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Methicillin-Resistant Staphylococcus aureus (MRSA): Changing Epidemiology in Hospital and Community Settings at a Tertiary Care Centre

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Abstract

Introduction: Methicillin-Resistant *Staphylococcus aureus* (MRSA) remains a major cause of both hospital-acquired (HA-MRSA) and community-acquired infections (CA-MRSA). Over the past two decades, the epidemiology of MRSA has shown a dynamic shift with increasing isolation of CA-MRSA among otherwise healthy individuals. Regional data from Eastern Uttar Pradesh are limited. Objective: To determine the prevalence of MRSA among clinical isolates of *Staphylococcus aureus*, to compare the epidemiological characteristics of HA-MRSA and CA-MRSA, and to study the antimicrobial susceptibility pattern of MRSA isolates. Material and Methods: A cross-sectional observational study was conducted in the Department of Microbiology, MLN Medical College, Prayagraj, from December 2023 to June 2025. A total of 2000 clinical samples including pus, wound swabs, blood, urine, sputum and body fluids were processed. *Staphylococcus aureus* isolates were identified by standard microbiological techniques. Methicillin resistance was detected using cefoxitin (30 µg) disc diffusion method as per CLSI guidelines. Results: Out of 2000 samples, 300 *S. aureus* isolates were obtained, of which 120 (40%) were MRSA. HA-MRSA constituted 70% (84/120) of isolates, predominantly from intensive care units and surgical wards, while CA-MRSA accounted for 30% (36/120), commonly associated with skin and soft tissue infections. High resistance was observed to fluoroquinolones, macrolides and aminoglycosides. All isolates remained uniformly sensitive to linezolid, vancomycin, teicoplanin and daptomycin. Conclusion: MRSA continues to be a significant public health concern in Eastern Uttar Pradesh. Although HA-MRSA remains predominant, the emergence of CA-MRSA highlights the need for continuous surveillance, strict infection control practices and rational antimicrobial stewardship. Keywords: MRSA, Hospital-acquired MRSA, Community-acquired MRSA, Antimicrobial resistance, Surveillance.

Keywords: *Methicillin-Resistant Staphylococcus aureus, Epidemiology, microbiological.*

INTRODUCTION

Staphylococcus aureus is a highly adaptable and virulent human pathogen that remains a major cause of both community-acquired and healthcare-associated infections worldwide. It is capable of causing a broad spectrum of clinical conditions, ranging from superficial skin and soft tissue infections to invasive and potentially fatal diseases such as septicemia, pneumonia, osteomyelitis, and infective endocarditis. The organism's ability to acquire resistance to multiple antimicrobial agents and to express numerous virulence factors contributes significantly to its clinical importance and persistence in hospital as well as community settings [1,2].

The introduction of methicillin in the late 1950s was initially considered a solution to penicillin-resistant *S. aureus* infections. However, the emergence of methicillin-resistant *Staphylococcus aureus* (MRSA) in 1961 rapidly undermined this therapeutic advancement. Methicillin resistance in *S. aureus* is primarily mediated by the acquisition of the *mecA*

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gene, which encodes an altered penicillin-binding protein (PBP2a) with reduced affinity for β-lactam antibiotics. This resistance mechanism confers cross-resistance to all β-lactam agents, severely limiting treatment options and posing a significant challenge to clinicians [3–5].

Over time, MRSA has evolved from being predominantly a hospital-associated pathogen to one with a substantial presence in the community. Traditionally, healthcare-associated MRSA (HA-MRSA) infections were linked to prolonged hospitalization, invasive procedures, indwelling medical devices, and prior antibiotic exposure. In contrast, the emergence of community-acquired MRSA (CA-MRSA) among individuals without traditional healthcare-related risk factors represents a major shift in MRSA epidemiology. CA-MRSA strains are often associated with skin and soft tissue infections and are known to possess distinct molecular and virulence characteristics, including the frequent presence of Panton–Valentine leucocidin (PVL) genes [6–8].

The expanding prevalence of MRSA in both healthcare and community settings has significant implications for infection control practices, antimicrobial stewardship programs, and empirical antibiotic therapy. Inadequate or delayed identification of MRSA can result in treatment failure, increased morbidity and mortality, prolonged hospital stay, and elevated healthcare costs. Therefore, continuous surveillance of MRSA prevalence and antimicrobial susceptibility patterns is essential for guiding effective therapeutic strategies and implementing appropriate infection prevention measures [9–11].

Despite the growing burden of MRSA infections in India, regional data on the prevalence, antimicrobial resistance patterns, and epidemiological trends of MRSA remain heterogeneous and limited, particularly from Eastern Uttar Pradesh. Local epidemiological data are crucial, as MRSA prevalence and resistance profiles may vary significantly across regions due to differences in antibiotic usage practices, healthcare infrastructure, and infection control measures. In view of these considerations, the present study was undertaken to assess the prevalence and clinico-microbiological profile of MRSA isolates in a tertiary care hospital in Eastern Uttar Pradesh, with the aim of generating region-specific data to inform clinical management and public health interventions [12–14].

AIMS AND OBJECTIVES

The objectives of the present study were to determine the prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) among clinical isolates of *Staphylococcus aureus* obtained from various samples, to compare the epidemiological characteristics of hospital-acquired and community-acquired MRSA infections, and to analyze the antimicrobial susceptibility patterns of MRSA isolates. In addition, the study aimed to highlight the importance of effective infection control practices and rational antimicrobial stewardship in limiting the spread of MRSA and optimizing patient management.

MATERIAL AND METHODS

Study Design and Setting

The present study was conducted as a cross-sectional observational study over a period of 19 months, from December 2023 to June 2025. The study was carried out in the Department of Microbiology, MLN Medical College and associated teaching hospital, Prayagraj, Uttar Pradesh, which is a tertiary care referral center catering to both urban and rural populations of Eastern Uttar Pradesh.

Sample Size and Study Population

A total of 2000 clinical samples received in the Microbiology laboratory during the study period were included for analysis. These samples were obtained from patients of all age groups and both sexes attending various outpatient departments (OPDs) as well as from hospitalized patients admitted to different wards and intensive care units (ICUs). The samples were processed to isolate *Staphylococcus aureus* and further evaluated for methicillin resistance to fulfill the study objectives.

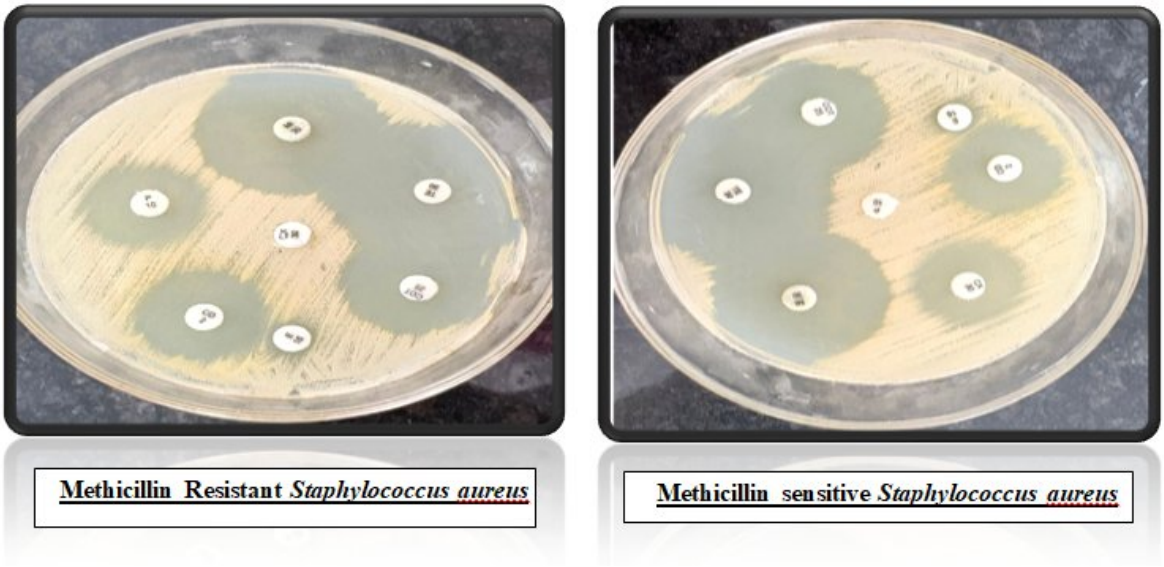
Sample Collection and Processing

Clinical specimens included pus, wound swabs, blood, urine, sputum, and other body fluids such as pleural fluid, ascitic fluid, and cerebrospinal fluid. Samples were collected under strict aseptic precautions by trained healthcare personnel and transported promptly to the Microbiology laboratory. All specimens were processed using standard microbiological techniques as per established laboratory protocols.

Isolation and Identification of *Staphylococcus aureus*
Specimens were inoculated onto appropriate culture media such as blood agar and MacConkey agar and incubated at 35–37°C for 18–24 hours. Identification of *Staphylococcus aureus* was based on characteristic colony morphology, Gram staining showing Gram-positive cocci in clusters, and positive catalase test. Confirmation was done using the coagulase test (slide and tube methods) along with other standard biochemical reactions, wherever required **[15].**

Detection of Methicillin Resistance
The detection of methicillin-resistant *Staphylococcus aureus* (MRSA) can be carried out using both phenotypic detection systems and molecular methods. Phenotypic methods include agar dilution tests, disc diffusion tests using oxacillin and cefoxitin discs, E-test for determination of oxacillin minimum inhibitory concentration (MIC), oxacillin screen agar, chromogenic media specifically designed for MRSA identification, and detection of penicillin-binding protein 2a (PBP2a) using latex agglutination kits. These methods are widely used in routine diagnostic laboratories due to their simplicity, cost-effectiveness, and reliability. Molecular methods for MRSA detection include polymerase chain reaction (PCR) for identification of the *mecA* gene, whole genome sequencing for comprehensive genetic characterization, and matrix-assisted laser desorption ionization–time of flight mass spectrometry (MALDI-TOF), which aids in rapid identification and resistance profiling.

For this study we have used CEFOXITIN DISC DIFFUSION TEST for detection of MRSA.
Identification Via Cefoxitin Disc Diffusion Technique



Observation: Changing Epidemiology
Increasing overlap between hospital and community strains.
• Antibiotic misuse and patient transfers contribute to spread.
• Molecular typing essential to track transmission.
• Rising CA-MRSA - Public health concern

Methicillin resistance among *Staphylococcus aureus* isolates was detected using the cefoxitin (30 µg) disc diffusion method on Mueller-Hinton agar, in accordance with Clinical and Laboratory Standards Institute (CLSI) guidelines. After incubation at 35°C for 18–24 hours, zones of inhibition were measured and interpreted as per CLSI criteria. Isolates showing resistance to cefoxitin were labelled as MRSA [15].

Antimicrobial Susceptibility Testing
Antimicrobial susceptibility testing of MRSA isolates was performed by the Kirby–Bauer disc diffusion method on Mueller-Hinton agar following CLSI recommendations. The antibiotic panel included drugs commonly used for the

treatment of *Staphylococcus aureus* infections. Results were interpreted as sensitive, intermediate, or resistant based on CLSI breakpoints.

Definitions and Classification of MRSA

Hospital-acquired MRSA (HA-MRSA) was defined as MRSA isolates obtained from patients who had been hospitalized for more than 48 hours at the time of sample collection or had a history of recent healthcare exposure, such as hospitalization, surgery, dialysis, residence in a long-term care facility, or the presence of indwelling medical devices within the preceding one year [6,7,16].

Community-acquired MRSA (CA-MRSA) was defined as MRSA isolates recovered from patients presenting from the community with no history of hospitalization, surgery, dialysis, or residence in a healthcare facility within the previous one year and without indwelling medical devices at the time of sample collection [6,7,16].

Inclusion Criteria

All non-duplicate clinical isolates of *Staphylococcus aureus* obtained from patients of all age groups and both sexes were included in the study. Samples from both hospitalized patients and community-based cases were considered.

Exclusion Criteria

Duplicate isolates obtained from the same patient, mixed or contaminated cultures, and samples with incomplete clinical or epidemiological data were excluded from the study.

RESULTS

A total of 2000 clinical samples were processed during the study period. Of these, 300 samples (15%) yielded *Staphylococcus aureus*. Among the *S. aureus* isolates, 120 were identified as methicillin-resistant *Staphylococcus aureus* (MRSA), resulting in an overall MRSA prevalence of 40%.

Distribution of MRSA Isolates

Out of the 120 MRSA isolates, 84 (70%) were classified as hospital-acquired MRSA (HA-MRSA), while the remaining 36 isolates (30%) were categorized as community-acquired MRSA (CA-MRSA). HA-MRSA constituted the predominant group, indicating a higher burden of MRSA infections within the hospital setting.

Specimen-Wise Distribution

Specimen-wise analysis revealed that the majority of MRSA isolates were obtained from pus and wound swabs, accounting for 55% of the total isolates. This was followed by blood samples (15%), urine samples (12%), sputum and other respiratory secretions (10%), and various sterile body fluids including pleural and ascitic fluids (8%). HA-MRSA isolates were predominantly recovered from pus/wound swabs and blood samples, whereas CA-MRSA isolates were mainly associated with skin and soft tissue infections, reflecting differences in clinical presentation between hospital- and community-associated cases.

Ward-Wise Distribution

Among the HA-MRSA isolates, the highest proportion was recovered from intensive care units (ICUs) and surgical wards, together accounting for nearly two-thirds of hospital-acquired MRSA cases. Medical wards contributed a comparatively smaller share. In contrast, CA-MRSA isolates were primarily obtained from outpatients and patients presenting to the emergency department without a history of recent hospitalization or healthcare exposure.

Antimicrobial Susceptibility Pattern

Antimicrobial susceptibility testing demonstrated that HA-MRSA isolates exhibited a high degree of multidrug resistance. A majority of HA-MRSA strains showed resistance to fluoroquinolones (85%), macrolides (75%), and aminoglycosides (70%). In comparison, CA-MRSA isolates showed relatively lower resistance rates to these antimicrobial classes, with resistance ranging between 40% and 45%.

Notably, all MRSA isolates, irrespective of their epidemiological classification, were uniformly susceptible to linezolid, vancomycin, teicoplanin, and daptomycin. No isolates of vancomycin-intermediate *Staphylococcus aureus* (VISA) or vancomycin-resistant *Staphylococcus aureus* (VRSA) were detected during the study period.

Epidemiological Observations

An overlap in the epidemiological characteristics of HA-MRSA and CA-MRSA isolates was observed, suggesting possible transmission between hospital and community settings. The presence of CA-MRSA strains in hospitalized patients and HA-MRSA strains in community settings indicates a blurring of traditional epidemiological boundaries.

Table 1. Prevalence of *Staphylococcus aureus* and MRSA among Clinical Samples

Parameter	Number	Percentage (%)
Total clinical samples processed	2000	100
Staphylococcus aureus isolates	300	15
MRSA isolates	120	40 (of *S. aureus*)
MSSA isolates	180	60 (of *S. aureus*)

Table 2. Distribution of MRSA Isolates According to Epidemiological Type

Type of MRSA	Number of Isolates	Percentage (%)
HA-MRSA	84	70
CA-MRSA	36	30
Total	**120**	**100**

Specimen-Wise Distribution of MRSA Isolates

Among the 120 MRSA isolates, the highest proportion was obtained from pus and wound swab specimens, accounting for 66 isolates (55%). This was followed by blood samples, which yielded 18 isolates (15%), and urine samples with 14 isolates (12%). Respiratory specimens including sputum and other respiratory secretions contributed 12 isolates (10%). The least number of MRSA isolates were recovered from other body fluids, comprising 10 isolates (8%). Thus, pus and wound swab specimens constituted the major source of MRSA isolates in the present study.

Table 3. Ward-Wise Distribution of HA-MRSA Isolates

Hospital Area	Number of HA-MRSA	Percentage (%)
Intensive Care Units	36	43
Surgical wards	20	24
Medical wards	18	21
Other wards	10	12
Total	**84**	**100**

Table 4. Antimicrobial Resistance Pattern of HA-MRSA and CA-MRSA Isolates

Antimicrobial Agent	HA-MRSA Resistance (%)	CA-MRSA Resistance (%)
Fluoroquinolones	85	45
Macrolides	75	40
Aminoglycosides	70	42
Linezolid	0	0
Vancomycin	0	0
Teicoplanin	0	0
Daptomycin	0	0

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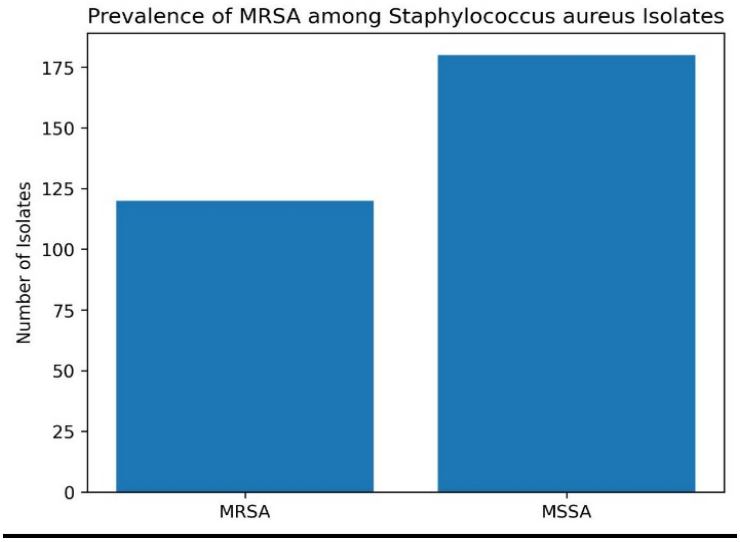

Figure 1. Prevalence of MRSA among *Staphylococcus aureus* Isolates
Bar diagram showing proportion of MRSA and MSSA among total S. aureus isolates.

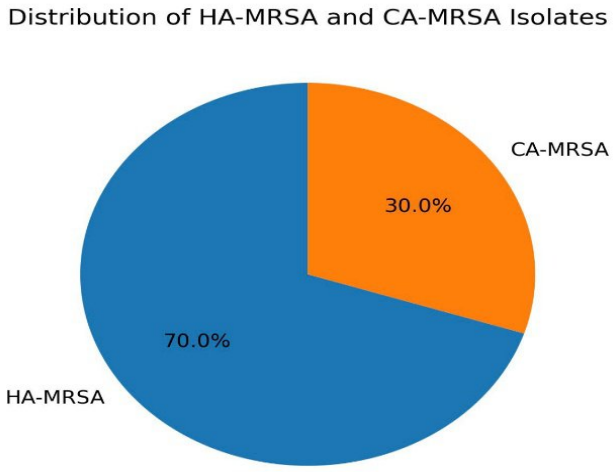

Figure 2. Distribution of HA-MRSA and CA-MRSA Isolates
Pie chart depicting the relative proportion of hospital-acquired and community-acquired MRSA

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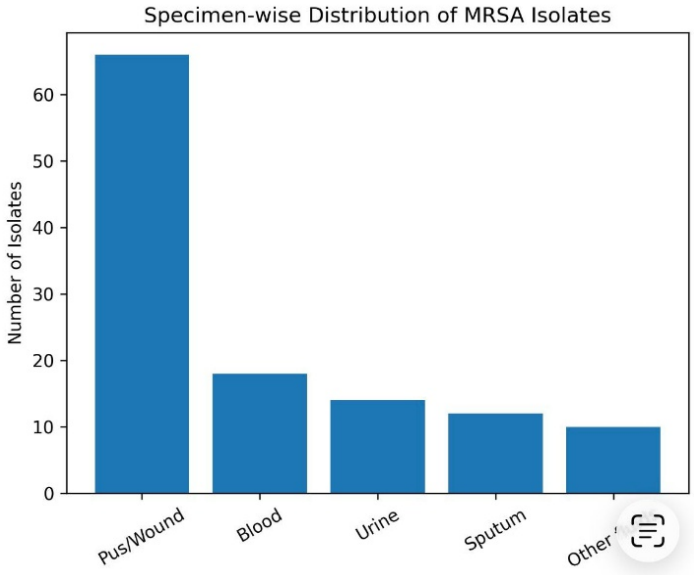

Figure 3. Specimen-Wise Distribution of MRSA Isolates
Bar chart showing distribution of MRSA isolates across different clinical specimens

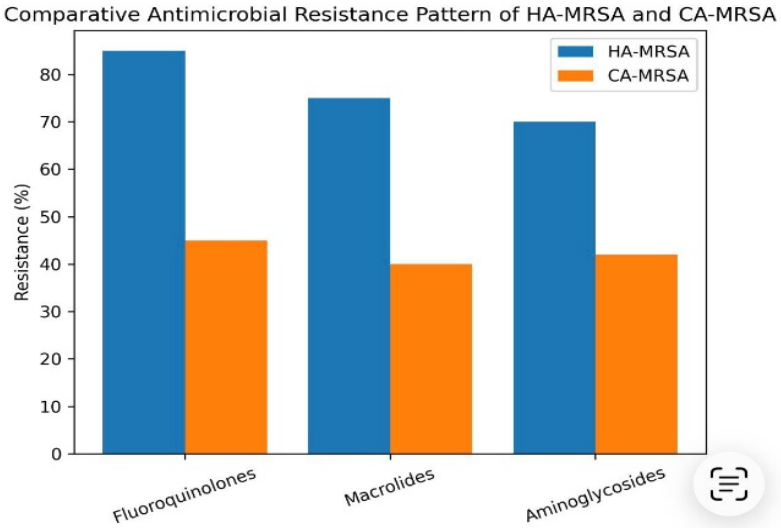

Figure 4. Comparative Antimicrobial Resistance Pattern of HA-MRSA and CA-MRSA
Grouped bar diagram comparing resistance rates between HA-MRSA and CA-MRSA isolates.

DISCUSSION

The present study highlights a substantial burden of methicillin-resistant *Staphylococcus aureus* (MRSA) infections, with an overall prevalence of 40% among *S. aureus* isolates. This finding is comparable to reports from several tertiary care centres across India, which have documented MRSA prevalence ranging from moderate to high levels. Such consistency underscores the continued endemicity of MRSA in Indian healthcare settings and reflects ongoing challenges in antimicrobial stewardship and infection control [12,17–19].

In the present study, hospital-acquired MRSA (HA-MRSA) constituted the majority of isolates, with a predominant distribution in intensive care units and surgical wards. This pattern is well recognized and can be attributed to multiple factors, including prolonged hospital stay, frequent use of broad-spectrum antibiotics, invasive diagnostic and therapeutic procedures, and the presence of indwelling medical devices. Intensive care units, in particular, serve as reservoirs for multidrug-resistant organisms due to high antibiotic selection pressure and increased patient-to-patient transmission, emphasizing the need for stringent infection control measures in these high-risk areas **[18,20].**

The emergence of community-acquired MRSA (CA-MRSA) in the present study represents a significant and concerning epidemiological shift. Traditionally confined to healthcare settings, MRSA is now increasingly encountered among individuals without prior healthcare exposure. Factors such as inappropriate antibiotic use in the community, easy over-the-counter availability of antimicrobials, poor adherence to prescribed regimens, overcrowding, and increased population mobility may contribute to the spread of CA-MRSA. The growing overlap observed between HA-MRSA and CA-MRSA strains further suggests bidirectional transmission between hospitals and the community, blurring the classical epidemiological distinction **[6,7,21].**

The antimicrobial susceptibility profile observed in this study reveals a high degree of multidrug resistance among HA-MRSA isolates, particularly to fluoroquinolones, macrolides, and aminoglycosides. In contrast, CA-MRSA isolates demonstrated comparatively lower resistance rates to these agents, consistent with previously reported trends. These findings highlight the selective antibiotic pressure prevalent in hospital environments and reinforce the importance of judicious antimicrobial use [19,22].

Encouragingly, all MRSA isolates in the present study remained uniformly susceptible to glycopeptides (vancomycin and teicoplanin), oxazolidinones (linezolid), and lipopeptides (daptomycin). The absence of vancomycin-intermediate *S. aureus* (VISA) or vancomycin-resistant *S. aureus* (VRSA) is a favourable observation and supports the continued role of these agents as drugs of choice for the treatment of severe MRSA infections. However, the reliance on a limited number of last-resort antimicrobials underscores the urgent need for sustained surveillance to detect emerging resistance at an early stage [3,9,23].

Overall, the findings of this study emphasize the importance of continuous monitoring of MRSA prevalence and resistance patterns to guide empirical antibiotic therapy. Strengthening hospital infection control practices, implementing robust antimicrobial stewardship programs, and promoting rational antibiotic use in both hospital and community settings are essential to curb the spread of MRSA and preserve the efficacy of existing antimicrobial agents.

CONCLUSION

Methicillin-resistant *Staphylococcus aureus* (MRSA) continues to represent a significant public health challenge in Eastern Uttar Pradesh, as evidenced by its substantial prevalence in the present study. Hospital-acquired MRSA remains the predominant form, particularly in high-risk areas such as intensive care units and surgical wards, reflecting the impact of prolonged hospitalization, invasive procedures, and selective antimicrobial pressure.

The increasing detection of community-acquired MRSA among individuals without prior healthcare exposure highlights a concerning epidemiological shift and underscores the potential for transmission between community and hospital settings. This evolving trend necessitates strengthened regional surveillance to monitor changes in MRSA prevalence and resistance patterns.

Implementation of robust infection control measures, including adherence to hand hygiene protocols, contact precautions, and environmental cleaning, is essential to limit the spread of MRSA within healthcare facilities. Equally important is the promotion of judicious antimicrobial use through effective antimicrobial stewardship programs to reduce unnecessary antibiotic exposure and prevent further emergence of resistance. Continuous monitoring and region-specific data generation are crucial for guiding empirical therapy, optimizing patient outcomes, and informing public health interventions aimed at controlling the burden of MRSA infections [11,14,24].

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