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RESEARCH ARTICLE

A Retrospective Overview of Staphylococcus aureus Bloodstream Infections: Trends in Prevalence and Antimicrobial Susceptibility Patterns in a Tertiary Care Setting in South India

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Abstract: ***Background***: Staphylococcus aureus bloodstream infections (SAB) are associated with high morbidity and mortality, particularly when caused by methicillin-resistant S. aureus (MRSA). Understanding local prevalence and antimicrobial susceptibility patterns is crucial for guiding empirical therapy and infection control practices. ***Objectives***: To determine the prevalence of MRSA among Staphylococcus aureus bloodstream isolates, assess their antimicrobial susceptibility patterns, and evaluate the extent of multidrug resistance in a tertiary care hospital in South India. ***Methods***: A retrospective cross-sectional study was conducted at Saveetha Medical College and Hospital, Chennai, India, analyzing blood culture samples collected from January to December 2024. Blood cultures were processed using the BACT/ALERT 3D system. Presumptive identification of S. aureus was performed by Gram staining, catalase, and coagulase tests, and confirmed using the VITEK 2 Compact System. Antimicrobial susceptibility testing was conducted using VITEK 2 AST-GP 235 cards, and results interpreted according to CLSI guidelines. Data were analyzed using descriptive statistics. ***Results***: Out of 8,426 blood cultures, 1,082 (12.84%) yielded positive isolates. Gram-positive bacteria constituted 36.41% (n = 397), with Staphylococcus aureus accounting for 6.8% (n = 74) of isolates. Methicillin resistance was observed in 32.43% (n = 24) of S. aureus isolates, while 30.6% (n = 92) of coagulase-negative staphylococci were methicillin resistant. All S. aureus isolates remained susceptible to vancomycin and linezolid. High susceptibility was also noted for rifampicin (90%) and tetracycline (67%), whereas reduced susceptibility was seen for ciprofloxacin (23%), erythromycin (27%), clindamycin (37%), and levofloxacin (47%). ***Conclusions***: MRSA accounts for nearly one-third of S. aureus bloodstream infections in this tertiary care setting, with preserved susceptibility to vancomycin and linezolid. High resistance rates to commonly used antibiotics demonstrate the necessity of continuous surveillance, rational antibiotic prescribing, and stringent infection control practices to limit the impact of multidrug-resistant S. aureus bacteremia.

Keywords: Staphylococcus aureus, MRSA, bloodstream infection, antimicrobial resistance, tertiary care, India.

INTRODUCTION

Bloodstream infections (BSIs), also known as bacteremia, are potentially life-threatening infections that can be either community-acquired or hospital-acquired. Hospital-acquired BSIs are associated with higher rates of morbidity and mortality, as well as increased overall healthcare costs. The crude mortality rate for BSIs is approximately 35%, with variations ranging from 12% to 80% depending on the source of the infection [1]. Primary or intravascular BSIs originate from the cardiovascular system itself, while secondary or extravascular BSIs arise from other infectious sites within the body. Coagulase-negative Staphylococcus (CONS) and Staphylococcus aureus are the most commonly isolated gram-positive bacteria in blood culture samples [2]. The World Health Organization (WHO) has identified antimicrobial resistance as one of the top ten global public health threats, with Staphylococcus aureus, particularly methicillin-resistant Staphylococcus aureus (MRSA), playing a significant role in this crisis [3].

S. *aureus* is a Gram-positive coccus that colonizes the skin and mucous membranes of approximately 30% of healthy individuals. Despite being a common commensal organism, *S. aureus* is also a formidable opportunistic pathogen responsible for a wide array of infections ranging from superficial skin infections to severe invasive diseases such as pneumonia, osteomyelitis, septic arthritis, infective endocarditis, and bacteremia. Among these, *S. aureus* bacteremia (SAB) is particularly concerning due to its strong association with high rates of complications and death, with case fatality rates ranging from 7% to 39% as documented in various clinical studies [4].

The emergence and rapid global spread of MRSA since its first detection in the United Kingdom in 1961 have further aggravated the challenges posed by *S. aureus*

infections. MRSA has now become endemic in many hospital environments and is increasingly reported in community settings as well. MRSA strains possess the mecA gene, which encodes an altered penicillin-binding protein (PBP2a) that has low affinity for beta-lactam antibiotics, rendering methicillin and related antibiotics ineffective [5]. As a result, MRSA infections are not only more difficult and expensive to treat but are also associated with worse clinical outcomes compared to infections caused by methicillin-sensitive *S. aureus* (MSSA).

Globally, MRSA is responsible for a substantial proportion of all *S. aureus* infections. In 2017, the U.S. Centres for Disease Control and Prevention (CDC) estimated that there were approximately 323,700 hospitalizations related to MRSA in the United States alone, resulting in over 10,600 deaths within a single year [6]. In Asia, MRSA prevalence remains alarmingly high, with WHO surveillance data indicating MRSA rates exceeding 20% in all WHO regions and surpassing 80% in some countries. In India, MRSA prevalence varies significantly across healthcare institutions, with studies reporting rates between 31% and 39% [7]. These disparities reflect differences in local infection control practices, antimicrobial usage policies, diagnostic capacities, and the presence or absence of structured AMR surveillance systems.

The clinical significance of MRSA extends beyond its high prevalence and resistance profile. MRSA infections are commonly associated with delayed appropriate therapy, increased hospital stays, greater need for intensive care, and higher treatment costs. The pathogen is often resistant not only to methicillin but also to multiple other antibiotics, including penicillin, erythromycin, gentamicin, ciprofloxacin, tetracycline, and cotrimoxazole [8]. Alarmingly, there have been increasing reports of reduced susceptibility to glycopeptides such as vancomycin, which have traditionally been considered the drugs of last resort for MRSA infections. This growing resistance threatens the effectiveness of even the most potent antibiotics and underscores the urgency of early detection, prompt initiation of targeted therapy, and robust infection prevention strategies.

Recent advances in antimicrobial development have introduced new agents with activity against MRSA, including ceftaroline, ceftobiprole, delafloxacin, dalbavancin, oritavancin, and iclaprim [9]. These drugs are at various stages of clinical use or research but may not be readily available or affordable in resource-limited settings. Consequently, the mainstay of MRSA treatment in low- and middle-income countries (LMICs) often remains reliant on vancomycin and linezolid. The increasing reliance on these drugs, coupled with the rise in resistance, makes surveillance of MRSA prevalence and susceptibility patterns critically important, particularly in high-risk environments such as tertiary care hospitals.

In addition to MRSA, coagulase-negative staphylococci (CONS) have also emerged as significant contributors to BSIs, particularly in patients with indwelling medical devices or compromised immune systems. While CONS are generally regarded as contaminants when isolated from a single blood culture, multiple positive cultures or isolation from sterile sites can indicate true bacteremia [10]. Differentiating between contamination and true infection is essential for appropriate clinical management, especially in trauma and ICU settings, where patients are frequently colonized by multidrug-resistant organisms.

This study was initiated to fill the critical gap in local epidemiological data regarding Staphylococcus aureus bloodstream infections, with a particular emphasis on methicillin-resistant Staphylococcus aureus (MRSA) in a tertiary healthcare setting in South India. The primary objective of this retrospective analysis was to determine the prevalence of MRSA among Staphylococcus aureus isolates obtained from blood cultures, assess their antimicrobial susceptibility patterns, and identify the extent of multidrug resistance. Furthermore, the study aimed to explore the clinical significance of MRSA bacteremia and identify the factors associated with adverse outcomes, including mortality.

MATERIALS AND METHODS:

Study Design and Setting

A retrospective cross-sectional study was conducted at Saveetha Medical College and Hospital, a tertiary care teaching hospital in Chennai, India. The study analyzed the prevalence and antibiotic susceptibility patterns of *Staphylococcus aureus* isolates from blood cultures collected over one year (January–December 2024). Data were retrieved from laboratory records and analyzed using the VITEK 2 automated identification and susceptibility system, which determines minimum inhibitory concentrations (MICs).

Sample Collection

Blood samples were obtained from patients admitted to medical wards and ICUs as part of routine diagnostic evaluation for suspected bacteremia. Cultures were processed using the BACT/ALERT 3D automated system, and flagged-positive samples were subjected to presumptive phenotypic identification.

Bacterial Identification

Presumptive identification of Staphylococcus aureus was initially based on colony morphology on blood agar, Gram staining showing Gram-positive cocci in clusters, and positive results for catalase and coagulase tests. Confirmation of species identity was carried out using the VITEK 2 Compact System (bioMérieux, Durham, NC), which utilizes a series of biochemical assays and automated identification algorithms.

Antimicrobial Susceptibility Testing

Susceptibility testing was performed using the VITEK 2 system with AST-GP 235 cards for Gram-positive organisms, following CLSI guidelines. Antibiotics tested included oxacillin, cefoxitin, erythromycin, clindamycin, gentamicin, ciprofloxacin, vancomycin, and trimethoprim-sulfamethoxazole. Interpretations were based on CLSI breakpoints.

Data Analysis

Susceptibility data were entered into Microsoft Excel and analysed using SPSS version 23.0. Descriptive statistics (frequencies and percentages) were used to summarize resistance patterns.

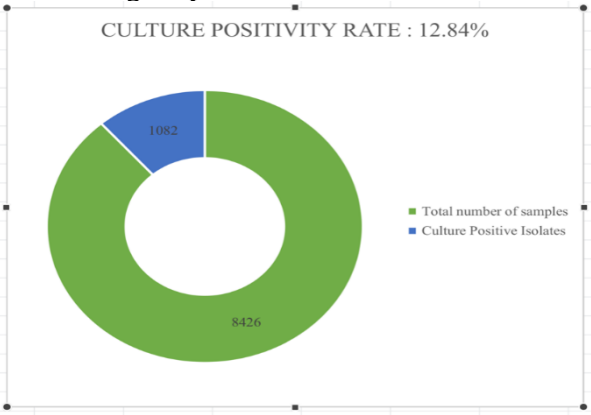
Ethical Considerations

The study received approval from the Institutional Ethics Committee of Saveetha Medical College and Hospital. As a retrospective analysis using anonymised data, informed consent was waived. Confidentiality was strictly maintained throughout the study.

RESULTS

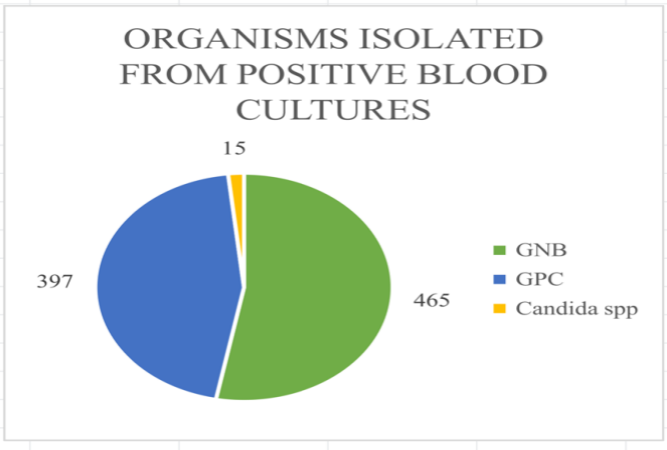
During the study period, a total of 8,426 blood culture samples were processed. Of these, 1,082 samples yielded positive isolates, corresponding to an overall blood culture positivity rate of 12.84% (n = 1,082) (Fig. A).

FIG (A): Pie chart showing the positive isolates obtained from total blood samples



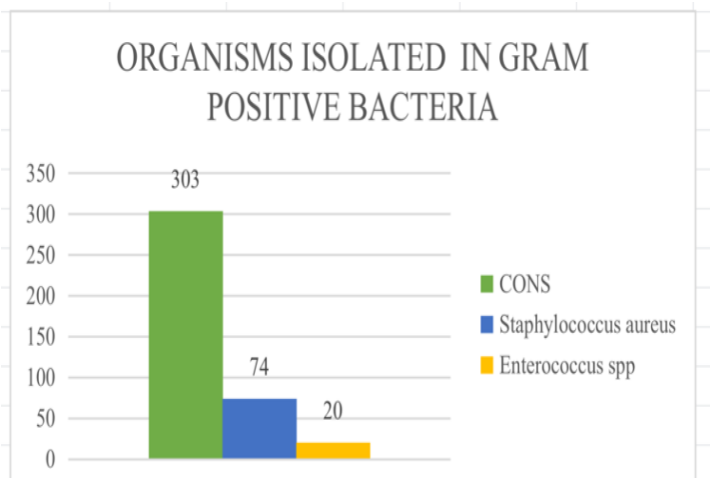
Analysis of the distribution of isolates revealed that Gram-negative bacteria were predominant, accounting for 42.69% (n = 465), followed by Gram-positive bacteria at 36.41% (n = 397), while *Candida* spp. represented 1.3% (n = 15) of the isolates (Fig. B).

FIG (B): Organisms isolated from positive blood cultures



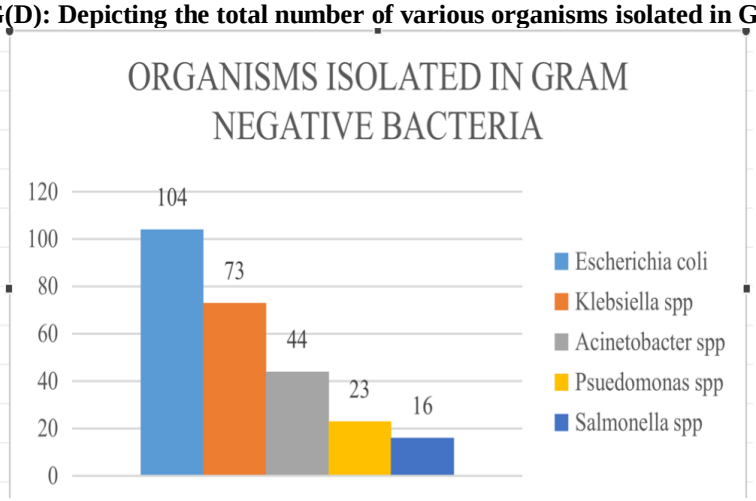
Within the Gram-positive group, *Staphylococcus* species emerged as the most frequently encountered pathogens. Among these, coagulase-negative *Staphylococcus* spp. (CoNS) were the leading isolates, comprising 28% (n = 303) of all culture-positive cases. *Staphylococcus aureus* was the next most common, representing 6.8% (n = 74) of isolates (Fig. C).

FIG (C): Depicting the total number of various organisms isolated in GPC



Among Gram-negative organisms, *Escherichia coli* was the most common isolate, detected in 9.61% (n = 104) of cases. This was followed by *Klebsiella* spp. (6.74%, n = 73), *Acinetobacter* spp. (4.06%, n = 44), and *Pseudomonas* spp. (2.1%, n = 23) (Fig. D).

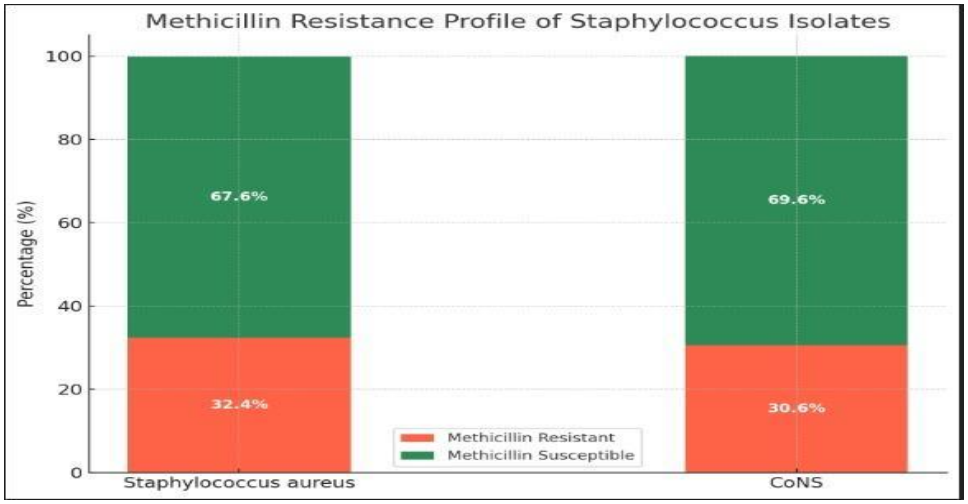
FIG(D): Depicting the total number of various organisms isolated in GNB



Methicillin Resistance in *Staphylococcus* Isolates

Resistance profiling of *Staphylococcus* isolates demonstrated a considerable burden of methicillin resistance. Among *S. aureus* isolates, 32.43% (n = 24) were identified as methicillin-resistant *Staphylococcus aureus* (MRSA), while the majority, 67.56% (n = 50), remained methicillin susceptible. In comparison, a higher proportion of methicillin resistance was observed among *CoNS* isolates, where 30.6% (n = 92) were methicillin resistant, and 69.6% (n = 211) were methicillin susceptible (FIG E).

FIG(E): Methicillin resistance among *Staphylococcus aureus* and Coagulase-negative Staphylococcus (CoNS) isolates



Antimicrobial Susceptibility Profile of Methicillin-Resistant *Staphylococcus aureus* Blood Isolates

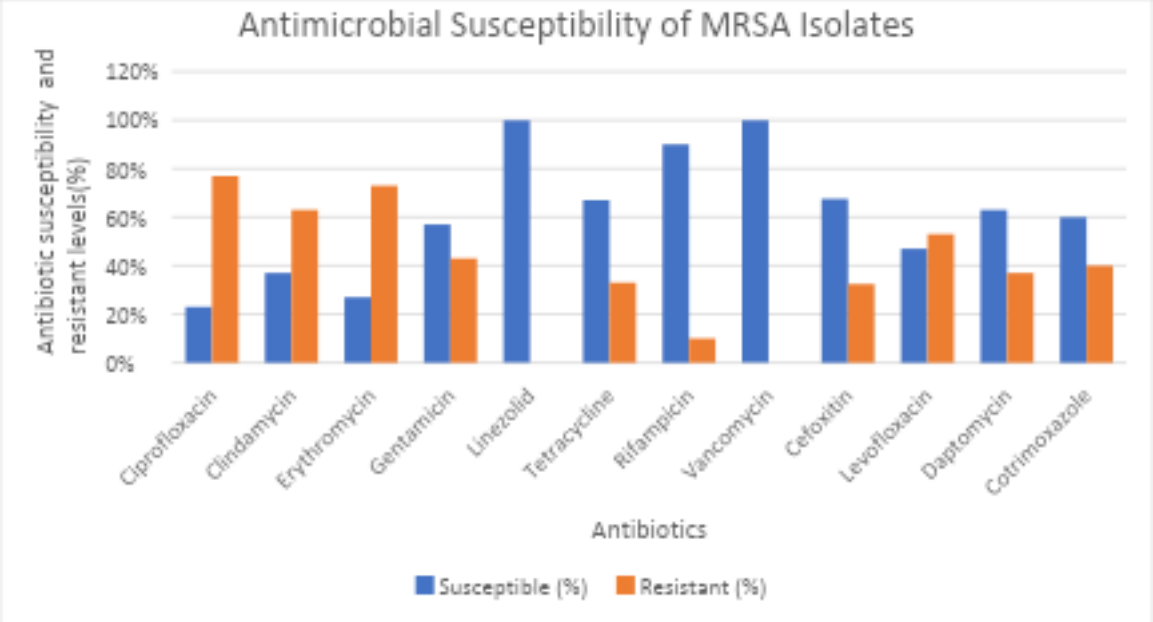
The antimicrobial susceptibility testing (AST) pattern of MRSA isolates is summarized in Figure F. All isolates retained 100% susceptibility to linezolid and vancomycin, highlighting the continued reliability of these agents as mainstays for MRSA bacteremia management. High susceptibility was also recorded for rifampicin (90%) and tetracycline (67%).

Moderate activity was observed with gentamicin (57%), cotrimoxazole (60%), daptomycin (63%), and levofloxacin (47%), reflecting a variable degree of therapeutic utility. By contrast, markedly reduced susceptibility rates were seen for clindamycin (37%), erythromycin (27%), and ciprofloxacin (23%), indicating limited effectiveness of these agents against MRSA bloodstream isolates in this setting, as shown in Table 1 and Figure E.

Table 1: showing Antimicrobial Susceptibility Profile of *Staphylococcus aureus* Blood Isolates

Antibiotic	**Susceptible (%)**	**Resistant (%)**
Ciprofloxacin	23%	77%
Clindamycin	37%	63%
Erythromycin	27%	73%
Gentamicin	57%	43%
Linezolid	100%	0%
Tetracycline	67%	33%
Rifampicin	90%	10%
Vancomycin	100%	0%
Cefoxitin	0	100%
Levofloxacin	47%	53%
Daptomycin	63%	37%
Cotrimoxazole	60%	40%

Figure E showing Antimicrobial Susceptibility Profile of MRSA Blood Isolates



DISCUSSION:

The present study provides an updated overview of the prevalence, methicillin resistance, and antimicrobial susceptibility patterns of *Staphylococcus aureus* bloodstream isolates in a tertiary care hospital in South India. Among 8,426 blood culture samples processed over one year, *S. aureus* accounted for 6.8% of all positive isolates, with methicillin resistance detected in 32.43% of strains. These findings highlight the persistent burden of *S. aureus* bacteremia (SAB), particularly methicillin-resistant *S. aureus* (MRSA), as a major contributor to bloodstream infections in hospitalised patients.

Prevalence of *Staphylococcus aureus* Bacteremia

The prevalence of *S. aureus* bacteremia in our study (6.8%) is comparable to previous reports from Indian tertiary care hospitals, where SAB prevalence ranges between 5% and 12% of all positive blood cultures [11,12]. Internationally, similar rates have been documented, with a multicenter European study reporting *S. aureus* among the top three causative pathogens of bloodstream infections [13]. The high incidence of *S. aureus* as a bloodstream pathogen reflects its dual role as a commensal coloniser and an opportunistic pathogen capable of causing invasive disease.

Burden of Methicillin Resistance

In our study, 32.43% of *S. aureus* isolates were methicillin-resistant. This is consistent with recent Indian surveillance data, where MRSA prevalence in bloodstream isolates has ranged from 30% to 40% [14]. Our findings are lower than reports from some Asian countries, where MRSA prevalence exceeds 50% [15], but higher than recent European and U.S. data, where comprehensive infection control strategies have reduced MRSA bacteremia rates to below 20% [16]. These variations may be attributed to differences in antimicrobial stewardship practices, infection control measures, and surveillance capacities across healthcare systems.

Antimicrobial Susceptibility Profile

Our susceptibility analysis revealed uniformly preserved sensitivity to vancomycin and linezolid, corroborating their continued role as reliable agents for the management of MRSA bacteremia. This aligns with studies from both India and abroad, which consistently demonstrate minimal resistance to glycopeptides and oxazolidinones [17, 18]. However, emerging reports of vancomycin-intermediate *S. aureus* (VISA) and linezolid-resistant strains are concerning and warrant vigilance [19].

High susceptibility to rifampicin (90%) and tetracycline (67%) in our isolates suggests these agents may retain adjunctive roles in therapy. By contrast, resistance to commonly used oral and parenteral agents such as ciprofloxacin (77%), erythromycin (73%), and clindamycin (63%) was alarmingly high, in line with prior Indian studies [20]. These resistance rates severely limit empirical treatment options and suggest that doctors should perform routine susceptibility testing to guide therapy.

Clinical and Public Health Implications

MRSA infections are associated with delayed initiation of appropriate therapy, longer hospital stays, higher treatment costs, and increased mortality compared to MSSA infections [21]. The mortality risk of SAB is reported to range from 20% to 40%, depending on host factors and timely initiation of effective therapy [22]. Our findings emphasise the importance of early recognition of SAB, accurate differentiation of true bacteremia from contamination (especially in cases

involving CoNS), and prompt administration of effective antibiotics.

The persistence of MRSA in Indian hospitals despite decades of awareness demonstrates the importance of strengthening antimicrobial stewardship programs (AMSPs), enhancing infection prevention and control (IPC) measures, and implementing robust national AMR surveillance systems [23] [24]. The high rates of multidrug resistance observed in our study also stress the importance of restricting indiscriminate antibiotic use, particularly fluoroquinolones and macrolides, which are widely misused in both community and hospital settings.

Future Directions

While novel antimicrobials such as ceftaroline, ceftobiprole, and long-acting lipoglycopeptides (dalbavancin, oritavancin) have shown promise against MRSA [9], their availability and affordability remain major challenges in resource-limited settings like India. Therefore, optimising the use of existing drugs, enforcing rational antibiotic prescribing, and strengthening diagnostic capacities should remain priorities. Additionally, molecular typing of MRSA strains and detection of resistance genes (e.g., *mecA*, *mecC*) would offer useful information regarding the epidemiology and clonal spread of resistant strains within healthcare facilities.

Limitations

This study has some limitations. Being retrospective and single-centre, it may not capture broader regional variations in MRSA prevalence. Clinical outcomes such as mortality and length of hospital stay were not analyzed, which could have provided deeper insights into the burden of MRSA bacteremia. Furthermore, molecular characterization of resistance genes was not performed, which could have strengthened the findings.

CONCLUSION

In conclusion, our study demonstrates a significant burden of MRSA bacteremia (32.43%) in a tertiary care hospital in South India, with preserved susceptibility to vancomycin and linezolid but high resistance to fluoroquinolones, macrolides, and lincosamides. These findings underscore the critical need for continuous surveillance of antimicrobial resistance patterns, rational antibiotic use, and stringent infection control practices to curb the rising threat of MRSA in hospital settings.

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