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Bacteriological Profile and Antimicrobial Resistance Pattern in Surgical Site Infection among Post-operative Oral cavity and Head and Neck Cancer Patients - First Report from Tertiary Cancer Centre of Tripura, India

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ABSTRACT

Postoperative infections in head and neck cancer (HNC), especially oral cavity cases, pose a serious clinical challenge, contributing to higher morbidity and mortality. The objective of this study was to identify the microbial pathogens responsible for surgical site infections (SSIs) in patients with oral cavity and HNC, and to characterise the antimicrobial resistance pattern. This retrospective study at a tertiary oncology centre analysed 498 patients undergoing surgery for oral cavity & HNC between January 1, 2023, and October 30, 2024. Demographic data, microbial isolates, and antimicrobial resistance were documented, compiled in Microsoft Excel, and statistically evaluated. Among 498 patients, 295 (59.2%) had HNC and 203 (40.8%) oral cavity malignancies, with SSIs occurring in 13.05% of cases. Gram-negative bacilli were the leading pathogens, comprising 94% of isolates in oral cavity cases and 60% in HNC, with *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* as the most common. *Staphylococcus aureus* was the most frequent Gram-positive isolate, present in 32% of HNC patients. Resistance profiling showed GNB had high resistance to third-generation cephalosporins, with *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, and *Enterobacter* spp. exceeding 80%. Carbapenem resistance was notably high in *Klebsiella pneumoniae* (>60%). Among Gram-positive cocci, *Staphylococcus aureus* exhibited substantial β-lactam resistance, though all isolates remained fully susceptible to linezolid. The alarming resistance trends observed among pathogens isolated from SSIs in patients with head and neck and oral cavity cancers underscore a critical challenge.

Keywords: Surgical site infection, oral cavity cancer, gram-negative bacilli, gram-positive cocci, antimicrobial resistance

INTRODUCTION

Healthcare-associated infections (HAIs) are recognised as a major contributor to increased morbidity and mortality, while also placing a substantial burden on healthcare systems, particularly in the postoperative setting. In routine clinical practice, the most frequently encountered HAIs include surgical site infections (SSIs), central line–associated bloodstream infections (CLABSI), ventilator-associated pneumonia (VAP), and catheter-associated urinary tract infections (CAUTI) (Pecorari et al., 2021). Despite recent progress in antibiotic treatment, SSIs remain a frequent and concerning complication following major oncologic procedures for HNC. The persistently high incidence of SSI is attributed to multiple factors, including the complexity of surgical techniques, poor preoperative nutritional status, and the microbial burden within the oral cavity. Furthermore, oral cavity cancer patients undergoing tumour excision, combined with reconstructive procedures and tracheostomy, often demonstrate increased bacterial colonisation of oropharyngeal secretions, largely due to impaired swallowing and reduced natural cleansing mechanisms of the mouth (Funahara et al., 2017).

The SSIs remain a significant postoperative complication, occurring in nearly 2% of surgical procedures and accounting for approximately 20% of all healthcare-associated infections. The incidence is notably higher among patients with oral cavity cancers compared to surgeries at other anatomical sites, largely due to the bacterial exposure of the operative field and the necessity of reconstructing the oral mucosal barrier. This risk is further amplified when surgical communication with the neck is present. (Balagopal et al., 2022).

The incidence of SSIs following HNC surgery may reach 10–45% of cases, despite the administration of prophylactic antibiotics. According to the Centers for Disease Control and Prevention (CDC), SSIs are defined as infections occurring within 30 days of the operative procedure and are identified by one or more criteria, including purulent discharge, a positive microbiological culture, or the requirement for intentional incision and drainage, accompanied by relevant clinical signs and symptoms. (Yao et al., 2017).

Effective prevention of SSIs relies on the administration of appropriate preoperative antimicrobial prophylaxis, meticulous compliance with aseptic techniques during surgery, and thorough postoperative management. Consequently, identifying the microbial flora responsible for SSIs and determining their antimicrobial resistance profiles is essential for guiding the selection of optimal prophylactic agents (Rao et al., 2023). Postoperative SSIs impose considerable physical, psychological, and economic burdens on patients, healthcare professionals, and hospital systems. Importantly, the occurrence of SSI can delay the initiation of critical postoperative radiotherapy, thereby increase the likelihood of cancer recurrence and reduce overall survival rates (Zenga et al., 2022). Understanding the antibiotic susceptibility patterns of prevalent pathogenic bacteria isolated from pus samples provides valuable guidance for choosing appropriate antimicrobial agents, determining optimal dosing regimens, and formulating effective treatment strategies (Kursheed et al., 2024).

Although several investigations on postoperative SSIs have been carried out in different regions of India, there remains a notable lack of data from the North-East. This gap in evidence provided the rationale for undertaking the present study, which sought to identify the microbial agents responsible for SSIs in patients with oral cavity and HNC, and to assess the antimicrobial resistance patterns of isolates obtained from pus samples at the Atal Bihari

Vajpayee Regional Cancer Centre (ABV-RCC), Agartala, Tripura, India.

MATERIALS AND METHODS

This retrospective investigation was carried out in the Department of Microbiology at the ABV-RCC, spanning the period from January 1, 2023, to October 30, 2024. During this timeframe, 498 patients who underwent surgical procedures for head-and-neck and oral cavity cancers were systematically observed.

Inclusion Criteria- Samples were obtained from surgical sites showing infection within 30 days of the postoperative period.

Exclusion Criteria- Specimens collected beyond 30 days after surgery, as well as those from postoperative patients other than oral cavity or HNC cases, were excluded.

Data collection

Demographic details were obtained from the medical records department, while microbiological information was collected from the clinical laboratory following approval from the Institutional Ethics Committee. Patient demographics, including age, sex, and tumour site, were extracted from medical records and evaluated as predictive variables. Written informed consent was secured from all participants. The demographic data were systematically documented using a standardised form.

Sample collection, culture, and sensitivity test

Pus swabs were obtained from the surgical sites with suspected SSIs and promptly forwarded to the microbiology laboratory for processing. The specimens were collected from patients admitted to the Surgical Oncology wards, as well as those attending the Outpatient Department (OPD) and the Surgical Intensive Care Unit (SICU). The swabs were inoculated onto blood agar and MacConkey agar plates. These cultures were incubated aerobically at 37°C, and the plates were examined for microbial growth after 24 hours (overnight) and after 48 hours. Any colonies that appeared were identified using standard phenotypic techniques. Subsequently, the isolates underwent antibiotic susceptibility testing by the Kirby–Bauer disc diffusion method using Mueller–Hinton agar medium, in accordance with the Clinical Laboratory Standards Institute (CLSI) guidelines.

Statistical Analyses

Data analysis was performed using Microsoft Excel (2019). For categorical variables, frequency distributions and percentages were computed to describe the dataset.

RESULTS

Culture and sensitivity testing of 73 pus samples revealed growth in 65 samples (89%), with the remaining 8 samples (11%) showing no growth. Among 498 individuals operated for oral cavity and HNC, 65 (13.05%) experienced SSIs. The incidence of surgical site infection was greater among postoperative oral cavity cancer patients, recorded as 25.61% (52/203), compared to 4.36% (13/298) in HNC patients. Culture positivity was noted in 25 samples from male patients (38.5%) and 40 female patients (61.5%), resulting in a male-to-female ratio of 1:1.6. Participants in the 51–60-year age group constituted the largest proportion in both cancer groups. Oral cavity malignancies were predominantly observed in females (70.1%), while HNCs were more common in males (80%) (Table 1).

Buccal mucosa was the predominant primary site in oral cavity cancers (70.8%), while laryngeal tumours (53%) and pyriform sinus (27%) were the most frequent sites in HNC. Analysis of 52 culture-positive SSI samples from oral cavity cancer patients yielded 67 bacterial isolates, of which 94% were Gram-negative bacilli (GNB), and 6% were Gram-positive cocci (GPC). *Pseudomonas aeruginosa* emerged as the predominant isolate (44.78%), followed by *Klebsiella pneumoniae* (19.40%) and *Escherichia coli* (13.43%). A total of 25 bacterial isolates were recovered from 13 culture-positive SSI samples in HNC patients, comprising 60% GNB and 40% GPC. The leading bacterial

pathogen identified was *Staphylococcus aureus* (32%), with *P. aeruginosa* and *K. pneumoniae* each accounting for 20% (Table 2).

Table 1: Demographic Characteristics of the Study Cohort

Variables	Oral Cavity Cancer			Head and Neck Cancer			
	Category	**No. of patients (n =58)**	**%**		**Category**	**No. of patients (n =15)**	**%**
Age	20-30	1	1.72%	Age	20-30	0	0
	31-40	7	12.06%		31-40	0	0
	41-50	15	25.86%		41-50	2	13.34%
	51-60	18	31.03%		51-60	7	46.66%
	61-70	13	22.44%		61-70	6	40%
	71-80	2	3.44%		71-80	0	0
	>80	2	3.44%		>80	0	0
Gender	Male	17	29.9%	Gender	Male	12	80%
	Female	41	70.1%		Female	3	20%
Site of Tumour	Ca Buccal mucosa	41	70.8%	Site of Tumour	Ca Larynx	8	53%
	Ca Base of Tongue	1	1.8%		Ca Pyriform sinus	4	27%
	Ca Gingivobuccal sulcus	4	6.8%		Ca Hypopharynx	1	7%
	Ca RMT	4	6.8%		Ca Supraglottic	2	13%
	Floor of mouth	3	5.1%				
	Ca lower alveolus	3	5.1%				
	Ca lower alveolus	1	1.8%				
	Ca PPW	1	1.8%				

Table 2: Bacteriological Profile in SSI among Oral Cavity Cancer and HNC Patients

Oral Cavity Cancer Patients				**HNC Patients**			
Bacteria Isolated (n=67)		**GNB (n=63)**	**GPC (n=04)**	**Bacteria Isolated (n=25)**		**GNB (n=15)**	**GPC (n=10)**
Name of Bacteria	**%**	**%**	**%**	**Name of Bacteria**	**%**	**%**	**%**
Pseudomonas aeruginosa	44.77% (n=30)	94.02%	5.98%	Staphylococcus aureus	32% (n=8)	60%	40%
Klebsiella pneumoniae	19.40% (n=13)			Pseudomonas aeruginosa	20% (n=5)		
Escherichia coli	13.43% (n=9)			Klebsiella pneumoniae	20% (n=5)		
Enterobacter spp	10.44% (n=7)			Escherichia coli	8% (n=2)		
Staphylococcus aureus	4.76% (n=3)			Other Enterobacteriaceae	12% (n=3)		
Citrobacter freundii	2.98% (n=2)			Enterococcus spp	8% (n=2)		
Proteus vulgaris	2.98% (n=2)						
Enterococcus spp	1.58% (n=1)						
Total samples having positive growth (n=52)				Total samples having positive growth (n=13)			

GNB demonstrated marked resistance to third-generation cephalosporins, with resistance rates exceeding 80% for *Pseudomonas aeruginosa, K. pneumoniae,* and *Enterobacter spp*. against ceftriaxone and cefotaxime in oral cavity cancer patients. Resistance to amikacin among *Escherichia coli* & *Pseudomonas aeruginosa* was notably low (< 30%) in both oral cavity and HNC patients, whereas *Klebsiella pneumoniae* and

Enterobacter spp. exhibited comparatively higher resistance to both amikacin & β-lactam inhibitor class. Carbapenem resistance was most pronounced in *Klebsiella pneumoniae*, with a prevalence of 61.6% (Table 3).

Table 3: Antimicrobial resistance pattern among Gram-negative Bacilli isolated from SSI of Oral Cavity and Head & Neck Cancers

Oral Cavity Cancers						
Antibiotics tested	**Pseudomonas aeruginosa (n=30)**	**Klebsiella pneumoniae (n=13)**	**Escherichia coli (n=9)**	**Enterobacter spp. (n=7)**	**Citrobacter freundii (n=2)**	**Proteus vulgaris (n=2)**
	R%	R%	R%	R%	R%	R%
Amikacin	13.4 (n=4)	69.3 (n=9)	22.2 (n=2)	42.9 (n=3)	50 (n=1)	50 (n=1)
Piperacillin/ tazobactam	33.4 (n=10)	77 (n=10)	44.4 (n=4)	71.4 (n=5)	50 (n=1)	50 (n=1)
Amoxycillin-Clavulanic Acid	IR	84.7 (n=11)	55.5 (n=5)	71.4 (n=5)	50 (n=1)	50 (n=1)
Ceftriaxone	80 (n=24)	92.3 (n=12)	66.6 (n=6)	85.7 (n=6)	50 (n=1)	50 (n=1)
Cefotaxime	80 (n=24)	92.3 (n=12)	66.6 (n=6)	85.7 (n=6)	50 (n=1)	50 (n=1)
Doxycycline	70 (n=21)	46.2 (n=6)	55.5 (n=5)	42.9 (n=3)	50 (n=1)	100 (n=2)
Levofloxacin	33.4 (n=10)	69.2 (n=9)	44.5 (n=4)	42.9 (n=3)	0	0
Meropenem	40 (n=12)	61.6 (n=8)	33.4 (n=3)	42.9 (n=3)	50 (n=1)	0
Head & Neck Cancers						
Antibiotics tested	**Pseudomonas aeruginosa (n=5)**	**Klebsiella pneumoniae (n=5)**	**Escherichia coli (n=2)**	**Other Enterobacteriaceae (n=3)**		
	R%	R%	R%	R%		
Amikacin	20 (n=1)	40 (n=2)	0	33.4 (n=1)		
Piperacillin/ tazobactam	0	60 (n=3)	0	66.6 (n=2)		
Amoxycillin-Clavulanic Acid	IR	60 (n=3)	0	66.6 (n=2)		
Ceftriaxone	40 (n=2)	80 (n=4)	50 (n=1)	66.6 (n=2)		
Cefotaxime	40 (n=2)	80 (n=4)	50 (n=1)	66.6 (n=2)		
Doxycycline	40 (n=2)	80 (n=4)	0	33.4 (n=1)		
Levofloxacin	20 (n=1)	80 (n=4)	50 (n=1)	33.4 (n=1)		
Meropenem	20 (n=1)	40 (n=2)	0	33.4 (n=1)		

NB: Other Enterobacteriaceae: Enterobacter spp (n=1), Citrobacter freundii (n=1), Proteus vulgaris (n=1), IR: Intrinsic Resistance

GPC isolated from oral cavity and HNC patients, particularly *Staphylococcus aureus*, exhibited high resistance to cefoxitin (54.5%). In contrast, *Enterococcus spp.* demonstrated lower resistance to vancomycin. Notably, all GPC isolates across both groups remained uniformly sensitive to linezolid (100%) (Table 4).

Table 4: Antimicrobial resistance pattern among Gram-Positive Cocci isolated from SSI of Oral Cavity and Head & Neck Cancers

Oral Cavity Cancer			**Head & Neck Cancer**	
Antibiotic Tested	**Staphylococcus aureus (n=3)**	**Enterococcus spp. (n=1)**	**Staphylococcus aureus (n=8)**	**Enterococcus spp. (n=2)**
	R%	**R%**	**R%**	**R%**
Amoxycillin-Clavulanic Acid	66.6 (n=2)	100 (n=1)	50 (n=4)	50 (n=2)
Ceftriaxone	66.6 (n=2)	100 (n=1)	50 (n=4)	IR
Cefotaxime	66.6 (n=2)	100 (n=1)	50 (n=4)	100 (n=2)
Cefoxitin	66.6 (n=2)	Not Tested	50 (n=4)	Not Tested
Doxycycline	0	100 (n=1)	25 (n=2)	100 (n=2)
Levofloxacin	100 (n=3)	100 (n=1)	50 (n=4)	100 (n=2)
Vancomycin	No break point (CLSI)	100 (n=1)	No break point (CLSI)	50 (n=2)
Linezolid	0	0	0	0

Out of Total (n=11) Staphylococcus aureus isolates, both post operative patients of Oral Cavity & Head & Neck Carcinoma patients were screened for the presence of Methicillin resistance by using the Cefoxitin Disk as per the CLSI latest guidelines. 6/11 = 54.5% of the Staphylococcus aureus were Cefoxitin resistant, i.e., MRSA (Methicillin Resistant Staphylococcus aureus).

DISCUSSION

This study highlights the occurrence of SSIs in oral cavity and HNC patients from a neglected region of India. Oral cavity cancers were predominantly seen in females (70.1%), whereas HNCs were more common in males (80%). Gender differences reflected variations in disease prevalence, lifestyle risk factors such as tobacco and alcohol consumption, and health-seeking behaviour. Consistent with prior Indian reports, buccal mucosa lesions were more frequent among women, while laryngeal cancers predominated in men due to higher tobacco and alcohol consumption (Bhattacharjee et al., 2021; Saquib et al., 2025).

The overall SSI rate observed was 13.05%, with higher incidence likely linked to prolonged surgeries, elevated oral microbial load, advanced disease stage, and variability in perioperative infection control. Stratification showed SSIs were more common in oral cavity cancers (25.61%) than in HNC (4.36%), consistent with the clean-contaminated nature of oral cavity procedures. These findings parallel earlier reports noting increased SSI risk among older patients with reduced systemic reserves (Jha et al., 2025).

In oral cavity cancers, buccal mucosa was the leading site for SSIs (70.8%), followed by the gingivobuccal sulcus and lower alveolus. Among HNC cases, the larynx accounted for the most infections (53%), with the pyriform sinus next in frequency. These patterns reflect the anatomical exposure and surgical complexity of these subsites—buccal mucosa resections often require extensive soft tissue handling and flap reconstruction, while laryngeal procedures are typically prolonged and involve airway manipulation, increasing susceptibility to bacterial contamination (Shi et al., 2020; Sotirović et al., 2024).

Polymicrobial growth was observed in 41.53% of cultures, consistent with oncological SSIs, in which endogenous flora and hospital-acquired pathogens frequently coexist (Hou et al., 2020). GNB comprised 84.78% (78/92) of isolates, while GPC represented 15.22% (14/92). These results align with reports from northeast India identifying GNB as the predominant pathogen in head and neck surgical infections (Deka et al., 2020). The oral cavity serves as

a reservoir for Gram-negative organisms, such as *P. aeruginosa*, while head and neck surgical wounds frequently acquire Gram-positive organisms, such as *S. aureus,* through skin colonisation, underscoring the impact of the surgical site environment (Rivas Caldas et al., 2015; Rao et al., 2023). In immunocompromised patients, *P. aeruginosa* commonly colonises intensive care and postoperative settings, with invasive devices such as catheters and ventilators serving as entry points (Litwin et al., 2021). The oral cavity serves as a significant reservoir for *Pseudomonas* spp., posing a serious threat in immunocompromised cancer patients (Abdulhak et al., 2025). The observed prevalence underscores the importance of rigorous infection control measures and tailored empiric therapy.

Resistance patterns varied across organisms and antibiotics. Among GNB, *K. pneumoniae,* and *Enterobacter* spp. showed over 80–90% resistance to third-generation cephalosporins, while *E. coli* exhibited 66.6% resistance. These findings mirror national trends of increasing cephalosporin resistance in surgical pathogens (Deka et al., 2020; Lathakumari et al., 2025; Singh et al., 2025). Conversely, amikacin demonstrated the highest efficacy against GNB, with notably low resistance, especially in *Pseudomonas aeruginosa*. These results support its role as a key agent in empirical therapy, consistent with previous studies (Gálvez et al., 2011; Rodrigues et al., 2021). Approximately 37.8% of GNB in our study were resistant to meropenem, comparable to reports from tertiary centres showing 30–50% resistance (Lathakumari et al., 2025; Kumari et al., 2022). Carbapenem resistance severely restricts treatment choices and is frequently linked to adverse clinical outcomes. Methicillin resistance was detected in 54.5% of *S. aureus* isolates (MRSA), aligning with tertiary hospital reports where MRSA rates typically exceed 40% (Patil et al., 2022; Singhal et al., 2022). Vancomycin resistance was observed in 33.3% of *Enterococcus* isolates (VRE), a worrisome finding given the restricted therapeutic option. Comparable VRE rates have been reported in oncology centres across India (Sivaradjy et al., 2021; Eichel et al., 2023). All GPCs were fully susceptible to linezolid, reinforcing its role in treating multidrug-resistant infections. Our results highlight the critical importance of retaining linezolid efficacy by restricting its use to confirmed cases of resistant infections.

Variations in pathogen profiles and resistance between the oral cavity and HNC highlight the need for site-specific empirical antibiotic protocols. Timely identification of resistant strains and strict antibiotic stewardship are essential to curb the spread of resistance genes in hospitals and the wider community. Ongoing surveillance is vital for updating antibiograms and ensuring the judicious use of last-line agents, such as linezolid and carbapenems, to combat antimicrobial resistance.

Limitations

This investigation has several limitations that should be acknowledged. First, as a single-centre study, the findings may not be generalizable to broader populations or different clinical settings. Second, the relatively small sample size restricts the statistical power of the analysis and may limit the robustness of the conclusions. Finally, the restricted use of antibiotic discs constrains the comprehensiveness of antimicrobial susceptibility testing, potentially overlooking variations in resistance patterns. These factors highlight the need for larger, multicentre studies with expanded antibiotic panels to validate and extend the present results.

CONCLUSION

This study concludes that SSIs in oral cavity cancers and HNC have developed high resistance to cephalosporins and carbapenems, along with the presence of MRSA and VRE, which is a growing burden of antimicrobial resistance in oncological surgery. The findings highlight the need for an antimicrobial stewardship program along with antimicrobial resistance surveillance to

reduce the impact of SSI in oncological surgery.

Statements and Declarations

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Author Contributions: "All authors contributed to the study conception and design. Conceptualization and sample collection were performed by Debapriya Baidya, Uma Debbarma, Data curation, methodology were performed by Saikat Dey, Original draft preparation were performed by Sukanta Nath and Ankita Debnath, Visualization and investigation was performed by Debapriya Baidya, Uma Debbarma, Supervision was performed by Debapriya Baidya, Uma Debbarma, Data analyses were performed by Matrujyoti Pattnaik, reviewing and editing were performed by Debapriya Baidya, Uma Debbarma and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript."

Data availability: *All data from this study are available from the corresponding author upon request.*

Ethical approval: The study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of Atal Bihari Vajpayee Regional Cancer Centre.

Consent to participate: "Informed consent was obtained from all individual participants included in the study."

Sample collection and molecular testing information: Samples were collected from the surgical department of Atal Bihari Vajpayee Regional Cancer Centre, Agartala, Tripura, and processed in the microbiology department.

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