Original Research

ANTIMICROBIAL SUSCEPTIBILITY PATTERNS OF BACTERIAL ISOLATES FROM PUS AND WOUND SWABS IN A TERTIARY CARE HOSPITAL OF NORTH INDIA

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ABSTRACT

Background: Wound infections represent a considerable clinical challenge, sometimes exacerbated by the rise of multidrug-resistant bacteria. These infections not only prolong recovery but also elevate hospitalizations, expenses, and morbidity rates.

Method: A cross-sectional study was performed at a tertiary care hospital in Northern India. Pus and wound swab specimens were obtained from infected patients and analyzed using standard microbiological techniques for bacterial identification. Antimicrobial susceptibility testing was conducted with the Kirby-Bauer disc diffusion method in accordance with CLSI recommendations. The analysis of data was conducted utilizing SPSS version 26.0.

Result: A total of 1132 isolates were detected, with Pseudomonas spp. (429), Klebsiella spp. (268), and E. coli (262) as the most predominant species. Elevated resistance rates were noted in all groups, especially towards beta-lactams and carbapenems. Staphylococcus aureus exhibited 55.5% susceptibility to gentamicin; nonetheless, a notable incidence of MRSA was observed. Strains of Vancomycin-resistant Enterococcus (VRE) were also detected.

Conclusion: The study highlights a concerning degree of multidrug resistance in bacterial pathogens associated with wound infections, demanding a transition to culture-guided antibiotic administration and stringent infection control protocols. The immediate execution of antibiotic stewardship and regional resistance monitoring initiatives is essential to address this escalating threat.

Keywords: Antimicrobial Resistance, Wound Infections, Multidrug-Resistant Bacteria, Pus And Wound Swabs, Gram-Negative Pathogens, Staphylococcus Aureus (MRSA), Antibiotic Susceptibility Patterns.

BACKGROUND

Wound infections are a major worldwide health issue, leading to substantial morbidity and mortality rates. These infections frequently hinder the rehabilitation process, resulting in prolonged hospitalizations, elevated medical costs, and an augmented risk of serious consequences. A primary concern in wound infection management is the increasing incidence of antimicrobial-resistant bacteria. These resistant strains restrict treatment options and complicate the attainment of successful therapeutic outcomes. Consequently, the meticulous and knowledgeable selection of antibiotics is increasingly crucial in clinical practice (Mohammed et al., 2017). When the epidermis, the body's principal barrier against microbial invasion, is compromised owing to damage or surgical intervention, microorganisms may penetrate the underlying tissues and induce infection.

www.ajmrhs.com
eISSN: 2583-7761

Date of Received: 12-03-2026
Date Acceptance: 19-03-2026
Date of Publication: 20-04-2026

Pus development is a frequent outcome of many diseases and signifies an active immune response. In clinical environments, specimens like pus and wound swabs are systematically collected and processed to identify the responsible microbes and assess their susceptibility to different antimicrobial treatments. The characteristics of wound infections differ, with instances of both monomicrobial and polymicrobial infections recorded. Nevertheless, monomicrobial infections are generally more common in the majority of instances (Filius & Gyssens, 2002).

The microbiological profile of wound and pus infections demonstrates a varied spectrum of bacterial pathogens. Gram-negative species are commonly isolated and frequently predominate in the bacterial spectrum. Prevalent gram-negative bacteria encompass Escherichia coli, Klebsiella species, Pseudomonas aeruginosa, Proteus species, and Acinetobacter species. Staphylococcus aureus, particularly methicillin-resistant Staphylococcus aureus (MRSA), is the most commonly identified gram-positive bacterium. Other gram-positive organisms, including coagulase-negative staphylococci and Streptococcus species, are frequently encountered.

The precise distribution of these diseases may fluctuate according on geographic location, hospital protocols, and patient demographics (Kaur Gill & Sharma, 2019). Antimicrobial resistance in these pathogens presents a substantial obstacle to efficient treatment. Staphylococcus aureus, although one of the most prevalent isolates, frequently demonstrates significant resistance to medications like penicillin, ampicillin, and tetracycline. Nonetheless, it typically exhibits diminished resistance to antibiotics such as gentamicin and vancomycin, which continue to retain efficacy. Conversely, gram-negative bacteria such as E. coli and Pseudomonas aeruginosa are progressively exhibiting multidrug resistance, especially to ampicillin, amoxicillin, and tetracycline. This resistance severely impedes the efficacy of first-line antibiotics, necessitating dependence on more potent and frequently costlier alternatives (Jobayer et al., 2021).

The clinical and public health ramifications of antimicrobial-resistant wound infections are significant. The indiscriminate and excessive utilization of antibiotics has significantly contributed to resistance, confounding empirical treatment approaches and underscoring the necessity for precision, data-driven therapy. Early detection of resistance microorganisms via laboratory testing and the execution of robust antibiotic stewardship programs are critical measures in managing these illnesses. Moreover, continuous monitoring of regional resistance patterns is essential for developing suitable treatment protocols and infection control strategies. By tackling these difficulties with a blend of clinical vigilance and policy initiatives, healthcare systems can enhance patient outcomes and alleviate the wider effects of antibiotic resistance (Kaur Gill & Sharma, 2019).

METHODOLOGY

Antimicrobial Susceptibility Tests

Bacterial isolates from pus and wound swabs underwent antimicrobial susceptibility testing via the Kirby-Bauer disc diffusion method, adhering to CLSI (Clinical and Laboratory Standards Institute) standards. Samples were obtained aseptically from infected wound sites of hospitalized patients using sterile swabs and were quickly processed in the microbiology laboratory. The detected bacterial pathogens were evaluated against a panel of antibiotics, including ampicillin, cefotaxime, imipenem, gentamicin, and other agents pertinent to both gram-negative and gram-positive bacteria. Zone diameters were analyzed to ascertain susceptibility or resistance profiles. Methicillin resistance in Staphylococcus aureus was verified using cefoxitin disc diffusion, while vancomycin resistance was assessed in Enterococcus spp.

Data Analysis

All acquired data were inputted and analyzed utilizing SPSS version 26.0. Descriptive statistics were utilized to display the frequency and proportion of various bacterial isolates and their antibiotic susceptibility profiles. Resistance patterns were compiled for each isolate against multiple antibiotics, and comparative tables were created to enhance visual interpretation. The analysis highlighted multidrug resistance by quantifying resistance percentages across antibiotic classes for each bacterial species.

Ethical Considerations

Ethical approval was secured from the Institutional Ethics Committee prior to the commencement of the investigation. Patient confidentiality was maintained, and all clinical specimens were utilized exclusively for diagnostic and research reasons without revealing personal identification. Consent, either written or verbal, was obtained as required, particularly for sample collection in clinical environments. The research complied with the ethical standards established in the Declaration of Helsinki and upheld rigorous confidentiality and data protection measures.

RESULT

Table 1: ANTIBIOGRAM - PUS, WOUND SWAB, Susceptible percentage (%)

ANTIBIOGRAM - PUS, WOUND SWAB												
PERCENTAGE (%) SUSCEPTIBLE												
Organism	**Number of isolates**	**Ampicillin**	**Amoxicillin/Clavulanic acid**	**Piperacillin/Tazobactam**	**Cefuroxime**	**Ceftriaxone**	**Cefotaxime**	**Cefepime**	**Imipenem**	**Meropenem**	**Amikacin**	**Gentamicin**
Escherichia coli	262	8.6	10.5	6.3	6.2	8.8	3.7	10.7	34.8	27.5	33.6	39
Klebs	26	-	5.6	3.4	6.5	5.3	2.4	6	20.	13	24.	29

iella sp.	8								3		7	
Pseudomonas sp.	429	-	-	25.7	-	-	-	-	35.6	23.3	30.2	8.2
Enterococcus sp.	38	51.6	-	-	-	-	-	-	-	-	-	-
Staphylococcus aureus	135	-	-	-	-	-	-	-	-	-	-	55.5

The antibiotic susceptibility data in Tables 1 and 2 offers critical insights into the resistance patterns of prevalent bacterial pathogens obtained from pus and wound swabs. These findings are essential for directing empirical therapy and executing successful infection control techniques in clinical environments.

Table 1 demonstrates significantly low susceptibility rates to various beta-lactam antibiotics in gram-negative organisms. Escherichia coli, consisting of 262 isolates, shown limited susceptibility to ampicillin (8.6%), amoxicillin/clavulanic acid (10.5%), and third-generation cephalosporins, including cefotaxime (3.7%) and ceftriaxone (8.8%). Even sophisticated medicines such as piperacillin/tazobactam (6.3%) and carbapenems like imipenem (34.8%) and meropenem (27.5%) shown restricted efficacy. Likewise, Klebsiella species, comprising 268 isolates, had limited susceptibility to these medicines, with only 5.6% susceptibility to amoxicillin/clavulanic acid and 20.3% to imipenem. The results demonstrate a significant prevalence of multidrug-resistant bacteria in these clinical samples.

Pseudomonas species (429 isolates), as indicated in Table 1, exhibited superior sensitivity to piperacillin/tazobactam (25.7%) and imipenem (35.6%) relative to other treatments. Nonetheless, gentamicin (8.2%) and meropenem (23.3%) exhibited diminished efficacy, indicating resistance to several treatment alternatives. Among gram-positive bacteria, Enterococcus species shown considerable susceptibility to ampicillin (51.6%), but Staphylococcus aureus (135 isolates) demonstrated 55.5% susceptibility to gentamicin, indicating it remains a feasible therapeutic option in numerous instances.

Table 2 further examines resistance to additional types of antibiotics. E. coli and Klebsiella spp. exhibited restricted susceptibility to ciprofloxacin (7.7% and 9%, respectively) and trimethoprim/sulfamethoxazole (36.5% and 28.5%). Doxycycline demonstrated marginally superior efficacy (33.6% and 32.2%, respectively); nonetheless, these rates are inadequate for reliable empirical application. Pseudomonas spp. exhibited susceptibility to aztreonam (41.5%) and ciprofloxacin (23.8%), although maintained resistance to the majority of other treatments.

In Table 2, gram-positive isolates of Enterococcus spp. exhibited intermediate susceptibility to doxycycline (54.8%) and vancomycin (68.6%), together with notable activity from linezolid (50%). Staphylococcus aureus exhibited considerable susceptibility to doxycycline (84.6%) and linezolid (66.6%), while demonstrating significant resistance to erythromycin (18.6%) and clindamycin (7.7%). Furthermore, only 37.3% of isolates were sensitive to cefoxitin, indicating a substantial prevalence of MRSA strains.

Both tables emphasize the pervasive antimicrobial resistance among wound infections and reinforce the necessity of culture-based therapy to guarantee proper and effective antibiotic utilization.

Table 2. ANTIBIOGRAM - PUS, WOUND SWAB , Susceptible percentage (%)

ANTIBIOGRAM - PUS, WOUND SWAB											
PERCENTAGE (%) SUSCEPTIBLE											
Organism	**Number of isolates**	**Ciprofloxacin**	**Trimethoprim/Sulfamethoxazole**	**Aztreonam**	**Doxycycline**	**Vancomycin**	**Ceftazidime**	**Linezolid**	**Erythromycin**	**Cefoxitin**	**Clindamycin**

Escherichia coli	262	7.7	36.5	-	33.6	-	-	-	-	-	-
Klebsiella sp.	268	9	28.5	-	32.2	-	-	-	-	-	-
Pseudomonas sp.	429	23.8	-	41.5	-	-	4.2	-	-	-	-
Enterococcus sp.	38	-	-	-	54.8	68.6	-	50	29.7	-	-
Staphylococcus aureus	135	16.7	49	-	84.6	-	-	66.6	18.6	37.3	7.7

Table 3. ANTIBIOGRAM - PUS, WOUND SWAB, Resistance percentage (%)

ANTIBIOGRAM - PUS, WOUND SWAB												
PERCENTAGE (%) Resistance												
Organism	**Number of isolates**	**Ampicillin**	**Amoxicillin/Clavulanic acid**	**Piperacillin/Tazobactam**	**Cefuroxime**	**Ceftriaxone**	**Cefotaxime**	**Cefepime**	**Imipenem**	**Meropenem**	**Amikacin**	**Gentamicin**
Escherichia coli	262	91.4	89.5	93.7	93.8	91.2	96.3	89.3	65.2	72.5	66.4	61
Klebsiella sp.	268	100	94.4	96.6	93.5	94.7	97.6	94	79.7	87	75.3	71
Pseudomonas sp.	429	100	100	74.3	100	100	100	100	64.4	76.7	69.8	91.8
Enterococcus sp.	38	48.4	100	100	100	100	100	100	100	100	100	100
Staphylococcus aureus	135	100	100	100	100	100	100	100	100	100	100	44.5

The antimicrobial resistance data presented in Tables 3 and 4 highlight the critical threat posed by multidrug-resistant (MDR) pathogens in wound and pus infections. These tables provide resistance percentages for a range of commonly isolated bacteria against multiple antibiotics, offering a comprehensive overview of the current therapeutic challenges faced in clinical settings.

Table 3 shows exceptionally high resistance levels among gram-negative organisms, particularly Escherichia coli and Klebsiella species. E. coli (262 isolates) exhibited over 90% resistance to several key antibiotics: ampicillin (91.4%), amoxicillin/clavulanic acid (89.5%), and cefotaxime

(96.3%). Similarly, Klebsiella spp. (268 isolates) showed near-total resistance to ampicillin (100%), cefotaxime (97.6%), and meropenem (87%). Even carbapenems like imipenem and meropenem, typically reserved for resistant infections, displayed limited efficacy, with resistance rates of 65.2% and 72.5% for E. coli, and 79.7% and 87% for Klebsiella spp., respectively. These findings confirm the emergence of extended-spectrum beta-lactamase (ESBL) and carbapenem-resistant strains in these settings.

Pseudomonas spp., with 429 isolates, also displayed significant resistance across nearly all antibiotics tested (Table 3). Notably, resistance to imipenem was 64.4%, and to gentamicin, an important aminoglycoside, was 91.8%. Resistance to piperacillin/tazobactam stood at 74.3%, further limiting treatment options for this notoriously difficult pathogen.

Among gram-positive organisms, Enterococcus spp. showed moderate resistance to ampicillin (48.4%) but complete resistance (100%) to nearly all other agents in Table 3, including carbapenems and aminoglycosides, suggesting intrinsic resistance and acquired resistance traits. Staphylococcus aureus also presented a concerning pattern, with complete (100%) resistance to most antibiotics listed in Table 3, except gentamicin, to which 44.5% remained susceptible.

Table 4 provides additional insights into resistance against alternative antibiotic classes. Both E. coli and Klebsiella spp. demonstrated over 90% resistance to ciprofloxacin and 100% resistance to aztreonam and vancomycin, indicating limited utility of these agents. Resistance to doxycycline was somewhat lower (66.4% for E. coli and 67.8% for Klebsiella), suggesting it may still offer partial activity.

Pseudomonas spp. showed a more variable resistance profile in Table 4. Resistance to aztreonam was 58.5%, which, while lower than other drugs, is still high. Ciprofloxacin resistance (76.2%) further emphasizes the challenges of treating these infections empirically.

For gram-positive isolates, Enterococcus spp. demonstrated 31.4% resistance to vancomycin, raising concerns about vancomycin-resistant enterococci (VRE). Staphylococcus aureus resistance to erythromycin (81.4%) and clindamycin (92.3%) was also significant, limiting the effectiveness of macrolides and lincosamides. Furthermore, 62.7% resistance to cefoxitin suggests a high prevalence of MRSA strains. However, resistance to doxycycline (15.4%) and linezolid (33.4%) was comparatively lower, indicating some remaining treatment options.

Table 4. ANTIBIOGRAM - PUS, WOUND SWAB, Resistance percentage (%)

ANTIBIOGRAM - PUS, WOUND SWAB											
PERCENTAGE (%) Resistance											
Organism	**Number of isolates**	**Ciprofloxacin**	**Trimethoprim/Sulfamethoxazole**	**Aztreonam**	**Doxycycline**	**Vancomycin**	**Ceftazidime**	**Linezolid**	**Erythromycin**	**Cefoxitin**	**Clindamycin**
Escherichia coli	262	92.3	63.5	100	66.4	100	100	100	100	100	100
Klebsiella sp.	268	91	71.5	100	67.8	100	100	100	100	100	100
Pseudomonas sp.	429	76.2	100	58.5	100	100	95.8	100	100	100	100
Enterococcus sp.	38	100	100	100	45.2	31.4	100	50	70.3	100	100
Staphylococcus aureus	135	83.3	51	100	15.4	100	100	33.4	81.4	62.7	92.3

DISCUSSION

The investigation of antimicrobial susceptibility

patterns of bacterial isolates from pus and wound swabs in a tertiary care hospital in North India offers essential insight into the growing issue of antibiotic resistance in clinical practice. Wound infections, frequently worse by bacterial colonization after trauma or surgery, are increasingly complicated by the presence of multidrug-resistant (MDR) organisms. This resistance compromises standard treatment methods and requires the utilization of broader-spectrum, frequently costlier antibiotics, imposing a significant strain on healthcare systems and patient outcomes (Ferraz, 2024).

The microbiological examination indicated that gram-negative organisms, including Escherichia coli, Klebsiella spp., and Pseudomonas spp., were prominent in these illnesses. These bacteria exhibited significantly elevated resistance to prevalent antibiotics, particularly beta-lactams and third-generation cephalosporins. For instance, E. coli demonstrated over 90% resistance to ampicillin and cefotaxime, whereas Klebsiella spp. exhibited analogous patterns. Even carbapenems such as imipenem and meropenem, generally employed as last-resort therapies, shown restricted efficacy. This suggests the potential establishment of extended- spectrum beta-lactamase (ESBL) and carbapenem-resistant bacteria, which are notoriously challenging to treat.

Among gram-positive organisms, Staphylococcus aureus, especially methicillin-resistant Staphylococcus aureus (MRSA), and Enterococcus species were notably abundant. The bacteria exhibited significant resistance to erythromycin, clindamycin, and, in certain Enterococcus isolates, vancomycin, indicating the presence of vancomycin-resistant enterococci (VRE). Nonetheless, medications such as doxycycline and linezolid continued to have some efficacy, particularly against Staphylococcus aureus, providing a glimmer of hope for treatment (S. Pumerantz, 2012).

These findings highlight the necessity of implementing culture-guided antibiotic therapy instead of depending on empirical treatment. Antimicrobial stewardship initiatives, consistent monitoring of resistance trends, and rigorous infection control protocols are crucial for mitigating the dissemination of multidrug-resistant pathogens (Lanckohr & Bracht, 2022). The research underscores the necessity for judicious antibiotic prescribing, prompt detection of resistant bacteria, and legislative initiatives to alleviate the imminent risk of antimicrobial resistance in healthcare facilities.

CONCLUSION

The study emphasizes the concerning increase in antibiotic resistance among bacterial isolates derived from pus and wound swabs in a tertiary care hospital in North India. The primary pathogens found were Escherichia coli, Klebsiella species, Pseudomonas species, Staphylococcus aureus, and Enterococcus species. These organisms exhibited extensive resistance to frequently utilized medicines, including ampicillin, cefotaxime, ciprofloxacin, and even carbapenems such as imipenem and meropenem, which are generally reserved for critical infections. The existence of extended-spectrum beta-lactamase (ESBL) and carbapenem-resistant strains in gram-negative bacteria, along with methicillin- and vancomycin-resistant strains in gram-positive cocci, signifies a significant treatment challenge.

The resistance rates discovered, especially in E. coli and Klebsiella spp., surpassed 90% for the majority of beta-lactam antibiotics and were exceedingly elevated for carbapenems, prompting apprehensions regarding the diminishing effectiveness of last-resort medications.

Pseudomonas spp. also demonstrated significant resistance to aminoglycosides and beta-lactam combinations. Staphylococcus aureus exhibited intermediate susceptibility to gentamicin and doxycycline, however a significant proportion was classified as MRSA. Likewise, Enterococcus spp. exhibited significant vancomycin resistance, indicating the onset of VRE.

This highlights the pressing necessity for the implementation of antibiotic stewardship programs, the execution of regular susceptibility testing, and the development of region- specific antibiotic policies. Culture-guided therapy should supplant empirical antibiotic use to reduce the future emergence of resistance. Moreover, infection control measures must be strengthened to avert nosocomial transmission of resistant infections. The findings underscore the imminent issue of antibiotic resistance and the urgent need for action in clinical practice and public health policy.

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