ORIGINAL ARTICLE

Clinical Profile of MRSA-Positive Primary, Secondary, and Surgical Site Skin and Soft Tissue Infections

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Abstract

Background: Methicillin-resistant *Staphylococcus aureus* (MRSA) is the principal pathogen isolated from skin and soft tissue infections (SSTIs), with clinical manifestations and risk factors varying by SSTI subtype. Understanding this variation in clinical presentation and associated risk factors within local populations is essential for effective diagnosis and management.

Objective: This study compares the diverse clinical characteristics of MRSA-associated subtypes of SSTIs in the local population.

Methods: This cross-sectional study was conducted at the Department of Pathology, Jinnah Sindh Medical University, Karachi, Pakistan, between May 2024 and April 2025. The study included 268 pus specimens collected from patients with clinically diagnosed SSTIs. The samples were cultured, and antibiotic susceptibility was performed to identify MRSA, which was confirmed by polymerase chain reaction using standard protocols. The relevant clinical data were gathered in pre-designed proformas, which were later entered into Microsoft Excel and analysed in SPSS using descriptive statistics, cross-tabulations, and the Chi-square test.

Results: Mean age of patients was 41.25±16.441. Of the total 268, 115 were primary bacterial infections and surgical site infections, and 38 were secondary bacterial infections. The most common SSTI type was surgical site infections (42.9%), followed by abscesses in the non-surgical infections category (24.3%). The study highlighted that MRSA-positive cases were highly prevalent in females (53.7%) among the age group 40-60 years (55.2%). Active smokers showed a preponderance for MRSA-positive primary bacterial infections (13.9%). A history of hospitalization was more common among the MRSA-positive surgical site infection cohort than in the other two groups (90.4%). The majority of subjects had moderate-severity wounds (51.9%), and the Torso was the most affected site (54.1%).

Conclusion: MRSA can be linked with varying degrees of clinical features and risk factors in SSTIs subtypes. These findings may provide evidence-based insights for improved patient care and treatment strategies.

Keywords: *Abscess, antibacterial agents, bacterial infections, methicillin-resistant Staphylococcus aureus, soft tissue infections, surgical wound infections.*

INTRODUCTION

Staphylococcus aureus is the most common etiologic agent isolated from skin and soft tissue infections (SSTIs). Methicillin-resistant *Staphylococcus aureus* (MRSA) has been established as a superbug and is included on the World Health Organization's bacterial pathogens priority list [1] *via* Microbial Surface Components Recognizing Adhesive Matrix Molecules, MRSA attaches to the epithelial cells, and immune evasion involves Protein A and coagulase. Toxins such as PVL and alpha-toxin destroy immune cells, while enzymes facilitate tissue invasion [2]. Biofilm formation and global regulators, such as *agr* (agr quorum-sensing system), further enhance the persistence and severity of infection [3]. Hence, a combination of factors increases MRSA's environmental adaptation and virulence, resulting in distinct epidemiological patterns of infection.

The clinical spectrum of MRSA-associated SSTIs ranges from superficial skin lesions to severe, debilitating necrotizing fasciitis [4]. Understanding the prevalence of MRSA across different infection types is crucial for developing targeted treatment strategies, implementing infection control measures, and affecting antibiotic stewardship practices. The SSTIs can be classified as primary bacterial infections (PBI), secondary bacterial infections (SBI), or surgical site infections (SSIs). Primary skin infections occur in previously healthy individuals without predisposing skin conditions or recent healthcare exposure, typically manifesting as cellulitis, abscesses, or impetigo [5]. These infections are predominantly caused by community-associated MRSA (CA-MRSA) strains, which present genetic characteristics and virulence profiles compared to healthcare-associated MRSA (HA-MRSA). The Secondary skin infections develop as complications of pre-existing dermatological conditions and in chronic wounds [6]. These infections often involve both HA-MRSA and CA-MRSA strains, highlighting the reciprocity between host susceptibility factors and pathogen virulence factors. The prevalence of MRSA among SSTIs is found to be as high as 48% in African territory [7]. In a tertiary care center in China, MRSA accounted for 32.75% of *S. aureus* isolates from

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SSTIs, with community-associated MRSA (CA-MRSA) being predominant [8]. In the US, MRSA is the most common cause of skin and soft tissue infections in emergency departments, with prevalence rates from 15% to 74% [9, 10]. The prevalence of MRSA is considerably high in Pakistan; a study from the Punjab sector reported 61.8% cases of MRSA [11].

SSIs represent a distinct category of SSTIs that occur following invasive procedures, ranging from minor dermatological surgeries to major reconstructive operations [12]. The prevalence of MRSA in surgical site infections varies based on procedural factors, patient characteristics, perioperative antibiotic prophylaxis, and institutional infection control practices [13]. In some African and Middle Eastern hospitals, over half of *S. aureus* SSIs are due to MRSA [14, 15]. Current epidemiological data suggest significant variability in MRSA prevalence across these three infection categories, influenced by factors such as geographical location, patient demographics, healthcare facility characteristics, and temporal trends [16]. The emergence of new MRSA clones, changes in antibiotic prescriptions, and new infection control practices are reshaping the epidemiological topography of skin infections.

Furthermore, the challenge of accurately diagnosing MRSA with laboratory methods and the possibility of treatment based on local infection rates highlight the need for comprehensive surveillance studies. Data from Pakistan is limited. Therefore, this research aims to analyse MRSA-positive cases in primary, secondary, and surgical skin infections and their relationship with clinical parameters to develop epidemiological insights in the local region. This will help to strengthen clinical guidelines, develop antibiotic selection policies, improve infection control, and design prevention strategies in our country.

METHODS

This comparative cross-sectional study was conducted at the Department of Pathology, Jinnah Sindh Medical University, Karachi, Pakistan, between May 2024 and April 2025. Approval from the institutional review board was sought before the commencement of the study (IRB: JSMU/IRB/2023/827).

The sample size was calculated using OpenEpi (Version 3), based on an anticipated frequency of 16% from the previous study, with a 95% confidence interval and a 5% margin of error [16]. The minimum required sample size was calculated to be 207 [17]. Using a non-probability consecutive sampling technique, 268 pus specimens from skin and soft tissue infections from various departments of Jinnah Postgraduate Medical Centre, Karachi, were collected during the stipulated time period. All patients with wounds or lesions clinically diagnosed as SSTIs, regardless of age or gender, were included. (SSIs were considered as a subset of SSTIs due to anatomical and microbial similarities). Patients who had been on antibiotics for one week or who did not consent to participate were excluded. The relevant demographic clinical data were collected in a pre-designed questionnaire. For subsequent categorization of the patient's weight status, the Body Mass Index (BMI) was calculated using the formula: weight (kg) / [height (m)]^2.

Patients were briefed on the procedure for collecting pus before sampling. Pus was collected from superficial wounds according to the standard protocol, by wiping the area with normal saline and swabbing along the leading edge of the wound [18]. A sterile needle and syringe were used to collect 5 -10 ml of aspirated material after appropriate surface decontamination from deeper wounds and abscesses. The samples were transported to the Jinnah Sindh Medical University diagnostics laboratory for sample processing.

The specimens were cultured on blood, Mannitol salt agar (MSA), and MacConkey's agar. Relevant biochemical tests made the identification of organisms. Antibacterial susceptibility testing was performed using the disc diffusion method, as outlined in the Clinical Laboratory Standards Institute guidelines. Strains that showed less than 21 mm of zone inhibition to cefoxitin 30 µg were considered MRSA [19]. The MRSA phenotypes were processed for *mecA* detection by polymerase chain reaction as per standard protocols.

Genomic DNA was extracted from overnight cultures of *S. aureus* isolates using a commercial bacterial DNA extraction kit (Qiagen, Germany) following the manufacturer's protocol. PCR amplification of the *mecA* gene was performed using specific primers: forward 5′-TCCAGATTACAACTTCACCAGG-3′ and reverse 5′-CCACTTCATATCTTGTAACG-3′, targeting a 162 bp product. The reaction mixture (25 µL) contained 12.5 µL of 2× PCR master mix (Thermo Scientific), 0.5 µM of each primer, 2 µL of template DNA, and nuclease-free water. Thermocycling conditions included an initial denaturation step at 94°C for 5 min, followed by 30 cycles of denaturation at 94°C for 30 sec, annealing at 55°C for 30 sec, and extension at 72°C for 1 min, with a final extension at 72°C for 5 min. PCR products were analyzed by electrophoresis on a 1.5% agarose gel stained with ethidium bromide and visualized under UV illumination [19].

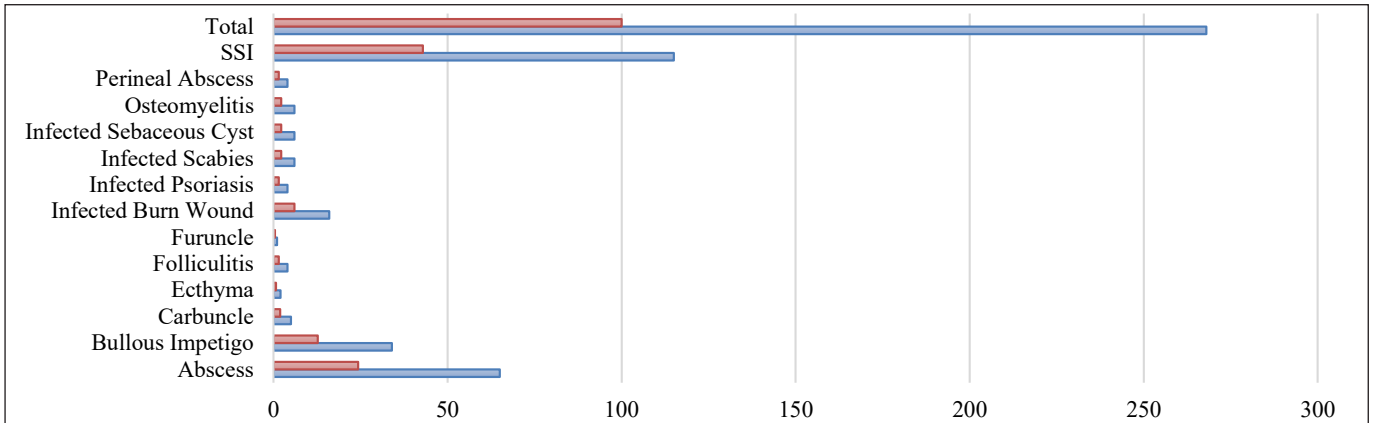
The data were recorded in Microsoft Excel and statistically analyzed on IBM SPSS Statistics for Windows, version 22.0 (IBM Corp, Armonk, NY, USA). The descriptive statistics were presented as frequencies, percentages, and standard deviations. The p-values were calculated using the chi-square test and the t-test.

RESULTS

The current study highlighted the various features of SSTI types. The mean age of patients was 41.25±16.441. Of the total 268, 115 were primary bacterial infections and surgical site infections, and 38 were secondary bacterial infections. The most common infection type was SSI (115, 42.9%), followed by abscess (65, 24.3%), as shown in **Fig. (1)**.

A majority of the individuals were between 40 and 60 years of age (148, 55.2%), with higher MRSA prevalence among the PBI and SSI groups (p=0.001). Overall, a higher prevalence of SSTIs was observed in females (144, 53.7%); likewise, females were more common in the SSI group (68, 25.4%). In subsets of PBI (51, 19%) and SBI (26, 9.7%), males were likely to be affected (p=0.001). Similarly, a significant number of participants were married (234, 87.3%). This observation was consistent across all SSTI types. A higher frequency of single, unmarried patients was observed in PBI (17; 6.3%), but this difference did not reach statistical significance (p=0.407). The study included more participants from urban areas (150, 56%), and 25.7% of PBIs were from the urban population, indicating higher rates compared to the other two types. However, the difference was not statistically significant. The rural population was slightly higher in the SSI group (58, 21.6%) (p=0.177). Unemployment among study subjects was 60.4%, and the majority of working individuals were employed in low-risk occupations, such as office workers and non-healthcare-associated staff. Among employed individuals, PBI was highly prevalent in MRSA-positive cases (50, 18.7%). Even so, high-risk occupations were linked with MRSA SSI (26, 19.7%). In the SBI group, a significant number of patients were employed (26, 9.7%), and associated with low-risk occupations (16, 42.1%) (p<0.001) (**Table 1**).

Table **2** compares patients' traits across various MRSA-positive SSTI types. According to the findings, a substantial proportion of enrolled participants had a normal weight (183, 68.3%), and overweight patients were found to be more affected with SSI (20, 17.4%). A majority of the patients reported no history of similar infections (227, 84.7%), and household contact history was observed more frequently in patients in the MRSA-PBI group (25, 21.7%) (p<0.001). Most of the enrolled subjects had not smoked or used any addictive substance (192, 71.6%). However, among those who had used such substances, the majority (37,13.8%) were users of betel nuts and leaves, and gutka (chewable tobacco preparations). Active smoking was noticed more commonly in the PBI group (16,13.9%), while patients in the SSI group were more likely to have a history of substance use (22,19.1%) (p<0.001). Another notable finding was that most participants had visited or been admitted to a healthcare facility in the previous 90 days (135, 50.4%). A history of hospitalization within 90 days was more common among SSI patients than in the other two groups (104, 90.4%) (p<0.001).



	Abscess	Bullous Impetigo	Carbuncle	Ecthyma	Folliculitis	Furuncle	Infected Burn Wound	Infected Psoriasis	Infected Scabies	Infected Sebaceous Cyst	Osteomyelitis	Perineal Abscess	SSI	Total
Percent	24.3	12.7	1.9	0.7	1.5	0.4	6	1.5	2.2	2.2	2.2	1.5	42.9	100
Frequency	65	34	5	2	4	1	16	4	6	6	6	4	115	268

Fig. (1): Frequency of various types of SSTIs among the study population.

Table 1: Demographic features of the study population according to the types of SSTIs.

Variables	Primary Bacterial Infections n (%)	Secondary Bacterial Infections n (%)	Surgical Site Infections n (%)	Total n (%)	p-value
Age range					
Under 20 years	9 (3.4)	8 (3)	18 (6.7)	35 (13.1)	0.001
Between 20.1 and 40.0 years	41 (15.3)	4 (1.5)	22 (8.2)	67 (25)	
Between 40.1 and 60.0 years	62 (23.1)	24 (9)	62 (23.1)	148 (55.2)	
Above 60.1 years	3 (1.1)	2 (0.7)	13 (4.9)	18 (6.7)	
Gender					
Male	51 (19)	26 (9.7)	47 (17.5)	124 (46.3)	0.001
Female	64 (23.9)	12 (4.5)	68 (25.4)	144 (53.7)	
Residence					
Urban	69 (25.7)	24 (9)	57 (21.3)	150 (56)	0.177
Rural	46 (17.2)	14 (5.2)	58 (21.6)	118 (44)	
Marital status					
Single	17 (6.3)	6 (2.2)	11 (4.1)	34 (12.7)	0.407
Married	98 (36.6)	32 (11.9)	104 (38.8)	234 (87.3)	
Occupation					
Employed	50 (18.7)	26 (9.7)	30 (11.2)	106 (39.6)	<0.001
Unemployed	65 (24.3)	12(4.5)	85 (31.7)	162 (60.4)	
Occupation risk					
High risk	5 (4.3)	10 (26.3)	11 (9.6)	26 (19.7)	<0.001
Low risk	45 (39.1)	16 (42.1)	19 (16.5)	80 (29.9)	
Not applicable	65 (56.5)	12 (31.6)	85 (73.9)	162 (60.4)	

Table 2: Distribution of various patients' traits among SSTIs subtypes.

Variables	Primary Bacterial Infections n (%)	Secondary Bacterial Infections n (%)	Surgical Site Infections n (%)	Total n (%)	p-value
Weight status					
Underweight	4 (3.5)	2 (5.3)	21 (18.3)	27 (10.1)	<0.001
Normal	92 (80)	28 (73.7)	63 (54.8)	183 (68.3)	
Overweight	11 (9.6)	8 (2.1)	20 (17.4)	39 (14.6)	
Obese i	6 (5.2)	0 (0)	7 (6.1)	13 (4.9)	
Obese ii	0 (0)	0 (0)	4 (3.5)	4 (1.5)	
Obese iii	2 (1.7)	0 (0)	0 (0)	2 (0.7)	
Contact with a known case					
No contact	86 (74.8)	26 (68.4)	115 (100)	227 (84.7)	<0.001
Household contact	25 (21.7)	10 (26.3)	0 (0)	35 (13.1)	
Non-household contact	4 (3.5)	2 (5.3)	0 (0)	6 (2.2)	
Substance use					
No	87 (75.7)	22 (57.9)	83 (72.2)	192 (71.6)	<0.001
Active smoker	16 (13.9)	10 (26.3)	8 (7)	34 (12.7)	
Former smoker	1 (0.9)	2 (5.3)	2 (1.7)	5 (1.9)	
Substance of any type	11 (9.6)	4 (10.5)	22 (19.1)	37 (13.8)	
Hospitalization in the last 90 days					
Yes	19 (16.5)	12 (31.6)	104 (90.4)	135 (50.4)	<0.001
No	96 (83.5)	26 (68.4)	11 (9.6)	133 (49.6)	

Table 3: Distribution of clinical and infection-related characteristics according to bacterial infection type.

Variables	Primary Bacterial Infections n (%)	Secondary Bacterial Infections n (%)	Surgical Site Infections n (%)	Total n (%)	p-value
Duration of illness					
<5 days	13 (11.3)	4 (10.5)	11 (9.6)	28 (10.4)	0.100
Between 5-10 days	57 (49.6)	18 (47.4)	33 (28.7)	108 (40.3)	
>10 days	45 (39.1)	16 (42.1)	71 (61.7)	132 (49.3)	
Setting					
Outpatient	72 (62.6)	32 (84.2)	28 (24.3)	132 (49.3)	<0.001
Inpatient	43 (37.4)	6 (15.8)	87 (75.7)	136 (50.7)	
Site					
Head and neck	29 (25.2)	4 (10.5)	0 (0)	33 (12.3)	<0.001
Torso	40 (34.8)	14 (36.8)	91 (79.1)	145 (54.1)	
Upper extremities	17 (14.8)	8 (21.1)	8 (7)	33 (12.3)	
Lower extremities	28 (24.3)	12 (31.6)	16 (13.9)	56 (20.9)	
Groin	1 (0.9)	0 (0)	0 (0)	1 (0.4)	
Severity					
Mild	19 (16.5)	22 (57.9)	73 (63.5)	114 (42.5)	<0.001
Moderate	81 (70.4)	16 (42.1)	42 (36.5)	139 (51.9)	
Severe	15 (13)	0 (0)	0 (0)	15 (5.6)	
Comorbidity					
Hypertensive vascular diseases	33 (28.7)	6 (15.8)	13 (11.3)	52 (19.4)	<0.001
Chronic inflammatory diseases	18 (15.7)	6 (15.8)	5 (4.3)	29 (10.8)	
Diabetes mellitus and other endocrinological disorders	19 (16.5)	10 (26.3)	59 (51.3)	88 (32.8)	
Chronic organ diseases	14 (12.2)	8 (21.1)	4 (3.5)	26 (9.7)	
No comorbidity	31 (27)	8 (21.1)	34 (29.6)	73 (27.2)	
Prior antibiotic use					
Beta lactam	11 (9.6)	0 (0)	20 (17.4)	31 (11.6)	0.020
Macrolides and Lincosamides	4 (3.5)	2 (5.3)	15 (13)	21 (7.8)	
Tetracycline	1 (0.9)	0 (0)	5 (4.3)	6 (2.2)	
Topical	8 (7)	2 (5.3)	8 (7)	18 (6.7)	
No antibiotics	91 (79.1)	34 (89.5)	67 (58.3)	192 (71.6)	

Table **3** presents the clinical and infection-related characteristics by bacterial infection type in SSTI cases. The duration of illness in the majority of patients was greater than 10 days (132, 49.3%), and most were hospitalized (136, 50.7%). Most SBI patients had a duration of illness of 5-10 days, and the majority were outpatients (32,84.2%) (p=0.100). Overall, Torso was the most affected site (145; 54.1%), and the majority of wounds were moderate in severity (139; 51.9%). Diabetes mellitus and other endocrinological disorders were seen in 88, 32.8% of total participants. Among the diabetes and endocrinological disturbances group, SSI were common (p<0.001). Although a significant number of patients had not used any antibiotic in the last 10 days (192, 71.6%), among those who had used antibiotics, the majority had used a beta-lactam (32, 11.6%). This finding was similar across PBI and SSI cohorts; However, in the SBI group, topical agents and macrolides/lincosamides were used more frequently (2, 5.3%) (p=0.020).

DISCUSSION

The current study describes various demographic and clinical features of bacterial skin and soft tissue infections. A significant number of patients were aged 40-60 years. This finding is supported by Sulaiman *et al.*,

who reported 47.8% of cases of bacterial skin infections among people aged 40 years or older [20]. SSTIs have shown a higher prevalence among females, consistent with a study from Saudi Arabia, which found that 78.8% of females were more likely to be affected [21]. In the present study, the observed sexual dimorphism can be attributed to multiple factors, including genetic predisposition, immune status, and social or behavioral characteristics of females.

The researchers observed that the current study did not show any relationship with increased body weight; however, in the patients with surgical site infections, overweight and obese individuals were identified. This contradicts the findings by Hu *et al*., who described a causal relationship between obesity and bacterial skin infections [22]. Among the SSI cohort, overweight and obese patients were noted, and this finding is in concordance with Gurunathan *et al.*, who documented that overweight and obese patients carried at least 20% and 50% higher odds of developing MRSA-positive SSI compared to normal weight patients, respectively [23]. The analysis conducted showed active smokers were more likely to develop MRSA-positive PBIs, whereas substance abusers showed a higher frequency of SSIs. Smoking has been associated with bacterial skin infections due to vasoconstriction, impaired oxygen supply, causing carbon monoxide-induced hypoxia, impaired neutrophil function, and delayed collagen deposition; however, the correlation of substance abuse with MRSA skin infections is not well described in the literature [24].

In the present study, the Torso was most affected by MRSA-positive SSTIs across all types. A recent study has also documented that the negative predictive value (NPV) of MRSA positivity was higher for SSTIs occurring above the waist (71%) than for those below the waist (63%) [25]. MRSA commonly colonizes the anterior nares, oropharynx, and skin folds. From the nares and upper body, bacteria can easily spread to nearby skin and soft tissues [26]. Regarding the co-morbid illnesses, metabolic syndrome was highly prevalent among all sub-types of SSTIs. A previous study from the region reported a higher prevalence of MRSA positivity among patients with diabetes mellitus; however, the literature does not support the association between other endocrinological conditions and MRSA positivity [27]. The possible findings in our study may be linked to higher MRSA carriage rates among patients with uncontrolled diabetes mellitus in the local population. The synergistic effects of obesity, diabetes mellitus, and dyslipidemia can increase inflammation, impair skin barrier function, and alter the skin microbiome. This effect needs to be further evaluated by studies. Overall, among MRSA-positive SSTIs, prior use of β-lactam ring antibiotics (penicillins, cephalosporins, carbapenems, monobactams, and β-lactam inhibitor combinations) was common. There is no direct evidence that prior use of beta-lactam antibiotics increases the risk of MRSA-positive skin infections. Still, beta-lactam resistance is central to MRSA biology and treatment strategies. This may be linked to the suppression of susceptible flora and the selective survival of MRSA strains due to prolonged use of β-lactam antibiotics.

LIMITATIONS

The small sample size cannot justify the generalizability of the results. Due to limited resources, molecular profiling was not performed. Data on surgical antimicrobial prophylaxis were not adequately available and therefore not analyzed in detail.

CONCLUSION

MRSA is widely associated with SSTIs, and its manifestations vary across subtypes. The current study showed the higher prevalence of MRSA SSTIs in middle-aged, married, unemployed, urbanized patients with a female preponderance. In the majority of cases, a prolonged illness duration with a prior history of hospitalization was noted. In this context, new possible parameters are identified. The infection was moderate overall, but in primary cases, severe wounds were observed. PBIs were highly related to hypertensive vascular diseases, but collectively, endocrine disorders were seen in MRSA-positive cases.

ETHICAL APPROVAL

Ethical approval was obtained from the Institutional Review Board (IRB) of Jinnah Sindh Medical University, Karachi (REF letter No. JSMU/IRB/2023/827, Dated: 6 Apr, 2024). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and the Helsinki Declaration.

CONSENT FOR PUBLICATION

Written informed consent was taken from the participants.

AVAILABILITY OF DATA

The data set may be acquired from the corresponding author upon a reasonable request.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORS' CONTRIBUTION

FZ contributed to the study's conceptualization, data collection, data analysis, and manuscript writing. DMS assisted in manuscript writing, and data analysis and Shabana assisted in data collection, manuscript writing, and review. SP assisted in data collection, data analysis, and manuscript writing.

GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work, the author(s) limitedly used ChatGPT (GPT-4, OpenAI) to get language suggestions and do minor proofreading in some parts of the manuscript. After using this tool/service, the author(s) reviewed and edited the content as needed and take full responsibility for the content of the published article.

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