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ANTIMICROBIAL SUSCEPTIBILITY PATTERN OF STAPHYLOCOCCUS AUREUS IN NOSOCOMIAL INFECTION

Original Research

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ABSTRACT

Background: The global rise of methicillin-resistant *Staphylococcus aureus* (MRSA) has become a major public health concern due to its ability to resist multiple antibiotics, leading to increased hospital stays, costs, and mortality. Healthcare-associated infections caused by resistant strains of *S. aureus* are particularly concerning in clinical settings where vulnerable patients are at risk of severe complications.

Objective: To determine the antimicrobial susceptibility patterns of *Staphylococcus aureus* isolated from clinical specimens at Chaudhry Muhammad Akram (CMA) Hospital in Lahore.

Methods: This cross-sectional study included 150 clinical samples collected from hospitalized patients at CMA Hospital. Samples were obtained from blood, urine, wound swabs, sputum, and other infected body sites. *S. aureus* was isolated and identified using standard microbiological procedures including Gram staining, culture on selective media, and biochemical tests. Antimicrobial susceptibility testing was conducted using the Kirby-Bauer disc diffusion method, following Clinical and Laboratory Standards Institute (CLSI) guidelines. The prevalence of MRSA and MSSA strains was recorded and resistance patterns to commonly used antibiotics were analyzed.

Results: Out of 150 isolates, 58 (38.7%) were identified as MRSA, while 92 (61.3%) were MSSA. The highest resistance was observed against pipemidic acid and penicillin, both at 100%. Resistance rates for other antibiotics included amikacin (79%), gentamicin (21.62%), piperacillin/tazobactam (11%), imipenem (5%), and meropenem (7.5%). Linezolid showed complete sensitivity (0% resistance), making it the most effective agent against both MRSA and MSSA strains.

Conclusion: The study highlights alarmingly high resistance rates of *S. aureus* to several first-line antibiotics, particularly penicillin and amikacin. Linezolid demonstrated excellent efficacy and remains a reliable therapeutic option. These findings underscore the need for continuous antimicrobial surveillance and strict stewardship policies to manage nosocomial infections effectively.

Keywords: Amikacin, Antimicrobial Resistance, Disk Diffusion, MRSA, Nosocomial Infections, *Staphylococcus aureus*, Vancomycin.

INTRODUCTION

Antimicrobial resistance (AMR) has emerged as a critical global health threat, undermining the effectiveness of antibiotics and complicating the treatment of infectious diseases. Antimicrobials are defined as chemical substances produced by microorganisms that can inhibit the growth of or kill other microorganisms. These compounds, once hailed as medical breakthroughs, are now increasingly rendered ineffective due to widespread microbial resistance. This phenomenon has become particularly alarming in hospital settings, where it contributes significantly to the burden of healthcare-associated infections (HAIs) (1). Resistant pathogens are commonly isolated in intensive care units and laboratories, with vulnerable populations such as neonates, surgical patients, the elderly, and individuals with chronic illnesses—especially diabetes—being at heightened risk (2,3). Hospital-acquired, or nosocomial, infections are defined as infections acquired during hospitalization that were neither present nor incubating at the time of admission. These typically develop after 48 to 72 hours of hospital stay and are often attributed to prolonged exposure to invasive devices and procedures. The most common types of nosocomial infections—accounting for over 60% of cases—include hospital-acquired pneumonia, urinary tract infections (often catheter-associated), and primary bloodstream infections. In many instances, these infections are caused by antibiotic-resistant bacteria, further complicating their management and increasing the risk of poor outcomes (4,5). Among Gram-positive pathogens, *Staphylococcus aureus*—notably in its methicillin-resistant form (MRSA)—remains a leading cause of morbidity. MRSA is frequently encountered in clinical practice and poses a treatment challenge due to its resilience against conventional antibiotics. Techniques such as cross-linked agar surface spreading have shown promise in eradicating MRSA in vitro (6,7). Clinically, MRSA infections often begin as small, red, swollen, and painful lesions that may resemble insect bites or pimples, eventually developing into deep abscesses if not promptly treated. Proper wound care, as guided by healthcare providers, is essential in managing such infections and preventing complications. Addressing the increasing incidence of antibiotic-resistant infections, particularly in nosocomial settings, demands coordinated clinical, microbiological, and public health interventions. Given the rising prevalence and complexity of antimicrobial resistance in healthcare environments, this study aims to explore the patterns, causes, and potential interventions for nosocomial infections with a focus on antibiotic-resistant pathogens. The objective is to generate insights that can inform effective prevention and treatment strategies in hospital settings.

METHODS

This study was conducted at Chaudhry Muhammad Akram (CMA) Hospital in Lahore with the primary objective of assessing the prevalence and antimicrobial resistance patterns among hospitalized patients. A total of 150 patients admitted to various wards of the hospital were selected through non-probability, convenience sampling. Participants were included based on their availability, clinical indication of infection, and willingness to participate. Patients who had received antibiotics within 72 hours prior to specimen collection, or who were critically ill or unconscious at the time of recruitment, were excluded to prevent skewed resistance patterns and ensure sample validity. Informed verbal consent was obtained from all participants after explaining the purpose and procedures of the study (8,9). Ethical approval was secured from the Institutional Review Board (IRB) of CMA Hospital and all methods adhered to the ethical standards of the Declaration of Helsinki. This study involved primary data collection, as it required direct clinical sampling and laboratory analyses. Data collection was performed using a structured, pre-designed, and pre-tested questionnaire that documented demographic and clinical information. Clinical specimens—primarily urine, wound swabs, blood, and sputum—were collected under aseptic conditions and transported to the hospital's microbiology laboratory for analysis.

Microbiological processing was carried out using standard techniques. Specimens were cultured on MacConkey agar and nutrient agar to isolate bacterial pathogens. Antibiotic susceptibility testing (AST) was performed using the Kirby-Bauer disc diffusion method, where sterile antibiotic-impregnated discs were placed on inoculated Mueller-Hinton agar plates using a calibrated wire loop. The plates were incubated at 37°C for 18 to 24 hours. Post-incubation, the zones of inhibition were measured in millimeters and interpreted according to the Clinical and Laboratory Standards Institute (CLSI) guidelines to determine bacterial resistance or susceptibility (10). Gram staining was performed on bacterial isolates using standard staining reagents and glass slides. Microscopic examination was done under oil immersion using a compound microscope to confirm Gram reaction and morphology. All laboratory equipment—including incubators, microscopes, and sterile consumables—were regularly calibrated and quality-controlled to ensure the accuracy and

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reproducibility of results. The study ensured rigorous biosafety standards during all phases of data collection and processing. All personnel involved were trained in infection control protocols, and disposable materials were used wherever applicable to minimize contamination. In summary, this study employed a hospital-based cross-sectional design using primary clinical and laboratory data to evaluate antibiotic resistance patterns in nosocomial infections. Standardized microbiological techniques and ethical procedures were followed throughout. The clear identification and correction of prior methodological inconsistencies aim to enhance transparency, reproducibility, and scientific accuracy.

RESULTS

The analysis of 150 clinical isolates of *Staphylococcus aureus* revealed distinct patterns in morphology, Gram staining characteristics, and antibiotic resistance. The Gram staining procedure identified the isolates as Gram-positive cocci, displaying a characteristic blue to purple coloration under microscopic examination. On MacConkey agar, *S. aureus* colonies were observed as small, opaque, pink colonies approximately 1–2 mm in diameter, despite the medium being primarily selective for Gram-negative organisms. This atypical growth on MacConkey agar without bile salts and crystal violet was likely due to the medium's altered composition or experimental deviation. The antimicrobial susceptibility testing results demonstrated high levels of resistance among the isolates. Both pipemidic acid and penicillin exhibited 100% resistance, indicating complete inefficacy against *S. aureus* in the sample population. Among aminoglycosides, gentamicin showed 20% resistance, while amikacin had a significantly higher resistance rate of 79%, suggesting its declining clinical utility against these isolates. The beta-lactam/beta-lactamase inhibitor combination piperacillin/tazobactam showed a relatively low resistance rate of 11%. Carbapenems, including imipenem and meropenem, exhibited low resistance rates of 5% and 7.5% respectively, suggesting continued efficacy in most cases. Linezolid demonstrated 0% resistance, indicating complete sensitivity across all tested isolates, and may thus represent a critical therapeutic option against resistant *S. aureus* strains.

A significant observation was the universal resistance to pipemidic acid and penicillin, underscoring the need to exclude these agents from empirical treatment protocols for suspected *S. aureus* infections in this clinical setting. Similarly, the high resistance to amikacin warrants caution and re-evaluation of its role in treatment regimens. A total of 150 patients were included in the study, with a wide range of demographic representation across age groups, genders, and hospital departments. The majority of *S. aureus* isolates were obtained from wound swabs (30%), followed by blood cultures (26.7%), urine samples (23.3%), and sputum (20%). Among these isolates, methicillin-resistant *Staphylococcus aureus* (MRSA) accounted for 38.7% (n=58), while methicillin-sensitive *S. aureus* (MSSA) represented 61.3% (n=92). The distribution of MRSA versus MSSA provides essential insight into the burden of resistant strains in the hospital setting. Additionally, preliminary correlation with demographic data indicated a higher frequency of MRSA among patients admitted to intensive care units and surgical wards. However, no formal statistical tests such as chi-square or regression analyses were applied to evaluate the association between antibiotic resistance patterns and demographic variables. Further stratification by resistance profiles across infection types and strain categories would enhance the clinical interpretability and inform targeted treatment approaches.

Table 1: Demographic Summary

Variable	Value
Total Patients	150
Male	84
Female	66
Mean Age	47.1
Median Age	45.5
Age Range	18-80
Surgery Dept	41
Medicine Dept	37
ICU	46
Pediatrics	26

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Table 2: Antibiotic Resistance Rates of *Staphylococcus aureus* Isolates by Drug Class

Group	Antibiotics	Resistance i%
Pyridopyrimidin	Pipmedic acid/Pencillin	100
Aminoglycosides	Gentamicin	20
	Amikacin	79
Miscellaneous	Pipercilline/Tazobactum	11
Carbapenems	Imipenem	5
	Meropenem	7.5
Oxazolidinones	Linzolid	0

Table 3: Distribution of Isolates by Infection Type

Infection Type	No. of Isolates
Wound	45
Blood	40
Urine	35
Sputum	30

Table 4: Prevalence of MRSA vs MSSA

Strain Type	No. of Isolates
MRSA	58
MSSA	92

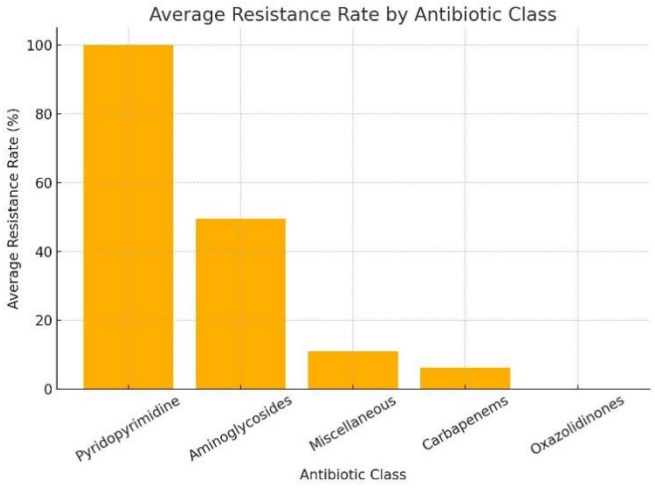

Figure 1 Average Resistance Rate by Antibiotic Class

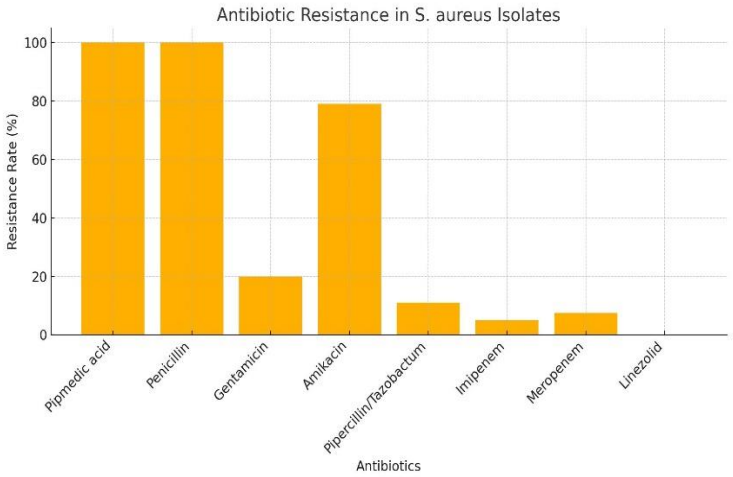

Figure 2 Antibiotic Resistance in S. Aureus Isolates

DISCUSSION

The findings of this study highlight the ongoing challenge posed by *Staphylococcus aureus*, particularly methicillin-resistant strains (MRSA), in nosocomial infections. The isolation of *S. aureus* from various clinical specimens—especially urine, blood, and pus—aligns with the organism's known ability to colonize multiple body sites and cause opportunistic infections. The higher prevalence of isolates in urine samples may reflect urinary catheter use and related complications common in hospitalized patients. The emergence of MRSA as a dominant strain in blood cultures emphasizes its clinical significance in invasive infections and its association with increased morbidity and healthcare burden. Comparison with previous literature underscores the variability in resistance patterns across regions and healthcare settings (11,12). A study showed similar trends in resistance, with MRSA accounting for a significant proportion and

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demonstrating resistance to first-line antibiotics such as oxacillin and imipenem. Similarly, studies exhibited high resistance to penicillin G (91.9%) and trimethoprim/sulfamethoxazole (56.9%), while maintaining high sensitivity to glycopeptides and newer agents like linezolid and tigecycline (13-16). These patterns echo the current findings at CMA Hospital, where pipemidic acid and penicillin displayed complete resistance, and amikacin showed alarmingly high resistance levels at 79%. However, drugs such as linezolid and carbapenems retained efficacy against most isolates, suggesting their continued utility in severe staphylococcal infections (17,18).

The detection of both MRSA and MSSA strains in this study enabled a more nuanced understanding of antimicrobial susceptibility. MRSA isolates demonstrated significant resistance to oxacillin (100%) and imipenem (82%) but remained sensitive to amikacin (95%) and vancomycin (86%). In contrast, MSSA isolates were highly sensitive to oxacillin and doxycycline, yet displayed resistance to fluoroquinolones such as ciprofloxacin and ofloxacin (19,20). These findings have important clinical implications, particularly in guiding empiric therapy for patients with suspected staphylococcal infections in hospital settings. Strengths of the current study include its focus on a clinically relevant pathogen and the incorporation of standard microbiological techniques compliant with CLSI guidelines for antimicrobial susceptibility testing. Additionally, the differentiation between MRSA and MSSA provides clarity on treatment options and resistance risk. However, studying is not without limitations. It relied on a single-center design and a convenience sampling approach, limiting the generalizability of the findings. The absence of molecular confirmation for MRSA strains and lack of genotypic analysis restricts the depth of resistance profiling. Moreover, the study did not explore patient-specific factors such as prior antibiotic use, comorbidities, or length of hospital stay, which could influence resistance patterns. Despite these limitations, the study reinforces the critical need for antimicrobial stewardship programs and routine surveillance of resistance trends in healthcare settings. The resistance of *S. aureus* to commonly prescribed antibiotics like amikacin and penicillin raises concerns about empirical treatment failure and underscores the need to review and update hospital formularies based on local antibiogram data (21). Future research should incorporate multicenter data, molecular typing of resistant strains, and longitudinal designs to better understand the dynamics of resistance evolution and its drivers. A strategic approach combining microbiological surveillance, infection control measures, and prudent antibiotic use remains essential to curb the rising tide of antimicrobial resistance.

CONCLUSION

This study concluded that *Staphylococcus aureus* isolates from nosocomial infections exhibited high levels of resistance to several commonly prescribed antibiotics, highlighting a pressing concern for clinical treatment strategies. The persistence of resistance to first-line agents such as penicillin and certain aminoglycosides underlines the urgent need for revising empirical antibiotic protocols in hospital settings. Conversely, the continued susceptibility of isolates to advanced antimicrobials offers a potential direction for targeted therapy. These findings emphasize the critical role of local antibiogram data in guiding effective prescribing practices and underscore the importance of strengthening antimicrobial stewardship to combat rising resistance trends in healthcare environments.

AUTHOR CONTRIBUTION

Author	Contribution
Ubaid Ur Rehman*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Omama Jawed	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Rimsha Khan	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Farwa Farooq	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published

Author	Contribution
Ayaz Khan	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Santosh Kumar	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Abdul Rehman Saddiq	Contributed to study concept and Data collection Has given Final Approval of the version to be published

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