (0.0)
Trimethoprim-sulfamethoxazole	20 (87)	1 (4.3)	2 (8.7)
Augmentin	6 (26.1)	4 (17.4)	13 (56.5)
Piprecillin/tazobenem	9 (39.1)	4 (17.4)	10 (43.5)
Meropenem	15 (65.2)	3 (13.04)	5 (21.7)
Gentamicin	14 (60.9)	4 (17.4)	5 (21.7)
Ciprofloxacin	12 (52.2)	2 (8.7)	9 (39.1)
Cefotaxim	5 (21.7)	7 (30.4)	11 (47.8)
Ceftriaxone	5 (21.7)	6 (26.1)	12 (52.2)
Cefixime	3 (13.04)	2 (8.7)	18 (78.3)
Vancomycin	22 (95.7)	1 (4.3)	0 (0.0)
Linezolide	22 (95.7)	1 (4.3)	0 (0.0)

At 10.7% (31 cases), Hodgkin lymphoma and other types were the second most prevalent. Ten percent (29 instances) each of head and neck malignancies and leukemia. Although the age distribution of the patients varied considerably by type of cancer, the results of this study are comparable to those of the prior study. Although the proportion of patients under the age of 15 was lower, leukemia was the most prevalent malignancy in this age group, affecting young males more frequently than females. Due to the earlier beginning of lymphoma in both sexes and breast cancer in women, a significant share of patients seeking treatment were young adults and middle-aged adults (15–49 years old). With colon, rectal, stomach, and esophageal cancers being the most common, primarily affecting older men and women, the elderly (50 years and above) constitute the second largest category[5,6].

Chemotherapy was administered to 84.1% of the patients in the current study, whereas radiation was administered to 15.9% of the patients. The majority of patients had treatment for one to six months (44.1%), more than a year (32.8%), and seven to twelve months (23.1%). The National Cancer Centre in Sana'a and regional centres in towns like Aden and Hadramawt treat the great majority of patients in Yemen's highly centralized oncology services. Because chemotherapy is more widely available than radiotherapy, it is the most popular treatment in Yemen. Many individuals with leukemia and breast cancer between the ages of 30 and 59 are regularly given it. There is very little access to radiotherapy, which frequently causes treatment delays. Many patients must endure lengthy waiting lists or go overseas for treatment due to the state-wide dearth of operating linear accelerators. Because of this, a large number of geriatric and advanced-stage patients who rely on radiation therapy experience serious treatment protocol gaps[6-8]. Total 16.6% of cancer patients experienced bacterial urinary tract infections (UTIs). *E. coli*, *P. aeruginosa*, *E. faecalis*, and *S. saprophyticus* were among the causative agents. The current rate (16.6%) falls within the international range, as UTI incidence among cancer patients varies considerably, ranging from 6% to 24%, largely due to weakened immunity, catheterization, and surgical interventions. Gram-negative bacteria isolates are typically the main cause of these infections, with *E. coli* being the most common pathogen[9].

Inappropriate antibiotic prescribing and misuse can lead to the emergence of antibiotic-resistant pathogenic bacteria, which can restrict treatment options, increase hospital admissions, increase treatment costs, and eventually increase mortality[17]. In many hospital departments across the world, antimicrobial resistant bacteria are spreading quickly; in Yemen, the issue is more pervasive and complicated[10-15]. Antimicrobial resistance is expected to be one of the main causes of death for both hospitalised and non-hospitalized people in both developed and developing nations if appropriate control and preventative measures are not put in place.

Gram-negative rods predominate in the bacterial profiles of cancer patients worldwide; however, multidrug-resistant (MDR) strains and a sizable percentage of Gram-positive organisms are usually seen. The most frequent bacterial isolates are *E. coli*: Usually responsible for 44% to 58% of all UTI infections in cancer patients[16,17]. Cefixime (100%) was found to be the most resistant drug for *E. coli* in the current investigation, followed by amoxicillin (68.4%), cefotaxime (63.2%), ceftriaxone (57.9%), and Augmentin (94.7%). Moderate resistance rates were also recorded for norfloxacin and ciprofloxacin (52.6%). However, several antibiotics showed comparatively good efficacy. Imipenem and meropenem showed the highest sensiti-vity rates (68.4%), followed by linezolid (63.2%) and gentamicin (57.9%).

Teicoplanin revealed perfect sensitivity (100%) with no identified resistance. Obtained findings are consistent with high resistance rates (>50%) for ampicillin/amoxicillin (70 to 100%), cefixime (third-generation cephalosporin) (88 to 90%), trimethoprim /sulfamethoxazole (cotrimoxazole) (62% to 73%), ciprofloxacin (51 to 77%), amoxicillin/clavulanic acid (65 to 72%), and cefepime (fourth-generation cephalosporin) (64% to 70%) resistance[18-21].

Ceftazidime resistance ranges from 47% to 69% and gentamicin resistance from 36 to 58% for moderate resistance rates (20%–50%). Resistance to amikacin ranges from 4 to 15% for low resistance rates (<20%), while resistance to carbapenems (such as imipenem and meropenem) ranges from 2-16%[19-22]. *E. coli* also shows concerning rates of antibiotic resistance in Yemen, especially to first-line oral antibiotics that are frequently used. Extended-spectrum beta-lactamase (ESBL) enzymes are produced by a number of clinical

isolates in large cities (such as Sana'a and Aden) that are categorized as multidrug-resistant (MDR)[8-13,22,23].

S. saprophyticus, which was isolated from urinary tract infections in cancer patients, had a high susceptibility profile to vancomycin and linezolid (95.7% each), followed by nitrofurantoin (91.3%) and trimethoprim-sulfamethoxazole (87%). On the other hand, cefixime (78.3%), augmentin (56.5%), ceftriaxone (52.2%), and cefotaxime (47.8%) showed substantial resistance rates. One of the main causes of simple UTIs in young women who are sexually active is *S. saprophyticus*. It is nonetheless quite vulnerable to antibiotics used as first-line treatment for urinary tract infections, such as nitrofurantoin, trimethoprim-sulfamethoxazole (TMP-SMX), fluoroquinolones, and aminoglycosides, even though it is naturally resistant to nalidixic acid and novobiocin[22-26]. Since *S. saprophyticus* is intrinsically resistant to many treatments frequently used for *E. coli* infections, it is essential to comprehend its distinct susceptibility features[16]. Clinical isolates typically show strong susceptibility to nitrofurantoin, trimethoprim-sulfamethoxazole, and fluoroquinolones (e.g., ciprofloxacin)[17], which is consistent with our findings about high susceptibility (first-line choices). High rates of resistance to cefixime (78.3%), Augmentin (56.5%), ceftriaxone (52.2%), and cefotaxime (47.8%) were found in *S. saprophyticus* in the present investigation. In contrast, data from around the world suggest that this bacterium is typically responsive to broad-spectrum antibiotics, such as gentamicin, amoxicillin-clavulanate, and second-generation cephalosporins. Additionally, *S. saprophyticus* is naturally resistant to novobiocin and nalidixic acid, in contrast to the majority of staphylococci[16,21-23]. There is growing evidence of methicillin/cefoxitin resistance mediated by the mecA gene in some clinical isolates, despite the fact that the majority of strains are sensitive to beta-lactam antibiotics. Furthermore, in certain regions, up to 20–30% of isolates may exhibit erythromycin and ampicillin resistance[16-18].

Limitations of the study

Although the study was successful in identifying bacterial causative agents and resistance patterns among cancer patients at the National oncology Centre in Sana'a, its main limitations include the short time frame of three months and the single-centre design; as a result, the findings may not be applicable throughout Yemen.

CONCLUSIONS

The findings highlight two major health concerns: the rising incidence of cancer among young adults (particularly women with breast cancer) and a wide-spread resistance crisis to beta-lactam antibiotics in bacteria causing urinary tract infections (UTIs). The highest concentration of cancer patients is observed among young adults aged 26–35 (24.1%), with a slight majority being female (54.1%). Breast cancer is the most common (26.9%), followed by Hodgkin lymphoma (10.7%) and leukemia (10%). *E. coli* and *S. saprophyticus* are the leading causes of UTIs. The results indicate a resistance crisis, with isolates exhibiting significant resistance to beta-lactam antibiotics. *E. coli* shows complete resistance (100%) to cefixime. Similarly, *S. saprophyticus* shows high resistance to both cefixime (78.3%) and augmentin (56.5%). There are therapeutic alternatives in which imipenem and meropenem are effective against *E. coli* (sensitivity ~68.4%), while vancomycin (95.7%) and linezolid remain highly effective against *S. saprophyticus.*

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AUTHOR'S CONTRIBUTIONS

Al-Yousfi NAA: formal analysis, conceptualization, writing original draft. **Nahshal IMA:** conceptualization, data organization. **Hassan SMA:** critical review. **Al-Shamahi EH:** data organization. **Al-Moyed KAK:** formal analysis. **Al-Hababi NM:** supervision, critical review. **Abdu SSA:** supervision, critical review. **Al-Shamahy HA:** supervision, critical review. Final manuscript was checked and approved by all authors.

DATA AVAILABILITY

The related author can provide the empirical data supporting the study's conclusions upon request.

CONFLICT OF INTEREST

Regarding this project, there are no conflicts of interest.

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