Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/jptcp.v29i04.7045

TO STUDY THE PREVALENCE OF MRSA AND ITS ANTIMICROBIAL SUSCEPTIBILITY PATTERN AMONG STAPHYLOCOCCUS AUREUS ISOLATED FROM VARIOUS CLINICAL SAMPLES

Dr. Raees Ahmed[1*], Dr. Anita E.Chand[2], Dr. Nashra Afaq[3]

[1*]PhD Scholar, Department of Microbiology, Government Medical College, Kota, Rajasthan.
[2]Sr. Professor, Department of Microbiology, Government Medical College, Kota, Rajasthan.
[3]Research Associate, Department of Microbiology, Rama Medical College Hospital and Research Centre, Kanpur, Uttar Pradesh, India.

***Corresponding Author:** Dr. Raees Ahmed
*E-mail : drraeesahmed52@gmail.com

ABSTRACT

Introduction: Methicillin-resistant *Staphylococcus aureus* (MRSA) is a common nosocomial infection that causes severe morbidity and mortality. MRSA (methicillin-resistant *S. aureus*) is now endemic in India. In India, the prevalence of Methicillin-Resistant Staphylococcus aureus (MRSA) ranges between 30 to 70%, resulting in high mortality, increased economic burden, and treatment failure in tertiary care facilities. Rapid and consistent MRSA detection is crucial for infection control and preventing unnecessary antibiotic use.

Aim and Objective: This study aimed to find out the prevalence of MRSA and to assess antibiotic activity against methicillin-resistant *Staphylococcus aureus* in vitro.

Material and Methods: This was a Cross-sectional observational study carried out in the Department of Microbiology at Government Medical College, Kota, Rajasthanfor a period of three years, starting from September 7, 2019, to September 6, 2022. A total of 384 *Staphylococcus aureus* isolated from different clinical samples were analyzed. MRSA isolates were screened and confirmed using standard methods recommended by the Clinical and Laboratory Standards Institute (CLSI). Methicillin resistance, in *Staphylococcus aureus* strains, was evaluated using cefoxitin. The Kirby-Bauer disc diffusion technique was used to assess the antibiotic susceptibility pattern of all MRSA strains. Antimicrobial susceptibility testing was performed using the Kirby-Bauer disk diffusion method according to the CLSI guidelines 2019.

Results: In the present study a total of 384 *Staphylococcus aureus* isolates were obtained from various clinical samples. The prevalence of MRSA was observed to be 48.1%. Among 384 *S. aureus* isolates, 70 (18.23%) belonged to (21-30) age group followed by 67 (17.45%) and least was observed in the age group 15 (3.91%) from (0-10) age group. The ratio of males was more compared to the females 195 (50.7%), 189 (49%) respectively in case of *S.aureus* and for MRSA Male was observed to be 98 (52%), female 87 (47.2%) respectively. The maximum number of isolates were observed forpus followed by urine and least for pleural fluid. It was also noted that Vancomycin was found to be the most sensitive with the sensitivity of 97.3%, followed by Linezolid 96.2% and then Teicoplanin 89.73 % was found to be the most effective drug of choice.

Conclusion: The prevalence of MRSA varies according to geographical region, hospital type, examined population, and detection technique. Effective antimicrobial activity as well as cost effectiveness should be considered in drugs prescribed for MRSA infections. Given the clinical implications of MRSA infection and its rapid transmission potential, MRSA strains must be evaluated on a frequent basis.

Keywords: MRSA, Disc Diffusion, CLSI, Prevalence, AST

INTRODUCTION

The Staphylococcus genus includes pathogenic organisms, with *Staphylococcus aureus* being the most prevalent. It has outperformed most treatment medicines discovered against it in recent years [1]. In the early 1960s, beta-lactamase resistant semi-synthetic penicillin's gave temporary respite. However, MRSA emerged shortly after methicillin became accessible for clinical use [2].

Methicillin resistance was first detected in *S. aureus* in 1961, [3,4] shortly after the agent was introduced clinically and over the last four decades, there has been a global epidemic of methicillin-resistant *S. aureus* (MRSA). [5-7] MRSA is usually acquired during exposure to hospitals and other healthcare facilities and causes a variety of serious healthcare-associated infections. The problem is exacerbated by the propensity of the organism to cause cross-infection and its ability to colonize individuals for months or years. Considerable selection pressure for this organism is applied in the hospital setting due to the now intensive use of the many antibiotics, particularly cephalosporins, to which the organism is resistant.

Many of these MRSA isolates are becoming multidrug resistant and are susceptible only to glycopeptide antibiotics such as vancomycin. Low level resistance even to vancomycin is emerging at present [8]. A significant obstacle that must be overcome in clinical settings is the presence of vancomycin resistance in *Staphylococcus aureus* (VRSA). Vancomycin, which is a glycopeptide antibiotic, has been considered for a long time to be the last line of defense against severe infections that are caused by methicillin-resistant *Staphylococcus aureus* (MRSA). On the other hand, the effectiveness of this essential antibiotic is being undermined by the appearance and proliferation of VRSA strains. In most cases, VRSA strains develop resistance by acquired genetic pathways, which often include the acquisition of vanA or vanB genes. Because these genes generate altered cell wall precursors, the binding affinity of vancomycin to its target site is decreased. As a result, the antibiotic is unable to effectively suppress the development of bacteria. Furthermore, vancomycin-intermediate *Staphylococcus aureus* (VISA) strains have been discovered. These bacteria have a decreased sensitivity to vancomycin, but they do not fulfill the requirements for complete resistance [9,10].

Prolonged hospital stays, indiscriminate use of antibiotics, lack of awareness, and receipt of antibiotics before coming to the hospital are some of the possible predisposing factors of MRSA emergence. The knowledge of MRSA prevalence and the current antimicrobial profile is necessary in selection of appropriate empirical treatment of these infections [9]. Control of MRSA in hospitals is essential. This can be achieved by proper implementation of hospital infection control measures and regular surveillance activity. MRSA infection, stressing the need for precision and promptness in MRSA identification in the clinical setting for the timely management of infections brought on by this superbug [10-12].

Furthermore, the development of resistance mechanisms and the spread of resistant strains within healthcare settings and communities may be better understood by the ongoing monitoring of resistance trends over time. This gives useful information. Early diagnosis of developing resistance patterns enables prompt actions, such as revisions in antibiotic prescription practices, deployment of infection control measures, and focused antimicrobial stewardship activities aimed at conserving the efficacy of current medicines [13,14].

Given the significance of MRSA infections for public health, it is essential to track the present scenario of MRSA prevalence, as part of antimicrobial resistance (AMR) surveillance, across a

variety of health care settings. Therefore, the present study was undertaken to study the prevalence and its antibiogram profile of MRSA isolates from various clinical samples.

MATERIAL AND METHODS

This was a cross sectional study carried out among the patients (inpatients and outpatients) conducted in the Department of Microbiology.

Data Collection and Procedure

Place of Study: The study was conducted in the Department of Microbiology, Government Medical College, Kota, Rajasthan, India.

Duration of Study: Data collection took place over a period of three years, starting from September 7, 2019, to September 6, 2022, following approval from the Departmental Research Committee (DRC).

The Ethical Letter: The Ethical clearance was duly obtained from the Institutional Medical College of GMC, Kota.

Statistical Analysis

Statistical analysis may include calculations of prevalence rates, descriptive statistics of sample characteristics, and comparisons of antimicrobial susceptibility patterns among different clinical samples. Additionally, the correlation between demographic variables and antibiotic resistance profiles may be analyzed using appropriate statistical tests. The significance level for statistical tests may be set at $p < 0.05$.

A total of 384 non repeated pus, wound swab, blood, nasal swab, throat swab, urine etc clinical samples from different clinical sampleswere received from the patients for bacteriological culture were included in the study.

Isolation and Identification of *Staphylococcus aureus*

The samples were inoculated on blood agar and mannitol salt agar (HiMedia laboratories private limited, India) and incubated aerobically at 37°C for 48 hours. The strains of *Staphylococcus aureus* were identified on the basis of colony morphology, Gram's stain, and different biochemical tests [15].

Antimicrobial Susceptibility Testing

The antimicrobial susceptibility testing was performed by Kirby-Bauer disc diffusion technique using Mueller-Hinton agar (HiMedia laboratories private limited, India) following Clinical and Laboratory Standards Institute (CLSI) guidelines 2019 [15].Identified morphologically and biochemically by standard laboratory procedures including tube coagulase test and DNase test using DNase agar (Oxoid Ltd, Basingstoke, Hampshire, England).

Table No. (A): Antibiotic discs used in this study

Sr. No.	Antibiotics	Conc. (µg)	Zone of inhibition (mm)		
			Resistant	Intermediate	Sensitive
1	Amikacin	30	≤14	15-16	≥17
2	Cefazolin	30	≤19	20-22	≥23
3	Cefepime	30	≤18	19-24	≥25
4	Cotrimoxazole	25	≤10	11-15	≥16
5	Cloxacillin	5	≤21	22-24	≥25
6	Clindamycin	10	≤14	15-20	≥21

7	Cefoperazone	75	≤16	17-21	≥22
8	Erythromycin	15	≤13	14-22	≥23
9	Levofloxacin	5	≤15	16-18	≥19
10	Tetracycline	30	≤14	15-18	≥19
11	Quinupristin-Dalfopristin	15	≤15	16-18	≥19
12	Teicoplanin	30	≤10	11-13	≥14
13	Linezolid	30	≤20	-	≥21
14	Vancomycin	30	≤14	15-16	≥17
15	Nitrofurantoin	300	≤14	15-16	≥17

Detection of Strains of MRSA by Cefoxitin Disc Diffusion Method

Susceptibility of *Staphylococcus aureus* isolates to cefoxitin (30µg) was determined by Kirby-Bauer disc diffusion method following CLSI guidelines [15]. The strains of *Staphylococcus aureus* which were found to be resistant to cefoxitin were screened as MRSA.

RESULTS

In the present study a total of 384 *Staphylococcus aureus* isolates were obtained from various clinical samples among the patients admitted.

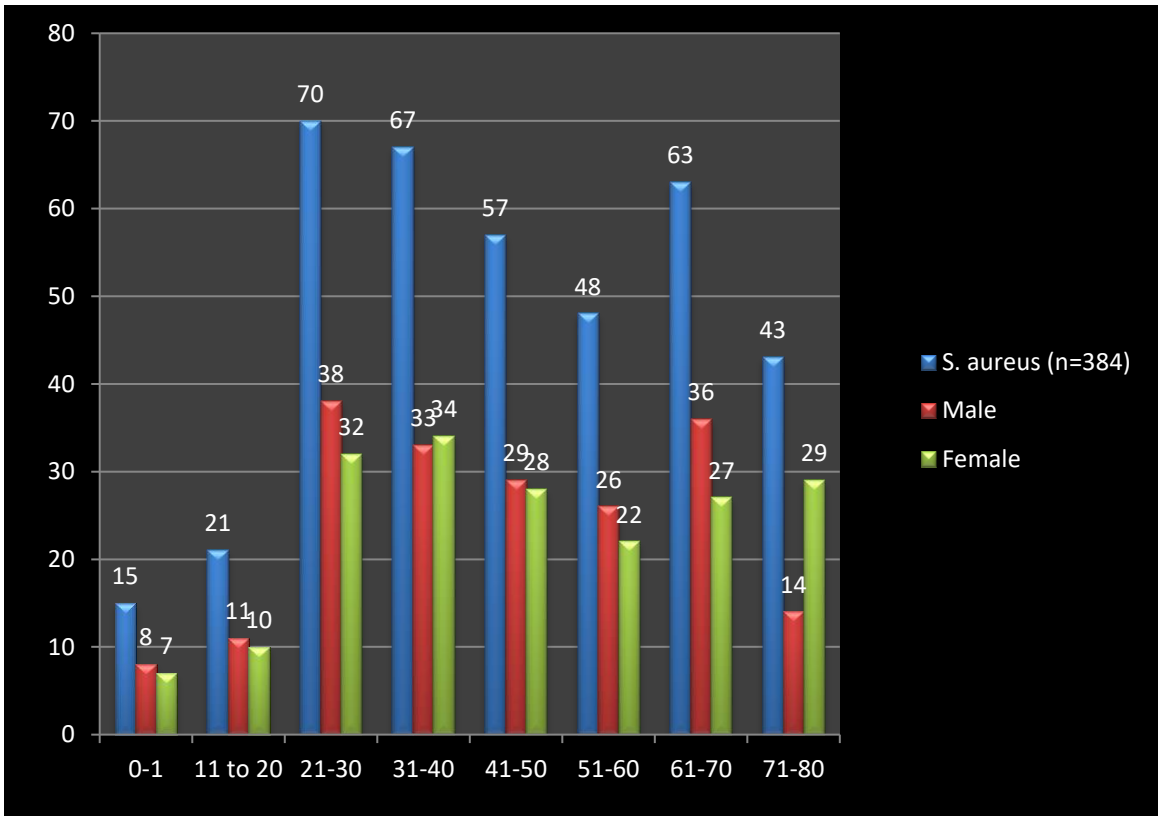
Table No. 1: Age and sex wise distribution of *Staphylococcus aureus* (n = 384).

Sr. No.	Age group	*S. aureus* No. (%)	Male No. (%)	Female No. (%)
1	0-10	15 (3.91)	8 (53.33)	7 (46.67)
2	11-20	21 (5.47)	11 (52.38)	10 (47.62)
3	21-30	70 (18.23)	38 (54.29)	32 (45.71)
4	31-40	67 (17.45)	33 (49.25)	34 (50.75)
5	41-50	57 (14.84)	29 (50.88)	28 (49.12)
6	51-60	48 (12.50)	26 (54.17)	22 (45.83)
7	61-70	63 (16.41)	36 (57.14)	27 (42.86)
8	71-80	43 (11.20)	14 (32.56)	29 (67.44)
	Total	**384 (100)**	**195 (50.78)**	**189 (49.22)**

Among 384 *S. aureus* isolates, 70 (18.23%) belonged to (21-30) age group followed by 67 (17.45%) from (31-40) age group, 63 (16.41%) from (61-70) age group, 57 (14.84%) from (41-50) age group, 48 (12.50%) from (51-60) age group, 43 (11.20%) from (71-80) age group, 21 (5.47%) from (11-20) age group, 15 (3.91%) from (0-10) age group.

Among 195 *S. aureus* isolated from male patients, 38 belonged to (21-30) age group followed by 36 from (61-70) age group, 33 from (31-40) age group, 29 from (41-50) age group, 26 from (51-60) age group, 14 from (71-80) age group, 11 from (11-20) age group, 8 from (0-10) age group.

Among 189 *S. aureus* isolated from female patients, 34 belonged to (31-40) age group followed by 32 from (21-30) age group, 29 from (71-80) age group, 28 from (41-50) age group, 27 from (61-70) age group, 22 from (51-60) age group, 10 from (11-20) age group, 7 from (0-10) age group.

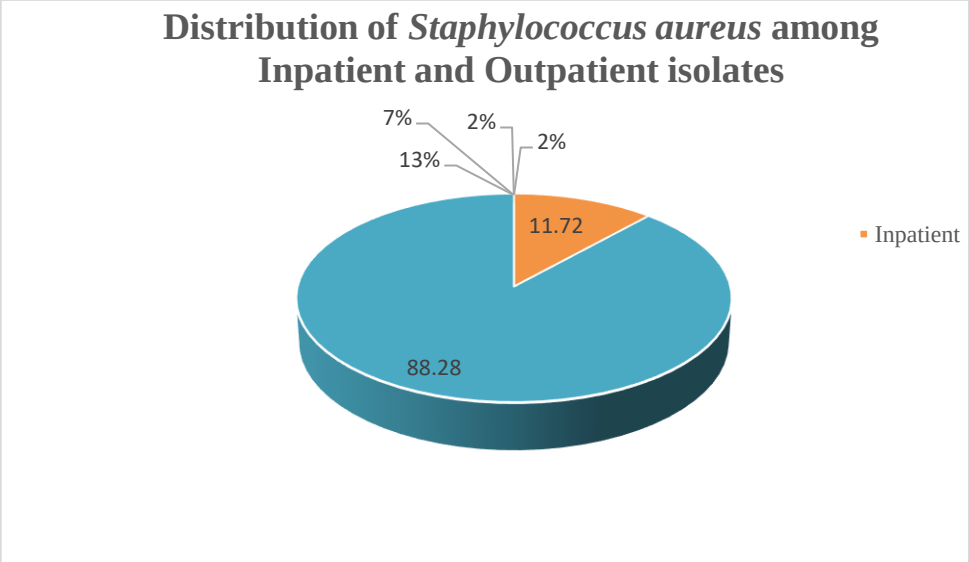


Graph No.1: Graphical Representation of Age and Sex Wise Distribution of *Staphylococcus aureus* (n = 384)

Table No. 2: Distribution of *S. aureus* isolates obtained from various clinical samples according to Inpatient and Outpatient isolates.

S. aureus **No. (%)**	**Inpatient isolates No. (%)**	**Outpatient isolates No. (%)**
384 (100)	45 (11.72)	339 (88.28)

Out of 384 (100%) *S. aureus* isolates, 339 (88.28%) were from outpatient isolates and45 (11.72%) were from inpatient isolates.

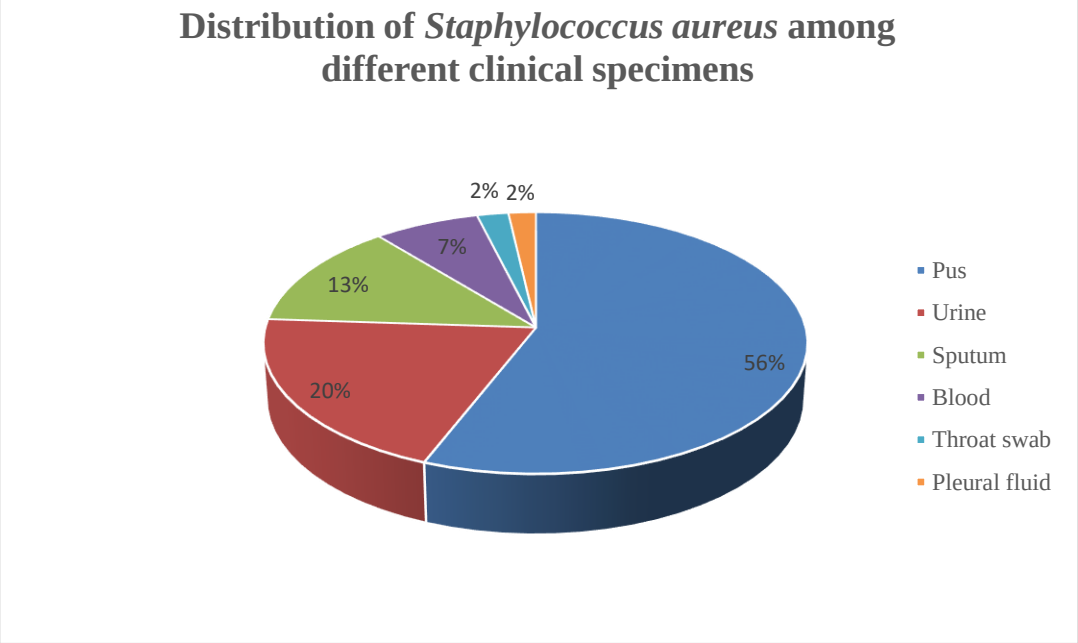


Graph No. 2: Graphical Representation of Distribution of *S. aureus* isolates among Inpatient and Outpatient isolates.

Table No. 3: Distribution of *S. aureus* isolates obtained from various clinical specimens.

Sr. No.	Clinical Specimens	Number of *Staphylococcus aureus*	Percentage (%)
1	Pus	215	56
2	Urine	77	20
3	Sputum	50	13
4	Blood	27	7
5	Throat swab	8	2
6	Pleural fluid	7	2
	Total	**384**	**100**

In the present study the highest percentage of *Staphylococcus aureus* isolates was obtained from pus samples (56%), followed by urine (20%), sputum (13%), blood (7%), throat swab (2%) and pleural fluid (2%).



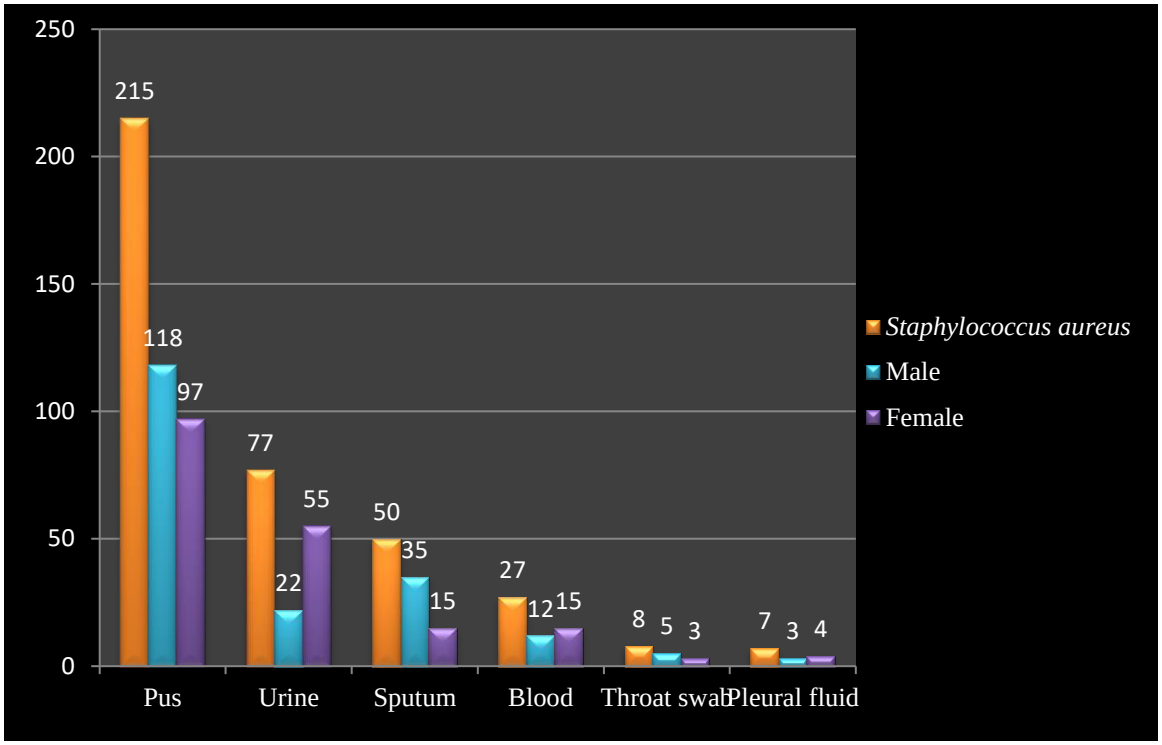
Graph No.3: Distribution of *Staphylococcus aureus* among different clinical specimens.

Table No.4: Gender wise distribution of *S. aureus* isolates obtained from various clinical samples.

1	Pus	215 (55.99)	118 (54.88)	97 (45.12)
2	Urine	77 (20.05)	22 (28.57)	55 (71.43)
3	Sputum	50 (13.02)	35 (70)	15 (30)
4	Blood	27 (7.03)	12 (44.44)	15 (55.56)
5	Throat swab	08 (2.08)	05 (62.50)	03 (37.50)
6	Pleural Fluid	07 (1.82)	03 (42.86)	04 (57.14)
	Total	**384 (100)**	**195 (50.78)**	**189 (49.22)**

Male patients:
Out of 195 (50.78%) isolates from male patients, 118 were from pus followed by sputum 35, urine 22, blood 12, throat swab 5 and pleural fluid 3.

Female subjects:
Of the isolates 189 (49.22%) from the clinical samples of the female subjects, 97 were from pus followed by urine 55, sputum 15, blood 15, pleural fluid 4 and throat swab 3.



Graph No.4: Gender wise distribution of *S. aureus* isolates obtained from various clinical samples.

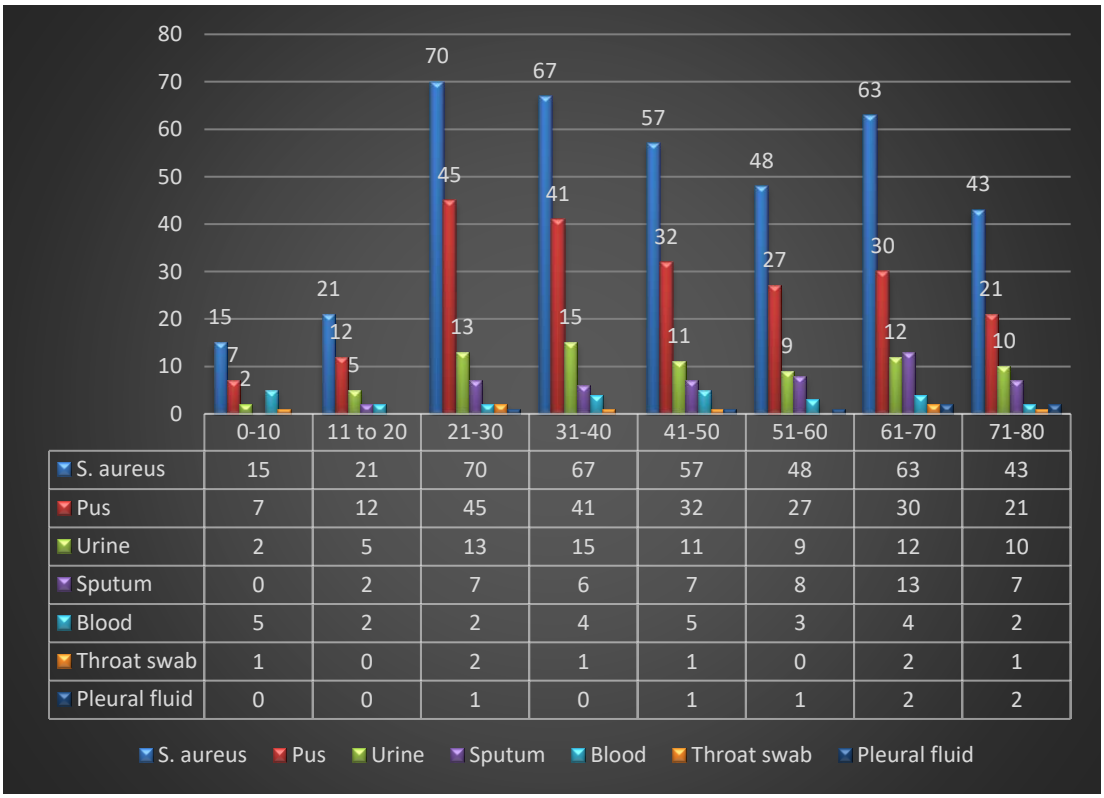
Table No. 5: Age group and sample wise distribution of *S. aureus* isolates.

Sr. No.	Age group	*S.aureus* N (%)	Pus N (%)	Urine N (%)	Sputum N (%)	Blood N (%)	Th.S. N (%)	P. Fluid N (%)
1	0-10	15 (3.91)	07 (46.67)	02 (13.33)	00 (0)	05 (33.33)	01 (6.67)	00 (0)
2	11-20	21 (5.47)	12 (57.14)	05 (23.81)	02 (9.52)	02 (9.52)	00 (0)	00 (0)
3	21-30	70 (18.23)	45 (64.29)	13 (18.57)	07 (10.00)	02 (2.86)	02 (2.86)	01 (1.43)
4	31-40	67 (17.45)	41 (61.20)	15 (22.39)	06 (8.96)	04 (5.97)	01 (1.49)	00 (0)
5	41-50	57(18.84)	32 (56.14)	11 (19.30)	07 (12.28)	05 (8.77)	01 (1.75)	01 (1.75)
6	51-60	48 (12.50)	27 (56.25)	09 (18.75)	08 (16.67)	03 (6.25)	00 (0)	01 (2.08)
7	61-70	63 (16.41)	30 (47.62)	12 (19.05)	13 (20.63)	04 (6.35)	02 (3.17)	02 (3.17)
8	71-80	43 (11.20)	21 (48.84)	10 (23.26)	07 (16.28)	02 (4.65)	01 (2.33)	02 (4.65)
	Total	**384**	**215**	**77**	**50**	**27 (7.03)**	**08 (2.08)**	**07 (1.82)**

		(100)	**(55.99)**	**(20.05)**	**(13.02)**			

Among 215/384 (55.99%)*S. aureus*isolated from pus sample, maximum 45 isolates were from 21-30 age group, followed by 41 isolates were from 31-40 age group, 32 isolates were from 41-50 age group, 30 isolates were from 61-70 age group, 27 isolates were from 51-60 age group, 21 isolates were from 71-80 age group, 12 isolates were from 11-20 age group and 7 isolates were from 0-10 age group.
Among 77/384 (20.05%) *S. aureus* isolated from urine sample, maximum15 isolates were from 31-40 age group, followed by 13 isolates were from 21-30 age group, 12 isolates were from 61-70 age group, 11 isolates were from 41-50 age group, 10 isolates were from 71-80 age group, 09 isolates were from 51-60 age group, 05 isolates were from 11-20 age group and 02 isolates were from 0-10 age group.

Among 50/384 (13.02%) *S. aureus* isolated from sputum sample, maximum 13 isolates were from 61-70 age group, followed by 08 isolates were from 51-60 age group, 07, 07, 07 isolates were from 21-30, 41-50, 71-80 age group, 06 isolates were from 31-40 age group and 02 isolates were from 11-20 age group.
Among 27/384 (7.03%) *S. aureus* isolated from blood sample, maximum 05, 05 isolates were from 0-10 and 41-50 age group, followed by 04, 04 isolates were from 31-40 and 61-70 age group, 03 isolates were from 51-60 age group, 02, 02, 02 isolates were from 11-20, 21-30 and 71-80 age group. Among 08/384 (2.08%) *S. aureus* isolated from throat swab sample, maximum 02, 02 isolates were from 21-30 and 61-70 age group, followed by 01, 01, 01, 01 isolates were from 0-10, 31-40, 41-50 and 71-80 age group.
Among 07/384 (1.82%) *S. aureus* isolated from pleural fluid sample, maximum 02, 02 isolates were from 61-70 and 71-80 age group, followed by 01, 01, 01 isolates were from 21-30, 41-50 and 51-60 age group.

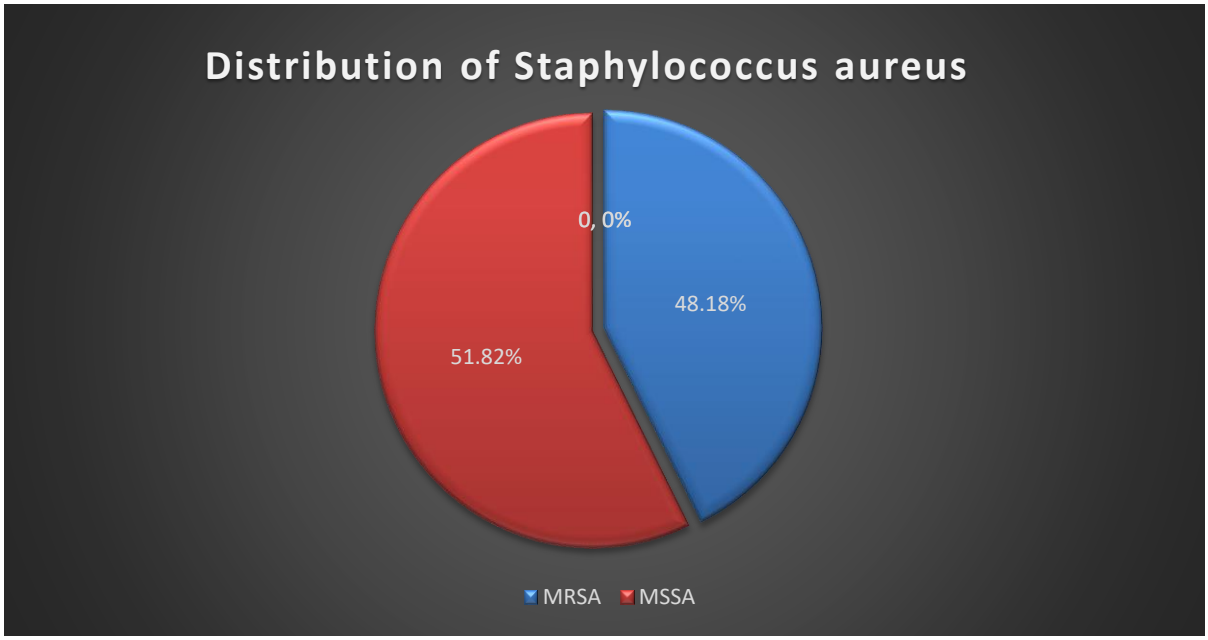


Graph No.5: Graphical Representation of Age group and Sample wise distribution of *S. aureus* isolates.

Table No.6: Distribution of *S. aureus* among MRSA and MSSA.

Staphylococcus aureus	**384**	**100%**
MRSA	185	48.18%
MSSA	199	51.82%

Among 384 *staphylococcus aureus*, 185 (48.18%) were methicillin resistant and 199 (51.82%) were methicillin sensitive.



Graph No. 6: Distribution of *Staphylococcal aureus* among MRSA and MSSA.

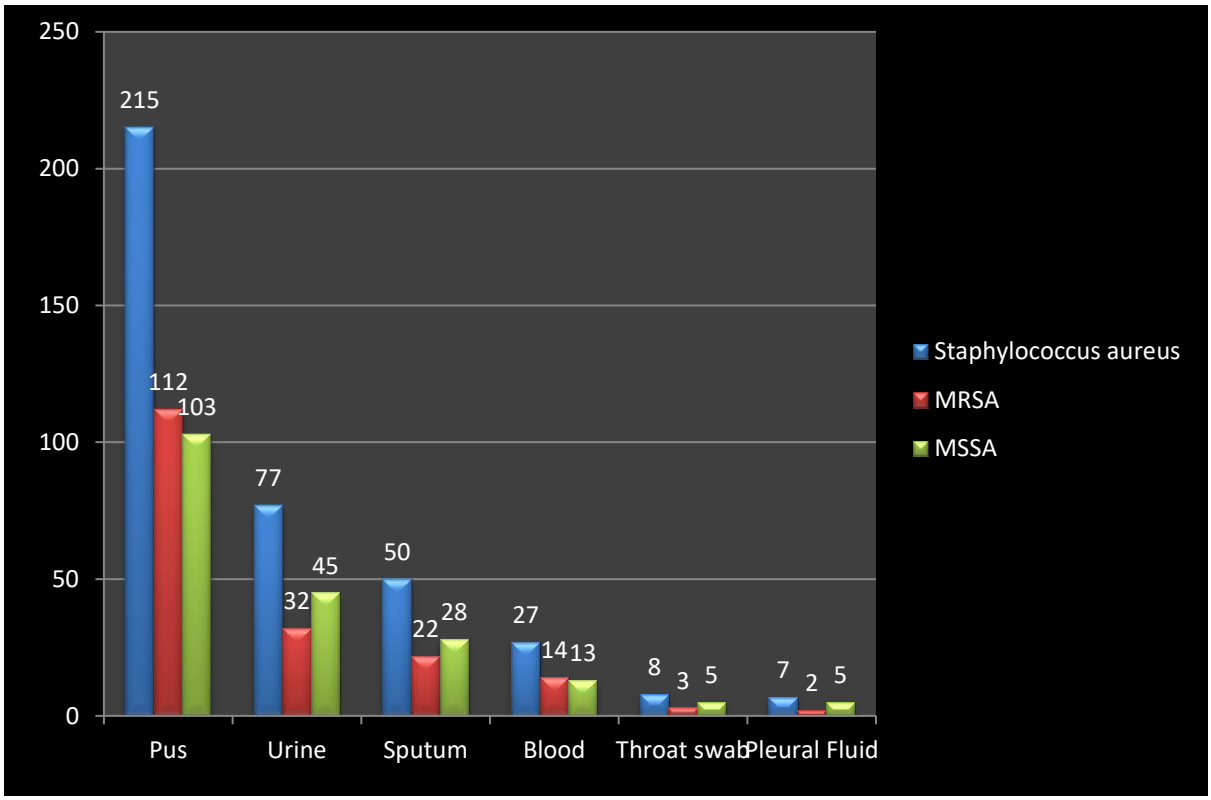
Table No. 7: Isolation of MRSA from different clinical specimens.

Sr. No.	**Clinical Samples**	***S. aureus* No. (%)**	**MRSA No. (%)**	**MSSA No. (%)**
1	Pus	215 (55.99)	112 (52.09)	103 (47.91)
2	Urine	77 (20.05)	32 (41.56)	45 (58.44)
3	Sputum	50 (13.02)	22 (44)	28 (56)
4	Blood	27 (7.03)	14 (51.85)	13 (48.15)
5	Throat swab	08 (2.08)	03 (37.5)	05(62.5)
6	Pleural Fluid	07 (1.82)	02 (28.57)	05 (71.43)
Total		384 (100)	185 (48.18%)	199 (51.82%)
df		5		
χ2 test		5.073		
P value		0.407^{NS}		

χ2 : Chi square test df: Degree of freedom NS: Non-significant (p>0.05 at 95% CI(ConfidenceInterval)

Among 185 (48.18%) MRSA isolates highest number was obtained from pus112, followed by urine32, sputum 22, blood14,throat swab3 and pleural fluid 2.

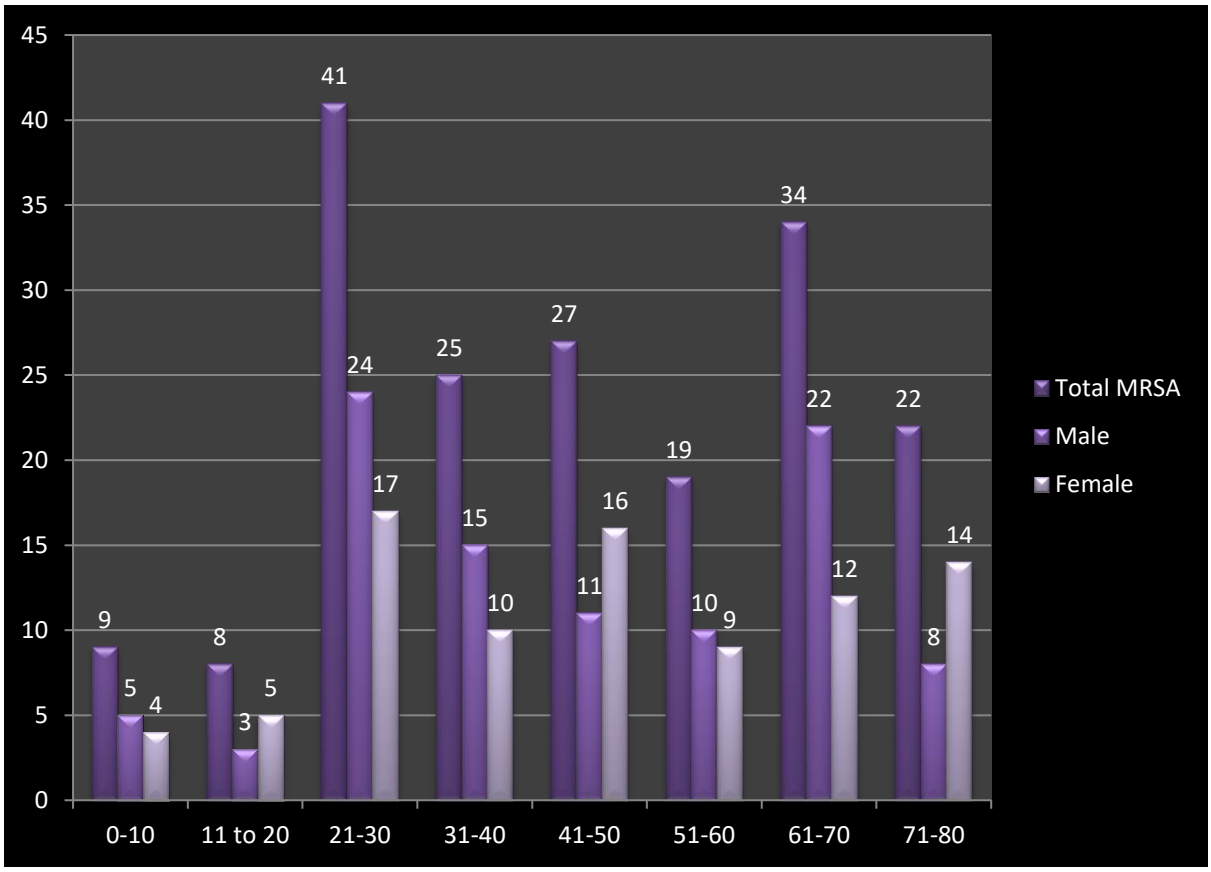
Among 199 (51.82%) MSSA isolates highest number was obtained from pus 103, followed by urine 45, sputum 28, blood 13, throat swab5 and pleural fluid 5. However, the result was insignificant statistically (p>0.05).



Graph No. 7: Isolation of MRSA from different clinical specimens.

Table No.8: Age and sex wise distribution of MRSA isolates.

Sr. No.	Age group	MRSA No. (%)	Male No. (%)	Female No. (%)
1	0-10	9 (4.86)	5 (55.56)	4 (44.44)
2	11-20	8 (4.32)	3 (37.50)	5 (62.50)
3	21-30	41 (22.16)	24 (58.54)	17 (41.46)
4	31-40	25 (13.51)	15 (60)	10 (40)
5	41-50	27 (14.59)	11 (40.74)	16 (59.26)
6	51-60	19 (10.27)	10 (52.63)	9 (47.37)
7	61-70	34 (18.38)	22 (64.71)	12 (35.29)
8	71-80	22 (11.89)	8 (36.36)	14 (63.64)
	Total	**185 (100)**	**98 (52.97)**	**87 (47.03)**



Graph No.8: Age and Sex wise separation of MRSA isolates.

Table No. 9: Age and MRSA isolates

Age	***S. aureus* No. (%)**	**MRSA No. (%)**	**MSSA No. (%)**
0-10	15 (3.9)	9 (4.86)	6 (3.01)
11-20	21 (5.46)	8 (4.32)	13 (6.53)
21-30	70 (19.77)	41 (22.16)	29 (14.57)
31-40	67 (17.44)	25 (13.51)	42 (21.11)
41-50	57 (14.84)	27 (14.59)	30 (15.07)
51-60	48 (12.5)	19 (10.27)	29 (14.52)
61-70	63 (16.4)	34 (18.37)	29 (14.57)
71-80	43 (11.19)	22 (11.89)	21 (10.55)
Total	384 (100)	185 (100)	199 (100)
df	7		
χ2 test	11.76		
P value	0.108 ^{NS}		

χ2 : Chi square test df: Degree of freedom NS: non-significant (p>0.05 at 95% CI(ConfidenceInterval)

Table No. 10: Gender and MRSA isolates

Gender	***S. aureus* No. (%)**	**MRSA No. (%)**	**MSSA No. (%)**
Male	195 (50.78)	98 (52.79)	97 (48.74)
Female	189 (49.22)	87 (47.02)	102 (51.26)
Total	384 (100)	185 (100)	199 (100)

df	7
χ2 test	11.76
P value	0.108 ^{NS}

χ2 : Chi square test df: Degree of freedom NS: non-significant (p>0.05 at 95% CI(ConfidenceInterval)

Among 185 MRSA isolates, 98 (52.97%) isolates belonged to male patients and 87 (47.03%) were from female patients. Among 98 MRSA isolated from male patients, 24 belonged to (21-30) age group followed by 22 from (61-70) age group, 15from (31-40) age group, 11 from (41-50) age group, 10 from (51-60) age group, 8 from (71-80) age group, 5 from (0-10) age group, 3 from (11-20) age group.

Among 87 MRSA isolated from female patients, 17 belonged to (21-30) age group followed by 16 from (41-50) age group, 14 from (71-80) age group, 12 from (61-70) age group, 10 from (31-40) age group, 9 from (51-60) age group, 5 from (11-20) age group, 4 from (0-10) age group. Maximum MRSA isolates were observed in male patients. The results were insignificant statistically (p>0.05)

DISCUSSION

Staphylococcal infections are a global health concern due to the increased medication resistance produced by these organisms. It accounts for 30% of hospital-acquired infections, with Staphylococcus being the most often isolated organism on culture in around 50% of bloodstream infections.*Staphylococcus aureus* poses a public health problem due to its rising virulence and resistance patterns, which concerns WHO. Increasing antibiotic resistance is a worrisome trend being observed worldwide. Methicillin-resistant *Staphylococcus aureus* (MRSA) was first reported in the United Kingdom (UK) in 1961 and has since been reported throughout the world as a nosocomial pathogen [16]. In recent years, vancomycin has been the preferred treatment for MRSA (Methicillin Resistant Staphylococcus aureus) infections. However, it has led to the emergence of vancomycin intermediate Staphylococcus aureus (VISA) and vancomycin-resistant Staphylococcus aureus (VRSA).

A steady increase in the occurrence of MRSA strains has been reported in hospitals globally including in India.MRSA is a notorious pathogen that can withstand and develop resistance against the available empirical drugs of choice.The availability of sensitive and specific methods for the accurate detection of antibiotic resistance in these bacteria has become an important tool in clinical diagnosis [17-19].

In the present study the prevalence of MRSA was observed to be 48.1 %. This study was in support with the study performed by the other authors Gadepalli R *et al*.,in 2009 and Gopalakrishnan R, *et al.*,in 2010 where the prevalence was found to be 41% and 40% respectively [20,21].Another study in India [22] recorded the prevalence of MRSA as 40-50 per cent. but in constrast with the study by Maj Puneet Bhatt et al in 2015 where the prevalence rate was observed to be 20% [23].

Table No. 11: Comparison of age-based prevalence of *Staphylococcus aureus* isolates with other studies

Present study (N=384)	**Kaur K *et al* (N=162) [24]**	**Goyal A *et al* (N=379) [25]**	**Mandal M *et al* (N=108) [26]**
21-30 years (70/18.23%)	16-40 years (70/43.2%)	20-40 years (193.29/51%)	21-30 years (39/36.11%)
31-40 years (67/17.45%)	-	0-20 years (98.54/26%)	11-20 years (23/21.29%)

In this present study, there were total 384 isolates of *Staphylococcus aureus***,** of which maximum isolates were obtained from the age group of 21-30 years (18.23%) followed by 31-40 years (17.45%).Our results were comparable to the study of Mandal M *et al* and Goyal A *et al* which showed high prevalence in the age groups of 21-30 years (36.11%) and 20-40 years (51%) respectively. However. In the study of Kaur K *et al* (table 11), the prevalence was high in the age group ranging from 16-40 years (43.2%). This could be due to wider margin of age range selected in their study.

Table No. 12: Comparison of gender based (Male: M, Female F) prevalence of *Staphylococcus aureus* isolate with other studies

Present Study (N=384)		**Kaur K et al (N=162) [24]**		**Mandal M *et al* (N=108) [26]**		**Sarrafzadeh F *et al* (N=250) [27]**		**Adhikari R *et al* (N=95) [28]**	
M	F	M	F	M	F	M	F	M	F
195 (50.78 %)	185 (49.22 %)	85 (52.4%)	44 (47.5%)	37 (34.26 %)	71 (65.74 %)	188 (75.2%)	62 (24.8%)	41 (43.16 %)	54 (56.84 %)
Ratio	1.03:1	1.93:1		0.52:1		3.03:1		0.76:1	

Of the total isolates, 195 *Staphylococcus aureus* (50.78%) isolates were from males while 189 isolates were from females (49.22%) with male:female ratio of 1.03:1. Among males, the maximum isolates were from the age group of 21-30 years while females it was 31-40 years (table 6.2).
In the study of Kaur K *et al*, there were 162 isolates of *Staphylococcus aureus*, of which 85 (52.4%) were obtained from females while 44 (47.5%) were obtained from male patients. The higher number of isolates was obtained frommale patients which was similar to our study. The male:female ratio was 1.93: which was higher that our study. The findings of the present study were also similar to that of SarrafzadehF*etal*who showed higher prevalence in males (188/75.2%) compared to females (62/24.8%). The male: female ration was very high in comparison to our study (3.03:1). In contrast, a study from Bihar conducted by Mandal M *et al* and a study conducted in Nepal by Adhikari R *et al*reported high prevalence of *Staphylococcus aureus* isolates in females compared to males. In females it was 71 (65.74%) and in males it was 37 (34.26%) in study of Mandal M *et al* and 41 (43.16%) and 54 (56.84%) respectively in study of Adhikari R *et al*. The male to female ratios in their study was low. i.e. 0.52:1 and 0.76:1, which were less in comparison to this study.

Table No.13 : Comparison of prevalence of *Staphylococcus aureus* isolates with other studies according to IPD and OPD

Present Study (N=384)		**Kaur K *et al* (N=162) [24]**		**Joshi S *et al* (N=12442) [29]**		**Maharjan M *et al* (N=74) [30]**		**Kaleem F *et al* (N=276) [31]**	
IPD	OPD	IPD	OPD	IPD	OPD	IPD	OPD	IPD	OPD
45 (11.75%)	339 (88.28%)	102 (62.96%)	60 (37.03%)	9084 (73.01%)	3358 (26.98%)	59 (79.73%)	15 (20.27%)	185 (67%)	91 (33%)

In this study, 339 (88.28%) of isolates were obtained from outpatients while 45 (11.75%) of isolates were from inpatients. In contrast to this study, the meta-analysis study of Joshi S *et al*reported majority of isolates to be from inpatients. The total number of isolates from inpatients was 9084 (73.01%). Their findings were similar to that of Kaur K *et al* and Maharjan M *et al* who also reported higher number of isolates from inpatients. The prevalences were 102 (62.96%) and 9084 (79.73%)

respectively (table 6.3).Likewise, another study of Kaleem F *et al* also reported high prevalence of Staphylococcus aureus isolates (MRSA) in inpatients (67%).

Table No. 14: Comparison of prevalence of *Staphylococcus aureus* isolates with other studies according to various clinical specimen

Present study (N=384)	**Usha MG et al N=190 [32]**	**Kandel SN et al (N=39) [33]**	**Kaur K (N=162) [24]**	**Nepal N et al (N=80) [34]**	**Maharjan M *et al* (N=74) [30]**
Pus 215 (56%)	Pus 126 (66.31%)	Urine 9 (23.1%)	Pus and Wound 96 (59.2%)	Pus 42 (52.5%)	Wound swab 27 (47.4%)
Urine 77 (20%)	Blood 16 (8.42%)	Pus 8 (20.5%)	Urine 30 (18.5%)	Wound swab 21 (26.3)	Pus 16 (41%)

In the present study most of the *Staphylococcus aureus* isolates i.e.215 were obtained from pus samples that accounted for 56% followed by urinesamples, the incidenceof which were 77 (20%) (table 6.4). Like the present study, the number of *Staphylococcus Aureus* isolates was high is pus sample in the studies conducted by Usha MG *et al* (126/66.31%), Kaur K et al (96/59.2%) and Niranjan N *et al* (42/52.5%) followed by blood (16/8.42%), urine (30/18.5%) and pus (16/41%) respectively. In contrast to our study, the study of Kandel SN *et al* showed higher incidence in urine sample (9/23.1%) followed by pus (8/20.5%). Another, study of Maharjan M *et al* reported higher incidence in wound swab (27/47.4%) followed by pus sample (16/41%). In their study, 26.2% of isolates were from ICU while 20.8% were isolated from Gynae ward.

Staphylococcus aureus is mainly found in environment and the surface of skin which could be the probable reason from high incidence of isolates from wound and pus samples. The pus and wound swab also are the potent causes of skin or soft tissue infection and surgical site infections [34].

In the present study, it was found that, out of 195 isolates of *Staphylococcus aureus* isolated from male patients, 60.5% was obtained from pus followed by 17.9% from the sputum sample, 11.3% from urine, 6.14 from blood, 2.6% from throat swab and 1.5% from pleural fluid. In case of 189 isolates obtained from female patients, 51.3% were obtained from pus sample, 29.1% from urine, 7.9% each from blood and sputum, 2% from pleural fluid and 1.6% from throat swab. With respect to age wise segregation of *Staphylococcus aureus* isolates from different clinical samples, we found that higher incidences were observed in the pus samples obtained from the patients belonging to 21-30 years of age. Incase of isolates from urine sample maximum isolates were in the age group of 31-40 years.

Table No. 15: Comparison of prevalence of MRSA among *Staphylococcus aureus* isolates with other studies

Present Study (N=384)		**Osman MM *et al* N=61 [35]**		**Arora S *et al* N=250 [36]**		**Jayshree *et al* N=29 [37]**		**Thati V *et al* N=358 [38]**	
MSSA	MRSA	MSSA	MRSA	MSSA	MRSA	MSSA	MRSA	MSSA	MRSA
199 (51.82%)	185 (48.18%)	36 (59%)	25 (41%)	135 (58.7%)	115 (41.3%)	17 (58.62%)	12 (41.38%)	73 (20.4%)	285 (79.6%)

The present study reported that, of 384 *Staphylococcus aureus* isolates, 185 (48.18%) were methicillin resistant (i.e. MRSA) while 199 (51.82%) were methicillin sensitive (MSSA). In the study of Osman MM *et al*,25 (41%) of *Staphylococcus aureus* isolates were MRSA while 36 (59%) were MSSA which was similar to our study. Likewise, in the study of Jayshree N et al, the prevalence of MRSA was 41.38% (12) while the study of Thati V *et al* showed a very high prevalence of MRSA i.e. 79.6% (285) which was higher than that observed in our study (table 15).

Table No.16: Comparison of prevalence of MRSA isolates in various clinical specimen with other studies

Present study (N=185)	**Kandel SN*et al* (N=18) [33]**	**Kaleem F*et al* (N=276) [31]**	**Rana Khara R *et al* (N=52) [39]**	**Joshi S *et al* (N=2695) [29]**
Pus (112/60.54/%)	Wound swab (7/38.8%)	Pus (190/69%)	Blood (19/36.54%)	Pus (1717/63.71%)
Urine (32/17.29%)	Pus (4/22.2%)	Respiratory sample (20/18%)	Pus (15/28.85%)	Blood (483/17.92%)

In this study, MRSA isolates was more in pus samples, i. e, 112 which accounted for 60.54%. Similar was the case for MSSA isolates. More isolates were obtained from pus sample (32/17.29%). There was no significant association between and the clinical samples and the incidence of MRSA and MSSA isolates.The result of our study was supported by the previous studies of Kaleem F *et al* and Joshi S *et al* who also reported higher prevalence of MRSA isolates in pus sample (69% and 63.71% respectively). However, in the study of Kandel SN *et al* more number of MRSA isolates were obtained wound swab (38.8%) while Rana Khara *et al* reported more prevalence of MRSA in blood samples (36.54%). These reports were in contrast to that of our study (table 16).
Likewise, a study from Chennai reported 40-50% incidence of MRSA strain [22] of which 17% was related to catheter related blood stream infections.

Table No. 17: Comparison of age-based prevalence of MRSA isolates with other studies.

Present study (N=185)	**Kaur K *et al* (N=83) [24]**	**Sarrafzadeh F *et al* (N=250) [27]**	**Lama U *et al* N=57 [40]**
21-30 years (41/22.16%)	16-40 years (36/43.2%)	19-64 years (173/69.2%)	21-30 (12/17.9%)

In this study, the prevalence of MRSA isolates was more in the age group of 21-30 years (41/22.16%). It was in support of the study of Lama U *et al* who also reported high prevalence in 21-30 years age group (12/17.9%). In contrast to the present study, Kaur K *et al* and Sarrafzadeh F *et al* reported high prevalence in the age groups of 16-40 years (43.2%) and 19-64 years (69.2%) respectively (table 17).

Table No. 18: Comparison of gender-based prevalence of MRSA isolate with other studies

Present Study (N=185)		**Rana Khara*et al* (52) [39]**		**Lama U *et al*(57) [40]**	
Male	Female	Male	Female	Male	Female
98 (52.97%)	87 (47.03%)	32 (61.54%)	20 (38.46%)	27 (47.37%)	30 (52.63%)

The present study documented a greater number of MRSA isolates in male patients(98/52.97%) compared to female patients (87/47.03%). Similar to this study, study of Rana Khara et al more prevalence in male patients (32/61.54%). However, in contrast to this study, study of Lama U et al documented more prevalence in female patients (30/52.63%) (table 18).

Table No.19: Antimicrobial susceptibility pattern among MRSA and MSSA isolates.

STUDY	YEAR	AK MRSA/MSSA	COT MRSA/MSSA	CL MRSA/MSSA	CD MRSA/MSSA	E MRSA/MSSA	LE MRSA/MSSA	TE MRSA/MSSA	TEI MRSA/MSSA	LZ MRSA/MSSA	VA MRSA/MSSA	NIT MRSA/MSSA
Present study	2022	76.22%/81.9%	25.95%/54.77%	44.32%/71.86%	63.78%/67.83%	56.22%/60.3%	66.49%/69.84%	72.97%/82.91%	89.73%/93.46%	96.22%/97.99%	97.3%/100%	75%/91.11%
Mohanty S et al [41]	2019						62.99%/84.71%				100%/100%	100%/100%
Lama U et al [42]	2017	85.96%/100%	-	5.26%/90%				43.85%/100%				
Ghosh S et al [43]	2016	-	45.45%/40%	-	45.45%/62.85%	18.18%/37.14%				100%/100%	100%/100%	
Rana Khara et al [44]	2016				40.38%/77.08%	36.54%/77.08%	86.54%/100%			96.15%/100%	100%/100%	
Jyoti K et al [45]	2016							37.5%/18.22%	100%/100%			
Osman MM et al [46]	2016							64%/25%				
Dhanalakshmi TA et al[47]	2012	-	67.86%/68.8%	-								
Shittu O et al [48]	2011							0/52.63%	100%/100%	100%/100%		
Arora S et al	2010	62.6%/91.11%	-	-						98.26%/100%	100%/100%	46.15%/50%

[49]												
Taj V et al [50]	2010	82.76 %/93.84%	-	-								
Pathak A et al [51]	2010	81.25 %/90.24%	25%/46.34 %	-	56.25 %/95.12%	50%/81.71 %	62.5 %/74.39%		100%/100 %			

From the table no. 19 it was observed the comparison of the sensitivity pattern evaluated in different research. It was also noted that Vancomycin was found to be the most sensitive with the sensitivity of 97.3%, followed by Linezolid 96.2%and then Teicoplanin 89.73 % was found to be the most effective drug of choice.The Co-trimoxazole and Chloramphenicolwere found resistance with 25.95% and 44.32% respectively.

Methicillin-resistant *Staphylococcus aureus* (MRSA) has become commonplace globally since it was initially recognised in a UK hospital in 1961,and poses a global threat causing serious infections in health facilities and the community, contributing 60% more deaths than the non-resistant form of the infections [52]. Recent developments in new antimicrobials against MRSA include ceftaroline, ceftobiprole, dalbavancin, oritavancin, iclaprim and delafloxacin, all of which are in various phases of clinical studies.Despite ongoing development of new treatments, active surveillance efforts, and advancements in infection control, the incidence of MRSA has emerged as a major source of morbidity, higher costs of healthcare delivery services, and increased mortality in hospitals over the past decades [53,54].

CONCLUSION

Drugs used to treat MRSA infections should have both effective antibacterial activity and be cost effective. Oral dosage options for linezolid and chloramphenicol can allow hospitalised patients to be discharged early while reducing the likelihood of VRSA emergence. Good hospital infection control procedures prove to be the mainstay against these infections, because medications can never be an adequate substitute for good medical practice.

Declarations:

Conflicts of interest: There is no any conflict of interest associated with this study

Consent to participate: We have consent to participate.

Consent for publication: We have consent for the publication of this paper.

Authors' contributions: All the authors equally contributed the work.

REFERENCES

1. Choo EJ. Community-associated methicillin-resistant staphylococcus aureus in nosocomial infections. *Infect Chemother* 2017;49:158–9. 10.
2. World Health Organization. Fact sheet antimicrobial resistance. 2018. Available: https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance
3. O'Riordan W, McManus A, Teras J, et al.. A comparison of the efficacy and safety of intravenous followed by oral delafloxacin with vancomycin plus aztreonam for the treatment of acute bacterial skin and skin structure infections: A phase 3, multinational, double-blind, randomized study. *Clin Infect Dis* 2018;67:657–66.
4. Turner NA, Sharma-Kuinkel BK, Maskarinec SA, et al.. Methicillin-resistant staphylococcus aureus: an overview of basic and clinical research. *Nat Rev Microbiol* 2019;17:203–18.

5. Qiao Y, Liu X, Li B, et al.. Treatment of MRSA-infected osteomyelitis using bacterial capturing, magnetically targeted composites with microwave-assisted bacterial killing. *Nat Commun* 2020; 11:1–13.
6. Tiwari HK, Sapkota D, Sen MR. High prevalence of multidrug-resistant MRSA in a tertiary care hospital of northern india. *Infect Drug Resist* .2008;1:57–61.
7. Dadashi M, Nasiri MJ, Fallah F, et al.. Methicillin-resistant staphylococcus aureus (MRSA) in iran: a systematic review and meta-analysis. *J Glob Antimicrob Resist* 2018;12:96–103.
8. Álvarez A, Fernández L, Gutiérrez D, et al.. Methicillin-resistant staphylococcus aureus in hospitals: latest trends and treatments based on bacteriophages. *J Clin Microbiol* 2019;57:e01006-19.
9. Garoy EY, Gebreab YB, Achila OO, et al.. Methicillin-Resistant Staphylococcus aureus (MRSA): prevalence and antimicrobial sensitivity pattern among patients-a multicenter study in asmara, eritrea. *Can J Infect Dis Med Microbiol* 2019;2019:8321834.
10. Lee J, Austin JM, Kim J, Miralles PD, Kaafarani HMA, Pronovost PJ, Ghimire V, Berenholtz SM, Donelan K, Martinez E. Developing and Testing a Chart Abstraction Tool for ICU Quality Measurement. Am J Med Qual. 2019;34(4):324-330.
11. Sabbagh P, Riahi SM, Gamble HR, Rostami A. The global and regional prevalence, burden, and risk factors for methicillin-resistant Staphylococcus aureus colonization in HIV-infected people: A systematic review and meta-analysis. Am J Infect Control. 2019;47(3):323-333
12. Abdul H. Siddiqui et al. Methicillin-Resistant Staphylococcus aureus. StatPearls [Internet]. 2023
13. Abao Xing et al. The Prevalence, Epidemiological, and Molecular Characterization of Methicillin-Resistant *Staphylococcus aureus* (MRSA) in Macau (2017–2022). *Microorganisms* 2024; *12*(1), 148.
14. Hasmukharay, K.; Ngoi, S.T.; Saedon, N.I.; Tan, K.M.; Khor, H.M.; Chin, A.V.; Tan, M.P.; Kamarulzaman, A.; Idris, N.B.; Niek, W.K. Evaluation of methicillin-resistant *Staphylococcus aureus* (MRSA) bacteremia: Epidemiology, clinical characteristics, and outcomes in the older patients in a tertiary teaching hospital in Malaysia. *BMC Infect. Dis.* 2023; *23*, 241.
15. Clinical and Laboratory Standards Institute. Performance standards for antimicrobial susceptibility testing, 29th informational supplement (M100-S22). Wayne Pa: Clinical and Laboratory Standards Institute; 2019 Jan.
16. Assadullah S, Kakru DK, Thoker MA, Bhat FA, 6. Hussain N, Shah A. Emergence of low level vancomycin resistance in MRSA. *Indian J Med Microbiol*.2003; 21: 196-198.
17. Sonavane, A, Mathur, M. Screening for vancomycin 7. intermediate - resistant *Staphylococcus aureus* among clinical isolates of MRSA. *Indian J Med Microbiol*.2007; 25: 79-80.
18. Mehdinejad M, Sheikh AF, Jolodar A. Study of .methicillin resistance in *Staphylococcus aureus* and species of coagulase negative Staphylococci isolated from various clinical specimens. *Pak J Med Sci*.2008; 24: 719-24.
19. Idree. s F, Jabeen K, Khan MS and Zafar A. Antimicrobial resistance profile of methicillin resistant staphylococcal aureus from skin and soft tissue isolates. *J Pak Med Assoc* .2009; 59: 266-269.
20. Gadepalli R, Dhawan B, Kapil A, Sreenivas V, Jais M,Gaind R, et al. Clinical and molecular characteristics ofnosocomial methicillin-resistant Staphylococcus aureus skin and soft tissue isolates from three Indian hospitals. JHosp Infect. 2009; 73:253–63.
21. Gopalakrishnan R, Sureshkumar D. Changing trends in antimicrobial susceptibility and hospital acquired infections over an 8 year period in a tertiary care hospital in relation to introduction of an infection control programme. J Assoc Physicians India. 2010;58:25–31.
22. Vikas Manchanda et al. Methicillin resistant *Staphylococcus aureus* (MRSA) in India: Prevalence & susceptibility pattern. Indian J Med Res. 2013 ; 137(2): 363–369.
23. Maj Puneet Bhatt, Gurpreet Singh Bhalla, Kundan Tandel, Prashant Jindamwar, CN Chaudhari, Naveen Grover Ajay Kumar Sahni. Antimicrobial Susceptibility Profile of Methicillin-resistant

Staphylococcus aureus at a Tertiary Care centre. Archives of clinicalmicrobiology. 2015; 6 : 3:6.
24. Kaur K, Gill AK, Kaur M. Methicillin resistance, vancomycin intermediate and vancomycin resistance Staphylococcus aureus prevalence in a tertiary care hospital of Punjab, India. National Journal of Laboratory Medicine, 2019; l-8(3): MO01-MO03.
25. Goyal A, Diwakar ML, Bhooshan S, Goyal S, Agrawal A. Prevalence and antimicrobial susceptibility pattern of methicillin-resistant Staphylococcus aureus [MRSA] isolates at a tertiary care hospital in Agra, North India – A systemic annual review. IOSR Journal of Dental and Medical Sciences (IOSR-JDMS). 2013; 11(6):80-4.
26. Mandal M, Dey S, Kumar D, Biswas PP, Nandan K and Sen A. Determination of vancomycin and linezolid resistance in staphylococcus aureus isolated from Katihar district of Bihar, India. J. Evolution Med. Dent. Sci. 2017 ;6(16):1244-1247.
27. Sarrafzadeh F, Mirzabiegi Z, Torabi-Nami M. Vancomycin-resistant Staphylococcus aureus isolates among hospitalized patients; a tertiary medical care center experience from Southern Iran. Cogent Medicine. 2016; 3(1):1163768.
28. Adhikari A, Kshetri B, Sharma KN, Khanal S, Panta OP, Sharma S et al. Prevalence of methicillin-resistant Staphylococcus aureus isolated from clinical samples at Narayani Samudayik Hospital, Chitwan, Nepal. TUJM. 2020; 7(1):37-42.
29. Joshi S, Ray P, Manchanda V, Bajaj J, Chitnis DS, Gautam V et al. Methicillin resistant Staphylococcus aureus (MRSA) in India: Prevalence & susceptibility pattern.Indian J Med Res. 2013; 137:363-9.
30. Maharjan M, Sah AK, Pyakurel S, Thapa S, Maharjan S, Adhikari N et al. Molecular confirmation of vancomycin-resistant Staphylococcus aureus with vanA Gene from a hospital in Kathmandu. International Journal of Microbiology, 2021; Article ID 3847347.
31. Kaleem F, Usman J, Sattar A, Amanat ST, Hassan A, Omair M et al. Current status of vancomycin susceptibility against methicillin resistant Staphylococcus aureus (MRSA) strains: A study at two tertiary care hospitals of Pakistan. African Journal of Microbiology Research. 2012; 6:6243-6.
32. Shilpa Arora. Prevalence of Methicillin-resistant *Staphylococcus Aureus* (MRSA) in a Tertiary Care Hospital in Northern India. J Lab Physicians. 2010 Jul-Dec; 2(2): 78–81.
33. Kandel SN, Adhikari N, Dhungel B. Characteristics of Staphylococcus aureus isolated from clinical specimens in a tertiary care hospital, Kathmandu, Nepal. Microbiology Insights, 2020; 13: Article ID 1178636120972695.
34. Nepal N, Mahara P, Subedi S, Rijal KR, Ghimire P, Banjara MR et al. Genotypically confirmed vancomycin-resistant Staphylococcus aureus with van B gene among clinical isolates in Kathmandu. Microbiology Insights. 2023; 16:1-9.
35. Osman MW, Osman MM, Mohamed NA, Osman SM, Magzoub M, El-Sanousi SM. Investigation on vancomycin resistance (VRSA) among methicillin resistant S. aureus (MRSA) in Khartoum State, Sudan. American Journal of Microbiological Research. 2016; 4(2):56-60.
36. Arora S, Devi P, Arora U, Devi B. Prevalence of methicillin resistanceStaphylococcus Aureus (MRSA) in a tertiary care hospital in Northern India. India J LabPhysician. 2010; 2(2):78-81.
37. Jayshree, Singh VK, Kumar A, Yadav SK. Prevalence of methicillin resistantstaphylococcus aureus (MRSA) at tertiary care hospital of Mathura, India. Progressiveresearch – an International Journal in Agriculture and Technology. 2016; 11(Special-
38. Thati VB, Shivannavar CT, Gaddad SM. Vancomycin resistance among methicillin resistant Staphylococcus aureus isolated from Intensive care unit of tertiary care hospital in Hyderabad. Indian J Med Res. 2011 ; 134(5):704-8.
39. Rana Khara R, Lakhani SJ, Vasava S, Shah K, Panjwani D. Methicillin resistant Staphylococcus aureus (MRSA) and vancomycin resistant Staphylococcus aureus (VRSA) from a rural based tertiary care and teaching hospital in Vadodara district, Gujarat. IAIM. 2016; 3(7): 187-95.

40. Lama U, Shah D, Shrestha UT. Vancomycin resistant Staphylococcus aureus reported from tertiary care hospital in Nepal. TUJM. 2017; 4(1):63-72.
41. Mohanty S, Behera B, Sahu S, Praharaj AK. Recent pattern of antibiotic resistance in *Staphylococcus aureus* clinical isolates in Eastern India and the emergence of reduced susceptibility to vancomycin. *J Lab Physicians*, 2019; 11:340-5.
42. Lama U, Shah D, Shrestha UT. Vancomycin resistant *Staphylococcus aureus* reported from tertiary care hospital in Nepal. *TUJM*, 2017; 4(1):63-72.
43. Ghosh S, Banerjee M. Methicillin resistance & inducible clindamycin resistance in Staphylococcus aureus. *Indian J Med Res,* 2016; 143: 362-4.
44. Rana KR, Lakhani SJ, Vasava S, Shah K, Panjwani D. Methicillin Resistant Staphylococcus aureus(MRSA) and Vancomycin Resistant Staphylococcus aureus(VRSA) from a rural based tertiary care and teaching hospital in Vadodara district, Gujarat. *IAIM*. 2016 July;3(7):187-195.
45. Kumari J, M S Shalini, M Chakrapani, K Vidyalakshmi and K B Gopalkrishna. Comparision of Etest and Agar dilution for determining minimum inhibitory concentration of vancomycin to healthcare-associated methicillin-resistant *staphylococcus aureus*. Asian *J Pharm Clin Res*, 31 March 2016; 9(4):1-3.
46. Osman MW, Osman MM, Mohamed NA, Osman SM, Magzoub M, El-Sanousi SM. Investigation on vancomycin resistance (VRSA) among methicillin resistant S. aureus (MRSA) in Khartoum State, Sudan. *American Journal of Microbiological Research*, 2016; 4(2):56-60.
47. Dhanalakshmi TA, Umapathy BL and Mohan DR. Prevalence of Methicillin, Vancomycin and Multidrug Resistance among *Staphylococcus aureus.* Journal of Clinical and Diagnostic Research. 2012 August, Vol-6(6): 974-977
48. Shittu AO, Oken K, Adesida S, Oyedara O, Witte W, Strommenger B *et al*. Antibiotic resistance and molecular epidemiology of Staphylococcus aureus in Nigeria. *BMCMicrobiol*, 2011; 11: 8.
49. Arora S, Devi P, Arora U, Devi B. Prevalence of methicillin resistance *Staphylococcus Aureus* (MRSA) in a tertiary care hospital in Northern India. *India J Lab Physician,* 2010; 2(2):78-81.
50. Taj Y, Abdullah FE, Kazmi SU. Current pattern of antibiotic resistance in Staphylococcus aureus clinical isolates and the emergence of vancomycin resistance. *Journal of the College of Physicians and Surgeons-Pakistan: JCPSP*, 2010; 20:728-32
51. Pathak A, Marothi Y, Iyer RV, Singh B, Sharma M, Eriksson B, Macaden R *et al*. Nasal carriage and antimicrobial susceptibility of *Staphylococcus aureus* in healthy preschool children in Ujjain, India. *BMC Pediatrics,* 2010; 10:100.
52. Tefera S, Awoke T, Mekonnen D. Methicillin and vancomycin resistant Staphylococcus aureus and associated factors from surgical ward inpatients at Debre Markos Referral Hospital, Northwest Ethiopia. *Infect Drug Resist*. 2021;14:3053–3062.
53. Aouati H, Hadjadj L, Aouati F, et al. Emergence of methicillin-resistant Staphylococcus aureus ST239/241 SCCmec-III Mercury in Eastern Algeria. *Pathogens*. 2021;10:1503.
54. Abd El-Hamid MI, Sewid AH, Samir M, et al. Clonal Diversity and Epidemiological Characteristics of ST239-MRSA Strains. *Front Cell Infect Microbiol*. 2022;12:782045.