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Antimicrobial Resistance in Bacterial Isolates from Patients Attending a Cancer Center

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ABSTRACT

Background: Bacterial infections are the most frequent complications in patients with malignancy, and the epidemiology of nosocomial infections among cancer patients has changed over time. There is increasing evidence from different parts of the world with high percentage of antimicrobial-resistant bacterial isolates in cancer patients. This study aimed to characterize the antimicrobial resistance in the bacteria isolated from clinical specimens from the cancer patients.

Methods: A hospital-laboratory-based, cross-sectional study was conducted on the bacteria isolated from the patients taking medical services at Nepal Cancer Hospital and Research Center (NCHRC), Lalitpur, during June 2023 to May 2024. All the clinical specimens received at the Department of Pathology and Laboratory Medicine, from patients admitted in the wards and OPD of the hospital were processed following standard guideline and protocol for isolation, phenotypic identification and antibiotic susceptibility testing.

Results: Out of the 4273 samples processed, bacterial growth was observed in 23% (987) of the samples with 1016 bacterial isolates. The most common isolates were *E. coli* 36% (364), *Klebsiella pneumoniae 24 %* (241), *Pseudomonas aeruginosa* 14% (144) and *Citrobacter freundii* 8% (78). Bacterial infection was significantly associated with age, gender, fever and prior antibiotic use. Antimicrobial susceptibility testing clearly showed that Gram-negative bacterial isolates were highly resistant to Amoxycillin-clavulanate (66.7% to 100%), Nitrofurantoin (60% to 100%) and least resistant to Amikacin (28% to 50%).Gram-positive were found to be resistant to Amoxycillin-clavulanate (36.8% to100), Ciprofloxacin (35.3% to 68.6%) and least resistant to Vancomycin (14.3% to 17.6%). Multidrug resistance was observed in 68% of the gram-negative and 46.5% in gram-positive bacterial isolates

Conclusions: The result clearly indicates the need for local antibiotic resistance/susceptibility dashboard, updated periodically for aligning the local treatment protocols for the hospital, which could help to rationalize the antimicrobial prescription, leading to better patient outcome in terms of morbidity and mortality in highly vulnerable group, like cancer patients.

Keywords: Antimicrobial resistance; bacterial infection; cancer; multi-drug resistance.

INTRODUCTION

Cancer is one of the major public health problems in Nepal, with 44,803 in five years prevalent cases, 22,008 new cases, and 14,704 deaths in 2022.[1] Cancer patients have a 3- 5 fold greater risk of severe sepsis in comparison with non-cancer patients, with an increased risk for hospital acquired infection (HAI) which are associated with increased therapeutic failure and high mortality rates.[2,3] Oncology patients on chemotherapy are at particular risk for bacterial and fungal infections and bloodstream infections remain the leading cause of morbidity and mortality.[4,5] More than half of all cancer cases and about 60% of deaths occur in developing countries.[6,7] The World Health Organization (WHO) has identified antimicrobial resistance as one of the greatest threats to human health, and it becomes challenging in immunocompromised cancer patients.[8] Treating bacterial infection in cancer patients is clinically challenging due to an increasing level of resistance for antibiotics used

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in empiric therapy.[9] The country specific information on types of bacterial infection in different types of cancer patients, different care modalities (OPD, Day care Vs IPD), infections acquired in hospital and particularly antimicrobial resistance in bacterial isolates from cancer patients in Nepal is not available. So, this study has been designed to investigate the bacterial infection, antibiotic resistance pattern and the associated factors in cancer patients, based at one of the referral level cancer hospital in Nepal, revealing the evidences for appropriate interventions in combating antimicrobial resistance.

METHODS

This hospital-laboratory based cross-sectional study was conducted based at Nepal Cancer Hospital and Research Center (NCHRC), Lalitpur, a comprehensive cancer care center with multidisciplinary departments taking care of different types of cancer patients with 100 inpatient beds, high end modern equipped operating rooms, intensive care units, and outpatient departments. The study sample collection period was from June 2023 to May 2024, following ethical approval (ref no: 113-2023) from Ethical Review Board, National Health Research Council (NHRC).

All cancer patients who visited the NCHRC, and provided written informed consent during the study period were enrolled as study participants. Socio-demographic and clinical data of the patients were obtained using a pre-structured questionnaire following the informed consent of the patients/guardians. A total of 4273 clinical specimens from 3504 cancer patients, were included for analysis, after excluding duplicate samples. Samples from same patients was included when readmitted for next episode of the diagnosis and treatment.

The clinical samples from cancer patients suspected of infections were collected by trained medical personnel. Samples were processed as per standard protocol for isolation of organisms and phenotypic identification.[10] Each sample container was labelled clearly with lab numbers, patient's name, date, age, and gender. MacConkey agar (MA) and Blood Agar (BA) were used for isolation of the organisms from pus, wound swab, aspirates, tips, and Chocolate agar was added to above for sputum specimens, while Cystine-Lactose-Electrolyte-Deficient (CLED) agar was used for isolation of bacteria from the urine samples. Five percent (5%) of the prepared culture media plates without inoculation or inoculated with standard ATCC cultures (*S. aureus* (ATCC-25923) and *E. coli* (ATCC-25922) were randomly selected and incubated aerobically for 24 hours at 37°C to ensure quality of the culture media including sterility. Antibiotic susceptibility testing was performed following modified Kirby-Bauer disk diffusion technique in line with the CLSI guidelines -2021.[11] The inoculum was prepared by picking parts of similar test organisms with a sterile wire loop and suspended in sterile normal saline. To standardize the density of the inoculum of bacterial suspension, 0.5 McFarland turbidity standard was used. The test organism was uniformly seeded over the Mueller-Hinton agar surface after which antibiotic-impregnated paper discs were placed on the agar medium and incubated at 37°C for 16 to 18 hours. Diameters of the zone of inhibition around the discs were measured to the nearest millimeter using a ruler and classified as Susceptible, Intermediate or Resistant. Susceptibility to Colistin was determined by broth micro-dilution method. Bacterial isolates resistant to 3 or more than 3 different class of antibiotics were considered as MDR.

Collected data were entered in excel worksheet and analyzed using Statistical Package for Social Science version 21.0. The Chi-square test was used to assess association between categorical variables, p-value < 0.05 was considered statistically significant at 95% confidence interval.

RESULTS

A total of 4273 samples were collected from 3504 cancer patients (Male = 49% and female = 51%) and the age ranged between 2 - 91 years. Highest percentage of patients belonged to age group 46-60 (44.1%) followed by >60 (36.4%). Nearly half (49.2%) of patients had a history of fever and 46.5% had used antibiotics prior to collection of specimen for culture and susceptibility testing. The baseline information of the study participants is presented in Table-1, below.

Table 1. Baseline information of the study participants.

Variables		Male (N=1717)	Female (N=1787)	Total
	Categories	n (%)	n (%)	n (%)
Age	≤ 15	29(53.7)	25(46.3)	54(1.5)
	16 to 30	110(58.8)	77(41.2)	187(5.3)
	31 to 45	162(36.4)	283(63.6)	445(12.7)
	46 to 60	763(49.4)	781(50.6)	1544(44.1)
	≥ 60	653(51.3)	621(48.7)	1274(36.4)
Fever	Yes	811(47.1)	912(52.9)	1723(49.2)
	No	906(50.9)	875(49.1)	1781(50.8)
Antibiotic use prior to culture & susceptibility testing	Yes	833(51.2)	795(48.8)	1628(46.5)
	No	884(47.1)	992(52.9)	1876(53.5)
Growth of bacteria in culture	Yes	485(57)	366(43)	851(24.3)
	No	1232(46.4)	1421(53.6)	2653(75.7)

Infection was found more common in males than females, and the association between gender and infection was statistically significant ($p < 0.001$). Age also showed a significant association with bacterial infection ($p < 0.001$), with the highest number of infected cases observed in patients aged 60 years or above, followed by < 15 years or younger The percentage of bacterial growth was 17.2% among patients who received antibiotic treatment prior to specimen submission for culture and susceptibility testing at NCHRC, which was significantly lower than the 21.5% among those who did not received antibiotics before culture ($p < 0.001$). There was no significant association between the type of cancer and bacterial infection ($p = 0.197$). The associations of gender, age, types of cancer and antibiotics use prior to culture is presented below in Table-2.

Table2. Associations of variables and bacterial infections.

Variables	Categories	Bacterial infection		p value
		No	Yes	
		n (%)	n (%)	
Gender	Male	1232 (71.7)	485 (28.3)	<0.001
	Female	1421 (79.5)	366 (20.5)	
Age	≤ 15	38 (75)	16 (25)	
	16 to 30	145 (81.7)	42 (18.3)	
	31 to 45	343 (81.4)	102 (18.6)	<0.001
	46 to 60	1300 (86.4)	244 (13.6)	
	≥ 60	827 (74)	447 (26)	
Fever	Yes	1126 (65.4)	597 (34.6)	<0.001
	No	1527 (90.3)	254 (9.7)	
Antibiotic use prior to Culture	Yes	1290 (82.8)	338 (17.2)	<0.001
	No	1363 (78.5)	513 (21.5)	
Classification of Cancer	Hematological	166 (83)	43 (17)	0.197
	Solid	2487 (75.5)	808 (24.5)	

Among the patients presenting with fever while reporting to hospital, 40.2% have been found to receive antibiotics before culture & susceptibility testing; while 57% of the patients did not have prior antibiotic use. Among the patients reporting to hospital without sign of fever, 59.8% received antibiotics prior to culture and susceptibility testing. The association was statistically significant ($p < 0.001$). (Table 3.)

Table 3. Association of prior antibiotic use and fever.

Particulars		Fever		No fever		Total		p value
		n	%	n	%	n	%	
Antibiotic use prior to culture	Yes	654	40.2	974	59.8	1628	46.5	<0.001
	No	1069	57.0	807	43.0	1876	53.5	
Total		1723	49.2	1781	50.8	3504	100	

Types of bacteria grown from clinical specimens:

Bacterial growth was detected in 23% (987/4273) samples. Mono bacterial growth was found in 97.06% (958/987) samples and poly-microbial (mixed) bacterial growth was observed in 2.9%(29/987) of the samples. Poly microbial growth was reconfirmed and reported, as the samples were from immune-compromised patients. A total of 1016 bacterial isolates from 851 cancer patients were obtained. The most common bacteria isolated were *E. coli* (36%), *Klebsiella pneumoniae* (7%) and *Pseudomonas aeruginosa* (14.%). 93%, (945/1016) of the isolates were Gram negative bacteria, while 7% (71/1016) of the isolates were Gram-positive bacteria. Distribution of the types of bacteria is given below inTable-4.

Table 4. Distribution of bacterial isolates.

S No	Bacteria	n	%
Gram negative bacteria			
1	*Escherichia coli*	364	35.8
2	*Klebsiella pneumoniae*	241	23.7
3	*Pseudomonas aeruginosa*	144	14.2
4	*Citrobacter freundii*	78	7.7
5	*Acinetobacter baumannii complex*	62	6.1
6	*Klebsiella oxytoca*	20	2
7	*Enterobacter cloacae*	8	0.8
8	*Proteus mirabilis*	10	1
9	*Proteus vulgaris*	3	0.3
10	*Providencia stuartii*	12	1.2
11	*Citrobacter koseri*	2	0.2
12	*Serratia marcescens*	1	0.1
Sub-Total		**945**	**93**
Gram positive bacteria			
1	*Staphylococcus aureus*	35	3.4
2	*Enterococcus faecalis*	19	1.9
3	*CONS*	17	1.7
Sub-Total		**71**	**7**
Total		**1016**	**100**

Most *E. coli* isolates were from urine, while *K. pneumoniae* and *P. aeruginosa* were common in sputum and urine. *S. aureus*, *E. faecalis*, and CONS were mainly isolated from wound swabs. Overall, urine, sputum and Tips yielded the highest number of bacterial isolates. *E. coli*, *K. pneumoniae*, *P. aeruginosa*, *C. freundii*, *A. baumannii*, and *S. aureus* showed a statistically significant association in distribution across various clinical sample types ($p<0.05$), whereas all other species exhibited no significant association with sample type. (Table 5).

Table 5. Distribution of bacterial isolates among different samples.

Bacterial isolates	Types of samples							p-value
	Fluid	blood	tips	pus	sputum	urine	wound swab	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	
E.coli	21 (5.8)	0 (0)	31 (8.5)	8 (2.2)	14 (3.8)	277 (76.1)	13 (13.6)	<0.001
K. pneumoniae	17 (7.1)	9 (3.7)	25 (10.4)	13 (5.4)	61 (25.3)	101 (41.9)	15 (6.2)	<0.001
P aeruginosa	20 (13.9)	8 (5.6)	15 (10.4)	7 (4.9)	42 (29.2)	38 (16.4)	14 (9.7)	<0.001
C. freundii	9 (11.5)	2 (2.6)	15 (19.2)	8 (10.3)	9 (11.5)	28 (35.9)	7 (9)	0.048
A. baumannii complex	5 (8.1)	2 (3.2)	11 (17.7)	8 (12.9)	15 (24.2)	17 (27.4)	4 (6.5)	0.006
K. oxytoca	1 (5)	0 (0)	3 (15)	3 (15)	4 (20)	7 (35)	2 (10)	0.584
E. cloacae	1 (12.5)	0 (0)	2 (25)	1 (12.5)	0 (0)	4 (50)	0 (0)	0.670
P. mirabilis	0 (0)	0 (0)	1 (10)	3 (30)	1 (10)	4 (40)	1 (10)	0.130
P. vulgaris	0 (0)	0 (0)	0 (0)	1 (33.3)	0 (0)	2 (66.7)	0 (0)	0.580
P. stuartii	2 (16.7)	0 (0)	1 (8.3)	2 (16.7)	0 (0)	6 (50)	1 (8.3)	0.523
C. koseri	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (100)	0 (0)	0.920
S. marcescens	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (100)	0 (0)	0.986
S. aureus	2 (5.7)	2 (5.7)	4 (11.4)	9 (25.7)	3 (8.3)	3 (8.6)	12 (34.3)	<0.001
E. faecalis	1 (5.3)	0 (0)	2 (10.5)	2 (10.5)	0 (0)	11 (57.9)	3 (15.8)	0.418
CONS	2 (11.8)	0 (0)	1 (5.9)	2 (11.8)	0 (0)	9 (52.9)	3 (17.6)	0.337

Gram-negative bacteria were found to be highly resistant to Amoxycillin/clavulanate. (66.7% to 100%). The majority of *E. coli* isolates (from urine) were resistant to Nitrofurantoin (71.7%) and Norfloxacin (67.5%) while majority of *K. pneumoniae* isolates (from urine) resistant to Nitrofurantoin (76.5%), Cefotaxime (75.1%), Ceftazidime (74.3%) and Amikacin (47.3%).*P. aeruginosa* isolates were resistant to Norfloxacin (61.3%) and Ofloxacin (50.7%) and Amikacin (29.9%). Furthermore, 57.7% of *Citrobacter freundii* isolates and 62.9% of *Acinetobacter baumanii* were resistant to Cefepime. In the study, 50% of *K. oxytoca* and *E. cloacae* showed resistance to Amikacin. *P. mirabilis* showed resistance rates of 60% to Nitrofurantoin and 40% to Amikacin, while *P. vulgaris* showed 60% resistance to Nitrofurantoin and no resistance to Amikacin. Additionally, *P. stuartii*, *C. koseri*, and *S. marcescens* showed resistance to Amikacin, with rates ranging from 33.3% to 50%. Carbapenem resistance among Gram-negative bacteria was detected, with rates between 25% and 59%. Notably, resistance to Colistin was not observed. (Table 6)

Table6. Antibiotic resistance pattern of Gram Negative bacterial isolates.

Antibiotics	*E. coli*	*K. pneumoniae*	*P. aeruginosa*	*C. freundii*	*A. baumannii complex*	*K. oxytoca*	*E. cloacae*	*P. mirabilis*	*P. vulgaris*	*P. stuartii*	*C. koseri*	*S. marcescens*
	N=364	N=241	N=144	N=78	N=62	N=20	N=8	N=10	N=3	N=12	N=2	N=1
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
NIT	201/277 (72.5)	75/101 (74.2)		21/28 (75)	17/17 (100)	5/6 (71.4)	6 (75)	6 (60)	2 (66.7)	10 (83.3)	2 (100)	1 (100)
AMC	364 (100)	241 (100)		78 (100)	62 (100)	18 (90)	6 (75)	7 (70)	2 (66.7)	11 (91.7)	2 (100)	1 (100)
AK	102 (28)	114 (47.3)	43 (29.9)	23 (29.5)	18 (29)	10 (50)	4 (50)	4 (40)	0 (0)	4 (33.3)	1 (50)	0 (0)
GEN	123 (33.8)	120 (49.8)	59 (41)	33 (42.3)	21 (33.9)	12 (60)	5 (62.5)	4 (40)	0 (0)	6 (50)	1 (50)	0 (0)
TOB	123 (33.8)	136 (56.4)	58 (40.3)	36 (46.2)	21 (33.9)	13 (65)	6 (75)	4 (40)	0 (0)	6 (50)	0 (0)	0 (0)
DO	112 (30.8)	113 (46.9)		29 (37.2)	20 (32.3)	12 (60)	6 (75)	5 (50)	1 (33.3)	8 (66.7)	1 (50)	0 (0)
CIP	134 (36.8)	156 (64.7)	66 (45.8)	41 (52.6)	28 (45.2)	11 (55)	5 (62.5)	5 (50)	1 (33.3)	7 (58.3)	0 (0)	0 (0)
NX	189/277 (68.2)	74/101 (73.2)	19/38 (50)	14/28 (50)	13/17 (76.5)	4/7 (57.1)	5 (62.5)	4 (40)	1 (33.3)	7 (58.3)	0 (0)	0 (0)
OF	142 (39)	160 (66.4)	73 (50.7)	38 (48.7)	33 (53.2)	12 (60)	4 (50)	4 (40)	2 (66.7)	8 (66.7)	1 (50)	0 (0)
LE	140 (38.5)	155 (64.3)	67 (46.5)	36 (46.2)	36 (58.1)	12 (60)	4 (50)	4 (40)	2 (66.7)	8 (66.7)	1 (50)	0 (0)
CX	134 (36.8)	145 (60.2)		27 (34.6)	37 (59.7)	14 (70)	6 (75)	5 (50)	2 (66.7)	8 (66.7)	0 (0)	0 (0)
CPM	136 (37.4)	166 (68.9)		41 (52.6)	34 (54.8)	12 (60)	5 (62.5)	5 (50)	1 (33.3)	8 (66.7)	0 (0)	0 (0)
CTX	168 (46.2)	181 (75.1)		44 (56.4)	36 (58.1)	10 (50)	4 (50)	6 (60)	1 (33.3)	7 (58.3)	0 (0)	0 (0)
CAZ	156 (42.9)	179 (74.30)	56 (38.9)	34 (43.6)	36 (58.1)	10 (50)	2 (25)	5 (50)	2 (66.7)	6 (50)	0 (0)	0 (0)
CFM	144 (39.6)	166 (69.9)	54 (37.5)	45 (57.7)	39 (62.9)	11 (55)	2 (25)	6 (60)	1 (33.3)	5 (41.7)	0 (0)	0 (0)
MRP	134 (36.8)	130 (53.9)	54 (37.5)	31 (39.7)	24 (38.7)	9 (45)	2 (25)	3 (30)	1 (33.3)	5 (41.7)	0 (0)	0 (0)
IMP	145 (39.8)	129 (53.5)	59 (41)	33 (42.3)	26 (41.9)	8 (40)	2 (25)	3 (30)	1 (33.3)	5 (41.7)	0 (0)	0 (0)
DOR	134 (36.8)	130 (53.9)	54 (37.5)	33 (42.3)	23 (37.1)	8 (40)	2 (25)	3 (30)	1 (33.3)	5 (41.7)	0 (0)	0 (0)
PIT	114 (31.3)	146 (60.6)	47 (32.6)	36 (46.2)	22 (35.5)	10 (50)	2 (25)	3 (30)	1 (33.3)	4 (33.3)	0 (0)	0 (0)
CL	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

NIT- Nitrofurantoin, AMC-Amoxicillin/clavulanate, AK- Amikacin, GEN- Gentamicin, TOB- Tobramycin, DO- Doxycycline, CIP-Ciprofloxacin, NX- Norfloxacin, OF- Ofloxacin, LE- Levofloxacin, CX- Cefoxitin, CPM-Cefepime, CTX-Cefotaxime, CAZ- Ceftazidime, CFM- Cefixime, MRP- Meropenem, IMP-Imipenem, DOR- Doripenem, PIT- Piperacillin tazobactam, CL- colistin,

Among gram-positive bacterial isolates, *S. aureus* isolates were resistant to amoxycillin/clavulanate (100%), Ciprofloxacin (68.6%) and Cefoxitin (60%).*E faecalis* was resistant to amoxycillin/clavulanate, Gentamycin (36.8%) and Vancomycin (15.8%). Coagulase Negative Staphylococcus aureus (CoNS) were resistant to amoxycillin/clavulanate (47.1%), Gentamycin (47.1%) and Vancomycin (17.6).(Table 7)

Table 7. Antibiotic resistance pattern in gram positive bacterial isolates.

Antibiotics	*S.aureus*	*E. faecalis*	CONS
	N=35	N=19	N=17
	n (%)	n (%)	n (%)
AMC	35 (100)	7 (36.8)	8 (47.1)
GEN	17 (48.6)	7 (36.8)	8 (47.1)
DO	11 (31.4)		
CIP	24 (68.6)	5 (26.3)	6 (35.3)
LE	20 (57.1)	5 (26.3)	6 (35.3)
CX	21 (60)		6 (35.3)
CAZ	18 (51.4)	4 (21.1)	5 (29.4)
VAN	5 (14.3)	3 (15.8)	3 (17.6)
TET	6 (17.1)	5 (26.3)	4 (23.5)

AMC-Amoxicillin/clavulanate, GEN- Gentamicin, DO- Doxycycline, CIP-Ciprofloxacin, LE- Levofloxacin, CX- Cefoxitin, CAZ- Ceftazidime, VAN – Vancomycin, TET – Tetracycline

Gram-negative bacterial isolates showed a high percentage of multidrug resistant (MDR). Among gram negative bacterial isolates MDR was found in 68% (643/945). Among gram positive isolates MDR was observed in 46.5% (33/71).

DISCUSSION

Bacterial infections are a cause of significant morbidity and mortality in cancer patients. This study is implemented to understand the spectrum of antimicrobial resistance in cancer patients, seeking cancer care from a referral level Cancer Hospital, NCHRC, located in the capital of Nepal.

In the current study, bacterial infections were detected in 23% of the specimens received at NCHRC laboratory, which is comparable with similar study findings from neighboring country India (21.9%) [9] and Ghana (22%).[12] This study finding is lower than reported in Zimbabwe (35.2%)[13] and Pakistan (43.6%)[14] and higher in blood stream infections from patients in general ward in Turkey (14.5%).[15] This may be due to the possible difference in IPC practices in different hospitals, highly vulnerable & immune-compromised cancer patients, patient and patient party's understanding and practice of hygiene and sanitation.

The higher percentage of infections observed among male patients in this study may be attributed to sex-related differences in immune responses, with males exhibiting relatively reduced immunological defense compared to females.[16] It may have some relation with better access to health care services by males than females in the developing countries like ours.[17,18]

The current study demonstrated the highest proportion of bacterial infections among cancer patients aged over 60 years. This may be attributed to age-related immune decline, the presence of multiple co-morbidities, increased exposure to healthcare settings, and physiological changes that predispose older individuals to infections.[19] The findings are consistent with those reported from another tertiary cancer care hospital in Nepal.[20] In contrast, pediatric cancer patients have been reported with bloodstream infections (BSIs) than adult patients, primarily due to chemotherapy-induced immunosuppression, prolonged neutropenia, and mucosal barrier injury in Ethiopia.[7]

In this study prior antibiotic use was significantly associated with culture positivity (P<0.001) and fever status. Antibiotics administered before specimen collection may have suppressed bacterial growth, leading to lower culture yield and potentially obscuring infection-related symptoms such as fever.[21] These findings underscore the importance of considering prior antibiotic exposure when interpreting culture results and clinical features.

In the present study, among the 1,016 bacterial isolates, Gram-negative bacterial growth predominated (93%), while Gram-positive bacterial growth accounted for only 7%, a finding comparable to reports from India.[9,22,] In contrast, some other studies have documented a higher incidence of Gram-positive bacterial infections.[14,23] The predominance of Gram-negative bacteria in cancer patients is primarily attributed to chemotherapy-related immunosuppression and disruption of mucosal barriers, which facilitate translocation of endogenous gastrointestinal flora. [24,25]

Among gram negative bacteria the predominant isolates were *E. coli* (35.8%), followed by *K. pneumoniae* (21%) and *P. aeruginosa* (14.2%). Similar results were reported in a retrospective study by Shrestha G et al[17] demonstrating *E. coli* as predominant in cancer patients with urinary tract infection. The incidence of infections with antibiotic-resistant Enterobacteriaceae is increasing worldwide, particularly in cancer patients, posing a threat to public health and a challenge to physicians. Enterobacteriaceae predominate in cancer patients due to chemotherapy-induced neutropenia and gastrointestinal mucosal damage along with selective pressure from prolonged hospitalization and broad-spectrum antibiotic use.[25]

In the present study among the Gram-positive bacterial isolates, *Staphylococcus aureus* was the predominant pathogen (3.4%) which is lower than previous reports where *S. aureus* was found to be the most common Gram-positive isolate (51.5%) in cancer patients. *S. aureus* is a major cause of sepsis among cancer patients, and its management remains challenging due to its high capacity to develop resistance to multiple antibiotics and the absence of an effective vaccine. [26]

68 % of the bacterial isolates were MDR in Gram-negative bacterial isolates, which is similar to other studies revealing MDR (83.3%) and &72.8%. [27, 28] The high rate of MDR found in this study among cancer patients may be explained by the fact that these patients had already been exposed to some kinds of antibiotics, during the previous episodes of infection/treatment. The high rate of MDR is also often correlated with numerous episodes of hospitalization and prolonged stays in the oncology unit of cancer patients.[27]

Antimicrobial resistance pattern showed that Gram-negative bacteria isolated in this study were resistant to Amoxiclav (62% to 100%) followed by Nitrofurans (60% to 100%), Fluoroquinolone (33.3% to 76.5%), tetracycline (30.8% to 75%), second generation Cephlosporin (36.8% to 75%), third generation (25% to 75.1%), fourth generation (33.3% to 70%), Piperacillin/tazobactam(25% to 60.6%), Carbapenem (33.3 % to 54%) and Aminoglycosides (28% to 65%). However, 28% to 50% of Gram-negative isolates were resistant to Amikacin. Similar was the findings in a study conducted in China. [28]. Furthermore, anticancer chemotherapy may have contributed the development of antibiotic-resistant mutants by exerting selective pressure on patients' commensal bacterial populations.[29]

Limitations of the study include single institutional specimen processing, the IPC and institutional treatment protocols is different institutes may be different, in absence of nationally standardized treatment protocol, which could contribute to infections.

CONCLUSIONS

The overall burden of bacterial infections among cancer patients was 23%, considerably higher (26%) in participants aged > 60 years and < 15 years (25%). 93%, (945/1016) of the isolates were Gram negative bacteria. The most common isolated bacteria were *E. coli* (36%), *Klebsiella pneumoniae* (24%) and *Pseudomonas aeruginosa* (14%). Urine and sputum were the most common clinical specimens received for culture and susceptibility testing, with highest yield of growth, indicating most common route of infection. No significant association between the type of cancer and bacterial infection was observed. Rationale antimicrobial use is a question, as 40.2% of the patients received antibiotics before reaching hospital and samples submitted for culture & susceptibility testing. Antibiotic resistance to first, second and third line of treatment was observed in most of the antibiotic under investigation, including amoxycillin-clavulanic acid to Amikacin, alerting the health system to carefully perform AMR surveillance and periodically updating the treatment protocol based on the scientific evidence.

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CONFLICT OF INTEREST

Authors declare there are no any conflicts of Interest.

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