Original Article

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Microbiology Section

Mupirocin Resistance among Methicillin Resistant and Sensitive *Staphylococcus aureus* from Skin and Soft Tissue Infections: A Cross-sectional Study at a Tertiary Care Hospital in Southern Haryana, India

POOJA SINGLA[1], DIMPI BHANKHUR[2], PRATIBHA MANE[3], JYOTI SANGWAN LATHWAL[4]

ABSTRACT

Introduction: *Staphylococcus aureus* is a bacterium associated with the majority of Skin and Soft Tissue Infections (SSTIs). It possesses a wide range of virulence factors and an inherent ability to acquire resistance mechanisms. The incidence of drug resistance in *S. aureus* has increased significantly. Mupirocin is a key treatment option for decolonisation of carriers. However, rising resistance to mupirocin poses a major challenge in the decolonisation of carriers and in preventing transmission of infection to susceptible individuals.

Aim: To determine the mupirocin susceptibility pattern in *Staphylococcus aureus* isolated from SSTIs at a tertiary care hospital.

Materials and Methods: The present study was an observational, cross-sectional study conducted over a period of two years in the Department of Microbiology, Shaheed Hasan Khan Mewati Government Medical College (SHKMGMC), Nalhar, Haryana, India. Out of a total of 2,156 pus samples, 160 isolates of *Staphylococcus aureus* were obtained and subjected to antimicrobial susceptibility testing using the disc diffusion method.

Results: Of the 160 *Staphylococcus aureus* isolates, 31.87% were methicillin-resistant *S. aureus* (MRSA). Overall mupirocin resistance was observed in 15.6% of isolates. High-level mupirocin resistance and low-level mupirocin resistance were noted in 11.87% and 3.75% of isolates, respectively. Inducible clindamycin resistance was detected in 17.5% of isolates. Co-resistance to mupirocin and MRSA was observed in 10.6% of cases, while combined resistance to mupirocin, MRSA, and inducible clindamycin was seen in 1.9% of isolates.

Conclusion: The proportion of mupirocin resistance was higher among MRSA isolates. A significant association was observed between high-level mupirocin resistance and MRSA.

Keywords: Antibiotics, Infection control, Pus

INTRODUCTION

Staphylococcus aureus, a Gram-positive bacterium, is a significant human pathogen associated with a wide spectrum of infections, ranging from mild SSTIs to severe systemic diseases [1]. Approximately 20-40% of the healthy adult population harbours *S. aureus* as a commensal organism in the anterior nares [2]. Colonisation with MRSA is associated with an elevated risk of severe postoperative or device-associated infections due to the organism's limited therapeutic options and multidrug-resistant profile [3]. The emergence of MRSA has become a global public health concern, posing major challenges to effective treatment and infection control strategies [4]. SSTIs caused by MRSA range from minor superficial infections such as impetigo and abscesses to severe invasive conditions, including cellulitis and necrotising fasciitis [5].

Mupirocin, A topical antibiotic derived from *Pseudomonas fluorescens*, has played a crucial role in the treatment and eradication of MRSA, particularly in nasal decolonisation protocols and the management of superficial skin infections. It was the first antibiotic approved for the topical treatment of impetigo after its introduction into clinical practice in 1985 [2]. Mupirocin acts by inhibiting bacterial protein synthesis through the inhibition of isoleucyl transfer RNA (tRNA) synthetase enzyme encoded by the *ileS* gene [6,7]. Widespread and prolonged use of mupirocin for decolonisation of healthcare workers, along with unrestricted over-the-counter use for local wound treatment, has led to the emergence of mupirocin resistance in *S. aureus* [8,9]. Mupirocin resistance is generally classified into low-level resistance (LLMR; minimum inhibitory concentration [MIC] 8–256 µg/mL) and high-level resistance (HLMR; MIC ≥512 µg/mL), mediated by distinct genetic mechanisms. The point mutations in the native ileS gene result in LLMR. The frequently reported mutations are V588F and V631F [10]. LLMR is commonly associated with point mutations in the native *ileS* gene, resulting in reduced affinity for mupirocin, whereas HLMR typically arises from acquisition of plasmid-borne *mupA* or *mupB* genes. The prevalence of mupirocin resistance varies widely across regions and is influenced by antibiotic prescribing practices, infection control policies, and population dynamics [11].

For phenotypic detection of mupirocin resistance, the Kirby-Bauer disk diffusion method is commonly used. However, the dilution method is the gold standard method for the detection of high and low-level mupirocin resistance. [12]. Mupirocin susceptibility testing is not routinely performed in many laboratories. This is concerning because low-level resistance may still respond to high-dose therapy, whereas high-level resistance is strongly associated with decolonisation failure [13].

Given the increasing concern regarding mupirocin resistance in MRSA, particularly in the context of SSTIs, continuous surveillance is essential to guide appropriate treatment strategies and infection control measures. This study aimed to determine the prevalence of mupirocin resistance among MRSA isolates obtained from SSTI

cases, with particular emphasis on differentiating between high-level and low-level resistance. Additionally, the study explores potential associations with resistance to other antibiotics. These findings are expected to enhance understanding of evolving resistance patterns in *S. aureus* and support the development of targeted strategies for the management and prevention of mupirocin-resistant infections in clinical settings.

MATERIALS AND METHODS

This was an observational, cross-sectional study conducted over a period of two years (January 2021-December 2022) in the Department of Microbiology at SHKMGMC, Nalhar, located in a rural and remote area of southern Haryana, India. Ethical approval was obtained from the Institutional Ethics Committee (Protocol No. EC/QA52/2019) prior to the commencement of the study.

Sample size: The prevalence of mupirocin resistance in *Staphylococcus aureus* was considered as the criterion for sample size calculation. Previous studies have reported mupirocin resistance rates ranging from 5% to 26% [1]. Therefore, assuming a prevalence of 12%, the sample size was calculated using the formula:

$n= Z^2PQ/d^2$

where Z=1.96 (for 95% confidence), P=0.12, Q=1-P=0.88, and d=0.05 (absolute precision). The minimum required sample size was calculated to be 162 *S. aureus* isolates. To achieve this sample size, a total of 2,000 patients with SSTIs were enrolled during the study period from January 2021 to December 2022.

Inclusion criteria: All outdoor and indoor patients (from wards and ICUs) of all ages and genders with any type of superficial or deep SSTIs were enrolled. In cases where multiple wound swabs from the same patient yielded S. aureus, only a single isolate was included in the study.

Exclusion criteria: Patients who refused to give informed consent or who had applied mupirocin ointment at the time of sample collection were excluded from the study.

Study Procedure

The study was explained to patients or their legal guardians in their local language, and informed consent was obtained. Clinicodemographic details such as age, gender, type of SSTI, and risk factors- including exposure to high-end antibiotics, hospitalisation in other healthcare facilities, surgery within the preceding 90 days, use of invasive devices, prior use of mupirocin, and co-morbidities- were recorded using a prestructured questionnaire proforma.

Sample collection and processing: The infected skin surface was cleaned with 70% isopropyl alcohol to minimise contamination. Wound swabs were collected from superficial skin lesions, while frank pus was aspirated using a sterile needle and syringe. All samples were transported to the microbiology laboratory within two hours in Amies transport medium.

Isolation and Identification: In the laboratory, samples were subjected to Gram staining and cultured on blood agar and MacConkey agar. Mannitol salt agar was used as a selective medium for *S. aureus*. Identification was performed using standard microbiological methods, including Gram staining, catalase test, slide and tube coagulase tests, mannitol fermentation, and DNase production.

Antimicrobial susceptibility testing: Antimicrobial susceptibility testing was performed using the Kirby–Bauer disc diffusion method in accordance with Clinical and Laboratory Standards Institute (CLSI) M100 guidelines [14]. The antibiotics tested included erythromycin (15 µg), clindamycin (2 µg), cefoxitin (30 µg), doxycycline (30 µg), cotrimoxazole (1.25/23.75 µg), penicillin (10 units), linezolid (30 µg), rifampicin (5 µg), ciprofloxacin (5 µg), and gentamicin (10 µg).

MRSA detection: MRSA was detected using the cefoxitin disc diffusion test. A cefoxitin (30 µg) disc was placed on a Mueller–Hinton agar (MHA) plate with lawn culture of 0.5 McFarland suspension of *S. aureus*. After overnight incubation at 37°C, a zone diameter of ≤21 mm was interpreted as MRSA. *S. aureus* ATCC 25923 was used as the control strain.

Inducible clindamycin resistance: Erythromycin (15 µg) and clindamycin (2 µg) discs were placed 15 mm apart on an MHA plate having a lawn culture of 0.5 McFarland suspension of *S. aureus*. After overnight incubation at 37°C, flattening of the zone of inhibition adjacent to the clindamycin disc (D-shaped zone) was considered positive for inducible clindamycin resistance.

Mupirocin resistance: Low-level and high-level mupirocin resistance were detected using 5 µg and 200 µg mupirocin discs, respectively. *Staphylococcus aureus* ATCC 25923 was used as the control strain. Discs were placed on an MHA plate with a lawn culture of *S. aureus* and incubated at 37°C for 24 hours. Absence of a zone of inhibition or growth of colonies up to the edge of both discs was interpreted as high-level mupirocin resistance (MuH). Absence of a zone around the 5 µg disc with the presence of a zone around the 200 µg disc was considered low-level mupirocin resistance (MuL).

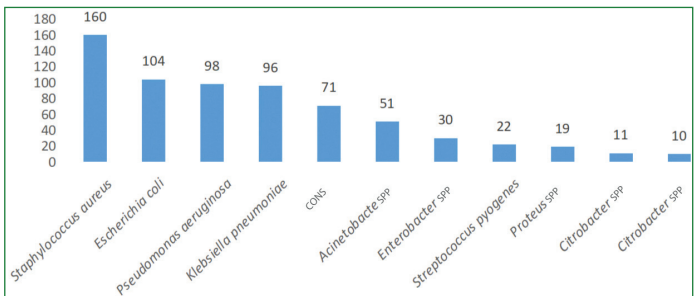
STATISTICAL ANALYSIS

Data were entered into Microsoft Excel and analysed using Statistical Package for the Social Sciences (SPSS) version 26.0. Descriptive statistics, including frequency, percentage, mean, and standard deviation, were used to summarise patient characteristics and the prevalence of mupirocin resistance. The Chi-square test and Independent t-test were applied to assess associations between categorical and continuous variables, respectively. Multivariate logistic regression analysis was performed to identify independent risk factors associated with mupirocin resistance. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 2,156 samples were collected from 2,000 patients during the study period, of which 1,278 (59.3%) were pus swabs and 878 (40.7%) were frank pus samples. Among the patients, 1,279 (63.9%) were male and 721 (36.1%) were female, with a male-to-female ratio of 1.77:1.

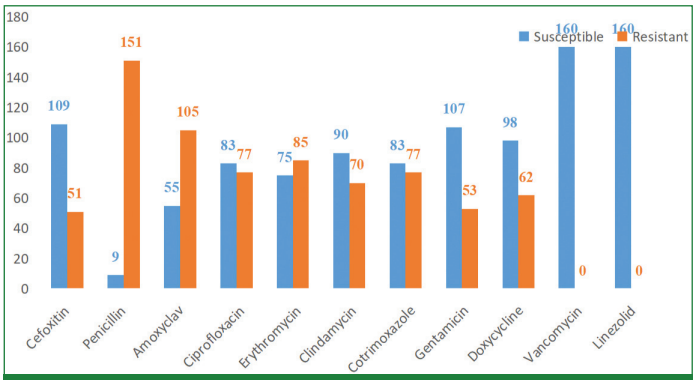
Bacterial culture: Out of the 2,156 samples processed, 672 (31.2%) showed growth of pathogenic organisms. *Staphylococcus aureus* was the most commonly isolated organism, accounting for 160 isolates (23.8%), followed by *Escherichia coli* (104; 15.5%), *Pseudomonas aeruginosa* (98; 14.6%), *Klebsiella pneumoniae* (96; 14.2%), coagulase-negative staphylococci (71; 10.6%), *Acinetobacter* spp. (51; 7.6%), *Enterobacter* spp. (30; 4.5%), *Streptococcus pyogenes* (22; 3.3%), *Proteus* spp. (19; 2.8%), *Citrobacter* spp. (11; 1.6%), and *Candida* spp. (10; 1.5%). These findings are shown in [Table/Fig-1].



[Table/Fig-1]: Distribution of microbial pathogens from culture-positive samples (n=672).

Antimicrobial Susceptibility Pattern of *Staphylococcus aureus*: Among the 160 *S. aureus* isolates, 51 (31.88%) were methicillin-resistant *S. aureus* (MRSA), while 109 (68.12%) isolates were methicillin-susceptible *S. aureus* (MSSA). The majority of isolates, 151 (94.37%), were resistant to penicillin, whereas all isolates

were susceptible to vancomycin and linezolid. The next highest susceptibility was observed with gentamicin. Variable susceptibility patterns were noted for other antibiotics, including amoxicillin-clavulanate, ciprofloxacin, erythromycin, clindamycin, cotrimoxazole, and doxycycline [Table/Fig-2]. Inducible clindamycin resistance was detected in 28 *S. aureus* isolates.



[Table/Fig-2]: Antimicrobial susceptibility pattern of *S. aureus* isolates (n=160).

Among the total *S. aureus* isolates, MRSA was isolated from 28 pus swabs and 23 frank pus samples. In contrast, MSSA was isolated from 45 pus swabs and 64 frank pus samples [Table/Fig-3].

Total isolates of *S. aureus* (n=160)	Pus swab (n=73)	Frank pus (n=87)
MRSA (n=51)	28 (54.9%)	23 (45.1%)
MSSA (n=109)	45 (41.28%)	64 (58.72%)

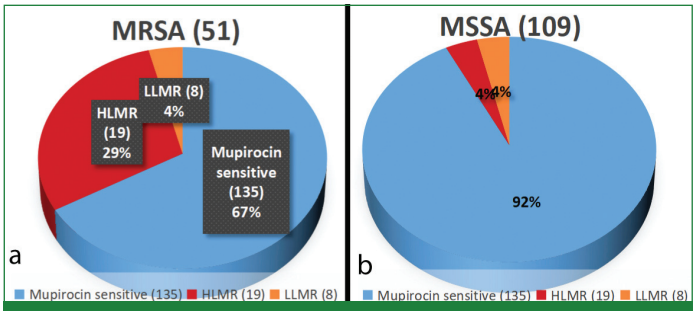
[Table/Fig-3]: Distribution of MRSA and MSSA among sample types.

Mupirocin Resistance among *S. aureus*: Out of the 160 *S. aureus* isolates, 25 (15.6%) exhibited mupirocin resistance. Mupirocin resistance was observed in 17 MRSA isolates and 8 MSSA isolates. A statistically significant association between mupirocin resistance and methicillin resistance was noted (p-value=0.001).

Among the mupirocin-resistant isolates, 19 (76%) demonstrated HLMR, while 6 (24%) showed LLMR. HLMR was more frequent among MRSA isolates than MSSA isolates. A statistically significant association was also observed between HLMR and methicillin resistance (p-value=0.03). The distribution of mupirocin and methicillin resistance patterns is summarised in [Table/Fig-4,5a,b].

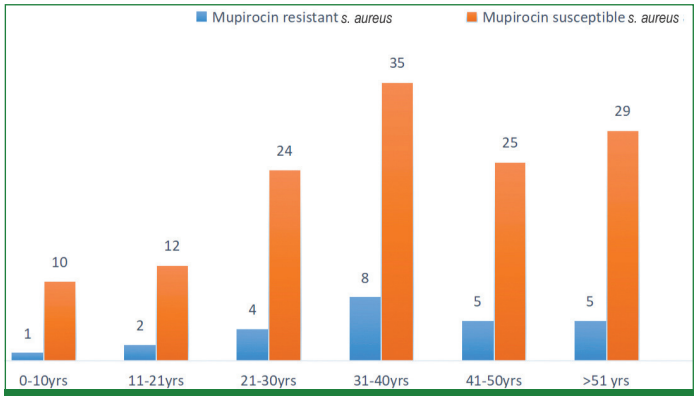
	Mupirocin sensitive	Mupirocin resistant	p-value	HLMR	LLMR	p-value
MRSA (51)	34	17	0.001, χ^2= 17.77	15	2	0.03 χ^2= 4.37
MSSA (109)	101	8		4	4	
Total (160)	135 (84.3%)	25 (15.6%)		19 (11.87%)	6 (3.75%)	

[Table/Fig-4]: Mupirocin resistance patterns among *S. aureus* isolates.



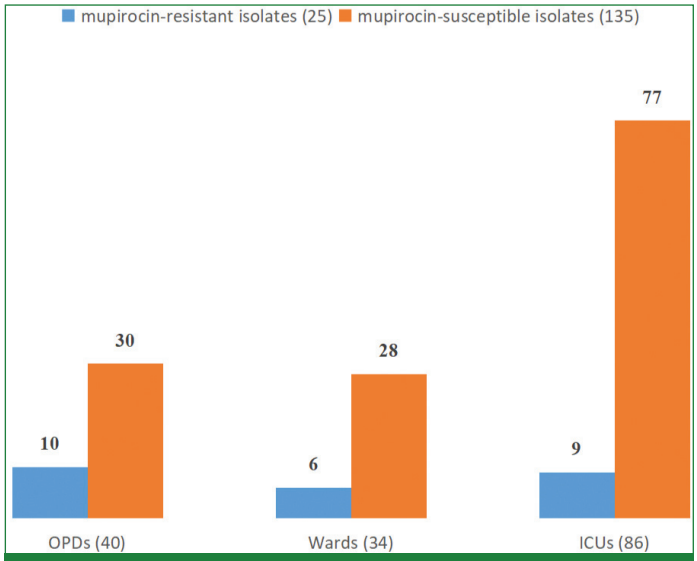
[Table/Fig-5]: a) Distribution of mupirocin resistance pattern in MRSA (left figure). b) Distribution of mupirocin resistance pattern in MSSA (right figure).

Clinico-epidemiological characterisation: Among the 160 culture-positive *S. aureus* isolates, the highest number of infections occurred in the 31-40-year age group both in mupirocin susceptible and resistant group, as shown in [Table/Fig-6]. The lowest number of infections was observed in the 0-10-year age group, followed by the 11-20-year age group. Although the median age was higher in the mupirocin-resistant group compared with the mupirocin-susceptible group, the difference was not statistically significant (p-value=0.27).



[Table/Fig-6]: Distribution of age in mupirocin-resistant and mupirocin-susceptible *Staphylococcus aureus* isolates. (p=0.27, i.e., no strong association observed between distribution of age and mupirocin susceptibility).

Of the 25 mupirocin-resistant *S. aureus* isolates, 40% (10/25) were from OPD, 36% (9/25) from ICUs and 24% (6/25) from general wards. Although it appears maximum isolates were from OPD, but no significant association was observed between hospital units (OPDs, Wards and ICUs) and mupirocin resistance with p-value= 1.05. These findings are shown in [Table/Fig-7].



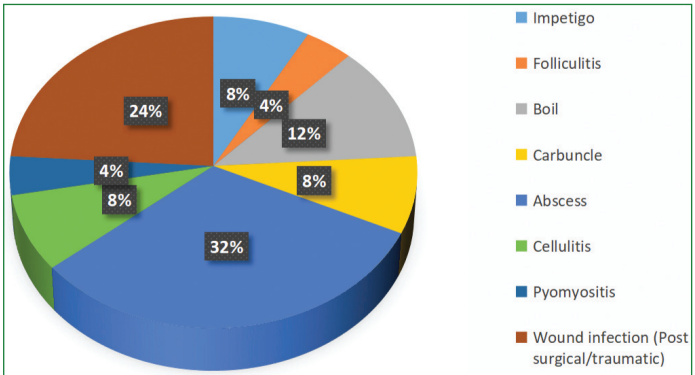
[Table/Fig-7]: Hospital location/unit wise distribution of mupirocin-resistant and mupirocin-susceptible *S. aureus* isolates.
(p=1.05, no significant association between hospital unit and mupirocin susceptibility)

Risk factors associated with mupirocin-resistant *S. aureus*: Among patients with mupirocin-resistant *S. aureus* infections (n=25), the most common predisposing factor was prior use of broad-spectrum antibiotics (76%), followed by previous mupirocin use (56%) and the presence of indwelling devices (52%). Other less frequent associated factors included prior MRSA colonisation or infection, history of hospitalisation or ICU stay, and immunosuppression or underlying co-morbidities. These findings are presented in [Table/Fig-8].

Risk factors	n (%)
Prior mupirocin use	14 (56%)
MRSA colonisation/infection	9 (36%)
Hospitalisation/ICU stay	8 (32%)
Broad-spectrum antibiotic use	19 (76%)
Indwelling medical devices	13 (52%)
Immunosuppression/comorbidities	5 (20%)

[Table/Fig-8]: Distribution of associated risk factors for mupirocin resistant *S. aureus*.

Clinical spectrum of SSTIs: Among the various clinical presentations of SSTIs, abscesses (32%) and wound infections (24%) were the most common conditions associated with mupirocin-resistant *S. aureus*. Other clinical presentations included boils, impetigo, cellulitis, carbuncle, folliculitis, and pyomyositis, as depicted in [Table/Fig-9].

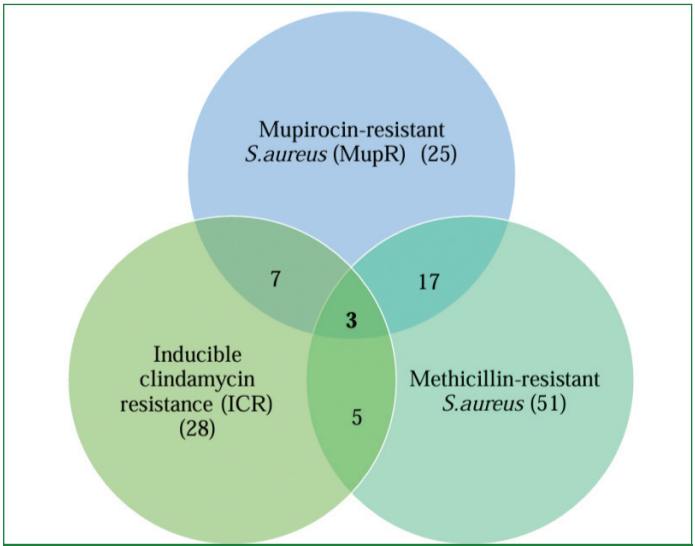


[Table/Fig-9]: Distribution of clinical diagnosis among mupirocin resistant *S. aureus* isolates.

Multidrug resistance pattern in mupirocin resistant *S. aureus* isolates: Of the 160 *S. aureus* isolates, 25 (15.6%) were mupirocin resistant, of which 19 (76%) exhibited HLMR and 6 (24%) exhibited LLMR. Among the mupirocin-resistant isolates, 17 (68%) were MRSA. Inducible clindamycin resistance was observed in seven mupirocin-resistant isolates, five of which were MRSA. Additionally, three mupirocin-resistant *S. aureus* isolates exhibited both MRSA and inducible clindamycin resistance. These resistance patterns are illustrated in [Table/Fig-10,11].

Total isolates (160)	n (%)
Mupirocin-resistant *S. aureus* (MupR)	25 (15.6%)
Methicillin-resistant *S. aureus* (MRSA)	51 (31.8%)
Inducible clindamycin resistance (ICR)	28 (17.5%)
Mup R+MRSA	17 (10.6%)
MupR+ICR	7 (4.4%)
MRSA+ ICR	5 (3.1%)
Mup R+ICR+MRSA	3 (1.9%)

[Table/Fig-10]: Distribution of mupirocin resistance, methicillin resistance, and Inducible Clindamycin Resistance (ICR) among *Staphylococcus aureus* isolates (n=160).



[Table/Fig-11]: Venn diagram showing distribution of mupirocin resistance, methicillin resistance, and Inducible Clindamycin Resistance (ICR) along with co-resistance pattern between *Staphylococcus aureus* isolates.

DISCUSSION

In the present study, *Staphylococcus aureus* was the most common bacterial pathogen isolated from pus samples, accounting for 23.8% of all culture-positive cases. This finding was consistent with several earlier Indian studies that have identified *S. aureus* as a predominant aetiological agent in SSTIs. Complications and persistent SSTIs were observed more frequently in infections caused by MRSA. The high frequency of *S. aureus* infections highlights its continued clinical significance in both hospital and community settings. Its inherent pathogenic potential and remarkable ability to acquire multiple antimicrobial resistance mechanisms likely contribute to its high incidence.

Among the 160 *S. aureus* isolates, 31.87% were identified as MRSA. MRSA remains a major cause of difficult-to-treat infections due to resistance to β-lactam antibiotics, including methicillin, penicillins, cephalosporins, and carbapenems. The MRSA prevalence observed in this study was comparable to rates reported in other Indian studies, such as Prakash R et al., who reported a prevalence of 29.3%, Kumar D et al., who reported 42%, and Jayakumar S et al., who reported 40.7% [6-8]. Variations in MRSA prevalence across regions may be attributed to differences in antibiotic usage patterns, infection control practices, and the patient populations studied. Strengthened surveillance systems and strict infection control strategies are essential to combat the growing burden of MRSA infections.

All *S. aureus* isolates in the present study were susceptible to vancomycin and linezolid, confirming that these agents remain reliable treatment options for MRSA infections. This finding was consistent with other Indian studies, including those by Kumar D et al., and Perumal PG et al., [7,11]. However, a very high rate of penicillin resistance (94.3%) was observed, in line with global trends resulting from widespread β-lactamase production among *S. aureus* strains. The variable susceptibility patterns noted for amoxicillin–clavulanate, ciprofloxacin, erythromycin, clindamycin, cotrimoxazole, and doxycycline reflect heterogeneous antibiotic pressure and differing prescribing practices across healthcare settings.

Mupirocin Resistance

In the present study, mupirocin resistance was detected in 15.6% of *S. aureus* isolates. Among the 160 isolates, HLMR and LLMR were observed in 11.87% and 3.75% of isolates, respectively. Notably, 76% of mupirocin-resistant isolates exhibited HLMR, which is concerning because high-level resistance is typically associated with plasmid-mediated *mupA* gene carriage and has the potential for rapid horizontal dissemination.

The mupirocin resistance rate observed in this study was comparable to or slightly higher than those reported in other Indian studies. This may be attributed to the study population, as a substantial proportion of patients were from ICUs. Indian studies have reported varying rates of mupirocin resistance: Mittal S et al., reported 6.75% HLMR, Rudresh MS et al., reported 8.2% HLMR and 17% LLMR, while Prakash R et al., and Perumal PG et al., reported rates similar to the present study (11.9% and 11.8%, respectively) [4-6,11]. These variations may be due to geographical differences, mupirocin usage practices, and differences in laboratory methods used for resistance detection, such as disc diffusion, agar dilution, E-test, and PCR.

Internationally, mupirocin resistance rates have generally been lower than those reported in India. Hesami S et al., from Iran reported four isolates with LLMR and one with HLMR among 150 strains [13], while Stratchounski LS et al., from Russia reported only 0.3% LLMR [14]. In contrast, Abdulgader SM et al., from South Africa reported higher resistance rates, with 18% LLMR and 4% HLMR among MRSA isolates [3], findings comparable to the present study. Fritz SA et al., (2013) from the United States reported a low prevalence of mupirocin resistance (2.1%) [15], likely reflecting stricter antibiotic regulations, controlled mupirocin use, and better infection control practices in developed countries. These observations underscore marked regional differences in mupirocin resistance, with higher rates observed in developing countries due to over-the-counter availability,

empirical use, and lack of routine resistance surveillance. [Table/Fig-12] shows comparison of MRSA, high and low level of mupirocin resistance in Staphylococcus from various studies [3-15].

Sr. no.	Study name	Region	Sample size	MRSA	LLMR	HLMR	Method used
1.	Present study, 2026	North India	160	31.87%	3.9% in MRSA	29.41% in MRSA	DDM
					3.67% in MSSA	3.67% in MSSA	
2.	Mittal S et al., 2019 [4]	North India	100	43.4%	-	6.75%	DDM
				42% CONS	-	9.23%	
3.	Rudresh MS et al., 2015 [5]	Central India	98	22.4%	17%	8.2%	DDM, ADM
			45	20% CONS	8.9%	15.6%	
4.	Prakash R et al., 2022 [6]	North India	600	29.33%	9.66%	11.93%	DDM, ADM
5.	Kumar D et al., 2020 [7]	North India	265	42%	7.2% in MRSA	11.71% in MRSA	DDM, E test
					1.3% in MSSA	7.79% in MSSA	
6.	JayKumar S et al., 2013 [8]	South India	113	40.7%	1 isolate	2 isolates	DDM, BDM
7.	Dardi CK, 2014 [9]	West India	267	100%	15.3%	5.9%	DDM
8.	Chaturvedi P et al., 2014 [10]	North India	82	100%	8.53%	9.75%	ADM, E test
9.	Perumal PG et al., 2022 [11]	South India	100	51%	9.8%	11.8%	DDM
10.	Damrolien S et al., 2020 [12]	East India	562	50.2%	14.1%	-	DDM
11.	Hesami S et al., 2013 [13]	Iran	150	11	4 isolates	1 isolate	DDM, MIC, PCR
12.	Stratchounski LS et al., 2005 [14]	Russia	879	33.5%	0.3%	-	ADM
13.	Fritz SA et al., 2013 [15]	USA	1089	-	2.1%	-	DDM, MIC, PCR
14.	Abdulgader SM et al., 2020 [3]	South Africa	212 *S. aureus*	44%	18% in MRSA	4% in MRSA	DDM, PCR
					3% in MSSA	1% in MSSA	

[Table/Fig-12]: Comparison of incidence of MRSA, high level and low-level mupirocin resistance in Staphylococcal species from various studies [3-15].
DDM: Disc diffusion method; BDM: Broth dilution method; ADM: Agar dilution method

Association between Methicillin and Mupirocin Resistance Staphylococci species

A statistically significant association (p-value=0.001) was observed between methicillin resistance and mupirocin resistance in this study. Mupirocin resistance was detected in 33.3% of MRSA isolates, compared with only 7.3% of MSSA isolates. Similar associations have been reported in studies from North and South India [5,10] as well as from South Africa [13]. This co-selection of methicillin and mupirocin resistance may be mediated by plasmid-encoded resistance determinants such as *mupA* and *mecA*. The emergence of such co-resistant strains poses significant therapeutic challenges and complicates infection control efforts.

Clinicoepidemiological Correlation

Analysis of SSTI distribution across age groups revealed an age-related trend, with the highest number of *S. aureus* infections occurring in patients aged 31-40 years. This may reflect greater occupational exposure, trauma, and healthcare contact in this age group. Mupirocin-resistant isolates recovered from ICU settings 36% (9/25) and from OPD 40% (10/25) were nearly same. highlighting the role of intensive antibiotic exposure and cross-transmission in high-dependency units. Similar observations have been reported by Dardi CK and Damrolien S et al., [9,12].

The key risk factors for mupirocin resistance identified in this study were prior use of broad-spectrum antibiotics (76%), previous mupirocin application (56%), and the presence of indwelling devices (52%). These findings are consistent with earlier reports that emphasise antibiotic pressure and invasive procedures as major contributors to the emergence and dissemination of antimicrobial resistance.

Among the various SSTIs analysed, impetigo was the most frequently observed clinical presentation. The second most common presentation was wound infection (post-surgical or traumatic). Other less frequent presentations included folliculitis, boils, abscesses, and cellulitis. Several factors contribute to the occurrence of SSTIs, including hot and humid climatic conditions, compromised immunity due to conditions such as diabetes mellitus, peripheral vascular disease, and advanced age. The high proportion of wound infections reflects challenges in infection control practices and surgical interventions. Condition-specific prevention and management strategies are therefore required in view of the rising burden of antimicrobial resistance.

Multidrug Resistance and Co-resistance

Among the MRSA isolates, 28 exhibited inducible macrolide-lincosamide-streptogramin B resistance (iMLSB/ICR). Seventeen isolates demonstrated co-resistance to mupirocin and methicillin, and three isolates exhibited triple resistance (mupirocin resistance + MRSA + inducible clindamycin resistance). Comparable multidrug resistance patterns have been reported by Kumar D et al., and Perumal PG et al., [7,11]. The co-existence of multiple resistance mechanisms severely limits therapeutic options and increases the risk of treatment failure and persistent colonisation.

Comparison with Global Data

Mupirocin resistance rates reported in developed regions such as the United States and Russia are relatively lower compared with those observed in India. This disparity may be attributed to differences in antibiotic stewardship practices, infection control policies, and regulated decolonisation strategies. The findings of the present study, demonstrating a 15.6% prevalence of mupirocin resistance with a predominance of high-level resistance, place India among regions with intermediate to high mupirocin resistance prevalence globally.

The increasing prevalence of high-level mupirocin resistance among MRSA isolates poses a significant threat to the effectiveness of MRSA decolonisation protocols. This may result in prolonged hospital stays, increased healthcare-associated infections, and overutilisation of higher-generation antibiotics. Mupirocin ointment and chlorhexidine baths remain the cornerstone agents for MRSA decolonisation. However, unchecked empirical use of mupirocin can lead to rapid dissemination of resistant strains within hospital settings. Therefore, routine mupirocin susceptibility testing, particularly in high-risk areas such as ICUs and surgical units, is strongly recommended. Restricting mupirocin use to confirmed MRSA carriers and implementing robust antimicrobial stewardship programs are critical measures to preserve its clinical efficacy.

Limitation(s)

This study was conducted at a single tertiary care centre with a moderate sample size, which may limit the generalisability of the findings. The incidence of *Staphylococcus* species and their resistance patterns may vary according to geographic region, age group, patient-specific risk factors, and hospital settings (critical versus non critical care units). Multicentric studies would provide more representative and generalisable data. Additionally, molecular

characterisation of mupirocin resistance genes (*mupA, mupB*, and *ileS*) was not performed, which could have offered deeper insights into the genetic mechanisms and transmission dynamics of resistance. Future studies incorporating molecular typing and longitudinal surveillance are therefore warranted.

CONCLUSION(S)

This study highlights a substantial prevalence of MRSA, with a strong association between methicillin resistance and mupirocin resistance. The high prevalence of HLMR, particularly in ICU settings, is a significant concern for infection control. Continuous surveillance, rational antibiotic use, and strict infection control measures are essential to curb the spread of multidrug-resistant *Staphylococcus* species. The findings of this study, along with comparative analyses, underscore the need for collaborative, multicentric investigations involving larger sample sizes and diverse geographic regions. A coordinated approach using standardised methodologies and data sharing would facilitate a more comprehensive understanding of the evolving landscape of mupirocin resistance in *S. aureus* and aid in developing effective strategies to address this growing public health challenge.

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PARTICULARS OF CONTRIBUTORS:

1. Professor, Department of Microbiology, Shaheed Hasan Khan Mewati Government Medical College, Nalhar, Nuh, Haryana, India.
2. Assistant Professor, Department of Microbiology, Shaheed Hasan Khan Mewati Government Medical College, Nalhar, Nuh, Haryana, India.
3. Professor, Department of Microbiology, Shaheed Hasan Khan Mewati Government Medical College, Nalhar, Nuh, Haryana, India.
4. Professor, Department of Microbiology, Shaheed Hasan Khan Mewati Government Medical College, Nalhar, Nuh, Haryana, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Dimpi Bhankhur,
Department of Microbiology, Shaheed Hasan Khan Mewati Government Medical College, Nalhar, Nuh-122107, Haryana, India.
E-mail: dimpibhankhur@gmail.com

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