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Research Article

Distribution and Antibiotic Resistance Profiles of MRSA Clinical Strains Across Different Age Groups and Genders: Implications for Targeted Infection Control and Antibiotic Stewardship Programs

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Abstract

Methicillin-resistant *Staphylococcus aureus* (MRSA) poses a significant public health challenge due to its resistance to multiple antibiotics. This study aims to investigate the distribution of MRSA resistant phenotypes across different age groups and genders, and to analyze the antibiotic resistance profiles of MRSA clinical strains.

A retrospective analysis was performed on MRSA clinical strains collected from King Fahad Medical City (KFMC). The study compared demographic characteristics, including gender and age, with the prevalence of MRSA resistant phenotypes, specifically multidrug resistant (MDR) and resistant (R) strains. Additionally, antibiotic sensitivity and resistance profiles were examined for various antibiotics.

A total of 361 clinical strains were isolated from different clinical sites, including sputum, wounds, throat, and miscellaneous sites. The findings revealed a predominance of MRSA resistant phenotypes among males, constituting 55.91% of MDR cases and 55.22% of all resistant strains. Regarding swab site distribution, 46.23% of MDR strains were isolated from sputum, 30.10% from miscellaneous sites (peripheral lines, abdominal wall, body fluid, tissue, etc.), and the least from throat swabs. MDR strains were most prevalent in the age groups 40-49 (21.15%), 50-59 (13.46%), and 80-89 (13.46%), with a significant difference observed in the 40-49 age group (p-value 0.0064).

MRSA strains showed high susceptibility to Vancomycin, Linezolid, Rifampicin, and Teicoplanin (100%), moderate sensitivity to Erythromycin (64.81%), and inherent resistance to Oxacillin (100%). Nitrofurantoin exhibited very low sensitivity (2.77%), indicating poor efficacy against MRSA.

In conclusion, the present findings highlight the need for targeted control measures against MRSA infection resistance and the implementation of antibiotic stewardship programs to preserve the efficacy of vital antibiotics and curb the spread of MRSA resistance. These insights support the development of effective strategies to combat antibiotic-resistant MRSA infections.

Keywords: MRSA; Antibiotic Susceptibility; MDR; Gender; Site of Sample

Introduction

Methicillin-resistant Staphylococcus aureus (MRSA) is a major public health concern due to its resistance to multiple antibiotics, complicating treatment options and leading to increased morbidity and mortality [1,2]. Understanding the distribution of MRSA resistant phenotypes among different demographics is crucial for developing effective control and treatment strategies [3,4]. Antimicrobial stewardship program mainly focused on the appropriate use of antimicrobials, such as antibiotics. Its goals are to improve patient health, reduce microbial resistance, and prevent the spread of infections caused by multidrug-resistant organisms [5].

Previous research has indicated variations in MRSA resistance based on demographic factors such as age and gender [6,7]. Factors contributing to these variations may include differences in healthcare exposure, antibiotic usage patterns, and underlying health conditions [8]. The present stuy builds on existing literature by providing a detailed comparison of MRSA resistant phenotypes, specifically multi-drug resistant (MDR) and resistant (R) strains, across diverse patient groups [2,9].

Moreover, the site of infection significantly influences the distribution of MRSA strains. For instance, sputum samples often show higher resistance rates due to the respiratory tract's frequent exposure to antibiotics and pathogens. Recognizing these site-specific variations is crucial for implementing targeted infection control measures [10].

The effectiveness of different antibiotics against MRSA is another key area of investigation. While antibiotics such as vancomycin (VAN), linezolid (LZD), rifampicin (RIF), and teicoplanin (TEC) have shown high sensitivity, others like erythromycin (ERY), oxacillin (OX), and nitrofurantoin (NF) demonstrate varying levels of resistance [11].

The present study provides a comprehensive analysis of these resistance patterns to guide accurate susceptibility testing and antibiotic selection.

The present study aims to analyze the demographic characteristics of patients with MRSA clinical strains, focusing on the distribution of resistant phenotypes across different age groups and genders. Additionally, it evaluates the antibiotic resistance profiles of these MRSA strains to contribute valuable insights into the epidemiology of MRSA, inform clinical practices, and underscore the importance of antibiotic stewardship programs in preserving the efficacy of essential antibiotics and preventing the spread of resistant strains.

Materials and Methods

Study design and data collection

A retrospective analysis was conducted at King Fahad Medical City (KFMC), Riyadh, Saudi Arabia, from January 2022 to December 2022. In total, 361 MRSA isolates from various clinical samples were isolated. Samples were collected from various sites, including sputum (MDR n = 43;R n = 89), wound (MDR n = 12; R n = 53), throat (MDR n = 10; R n = 20), and miscellaneous (peripheral lines, abdominal wall, body fluid, tissue, and swab etc) (MDR n = 28; R n = 106). The data collection criteria are divided into pediatric and adult age categories according to male and female gender. The gender were categorized into male (MDR n = 52; R n = 148), and female (MDR n = 41; R n = 120), The age groups were divided into different categories: pediatrics (0-1yrs (MDR n = 5; R n = 20); 2-5 yrs (MDR n = 6; R n = 17); 6-9 yrs (MDR n = 9; R n = 18); 10-19 yrs (MDR n = 5 ;R n = 26)), young adults (20-29 yrs (MDR n = 6; R n = 22); 30-39 yrs (MDR n = 13; R n = 36); 40-49yrs (MDR n = 12; R n = 23)), adults (50-59 yrs (MDR n = 11; R n = 29); 60-69 yrs (MDR n = 9; R n = 33)), and geriatrics (70-79 yrs (MDR n = 5; R n = 29); 80-89 yrs (MDR n = 9; R n = 13);90-110yrs (MDR n = 2; R n = 2)).

MRSA identification and antimicrobial susceptibility testing

The total of 361 MRSA strains isolated from various clinical samples were identified and antimicrobial sensitivity (AST) were performed using Phoenix BD instrument (Becton Dickinson Diagnostic Systems, Sparks, MD, USA). The following antibiotics were tested for antimicrobial sensitivity (AST): Erythromycin (ERY), Clindamycin (DA), Trimethoprim-Sulfamethoxazole (STX), Vancomycin (VAN), Oxacillin (OX), Linezolid (LZD), Nitrofurantoin (NF), Rifampicin (RIF), Teicoplanin (TEC). The results were interpreted and reported according to the 32nd Edition of the CLSI-M100 document and classified as susceptible and resistant [12]. The AST results were classified into two categories: resistant (R) and multidrug-resistant (MDR). MDR isolates were the bacterial strains which were resistant to one or more antibiotics from three or more antibiotic classes and R isolates are the bacterial strains which are resistant to one or more antibiotics from any one antibiotic classes [13].

Statistical analysis

Descriptive and inferential statistical methods were performed using the GraphPad Prism software version 1.2.3. Regarding the inferential statistics, the demographic and resistant phenotypes were analyzed by gender using 2×2 contingency table analyses and Fisher's exact test to compare MDR and R resistant phenotypes with gender. The results were considered significant if the *P*-value was ≤0.05. Simple frequencies (n) and percentages (%) were calculated for each variable.

Results

A total of 361 clinical strains were isolated from various clinical samples including sputum, wound, throat and miscellaneous sites during the year January 2022 to December 2022.

Gender distribution and resistant phenotypes of MRSA clinical strains

The comparison of demographic characteristics of patients with resistant phenotypes of MRSA clinical strains based on gender are as follows, multi-drug resistant (MDR) strains were found to be 93 out of which males were 55.91% and females were 44.08% and a total of 268 strains were identified as resistant strains, more resistant strains were identified in male 55.22% in comparison with female gender.

Site of swab and resistant phenotypes of MRSA clinical strains comparison showed the following distribution a total of 93 MDR stains were isolated, among all the sites from sputum 46.23% MDR strains were obtained followed by miscellaneous 30.10% and least MDR strains were obtained from throat. Whereas, miscellaneous sites 39.55%and sputum 33.20% have a higher proportion of resistant MRSA clinical strains compared to wound 19.77% and throat 7.46% swabs (Table 1).

Age distribution and resistant phenotypes of MRSA clinical strains

The comparison of age distribution and resistant phenotypes of MRSA clinical strains are as follows, the highest proportions of MDR phenotypes were found in the age groups 40-49 (21.15%), 50-59 (13.46%), and 80-89 (13.46%). This indicates a higher prevalence of MDR MRSA strains among middle-aged and older adults. No MDR phenotypes were observed in the 10-19 and 90-95 age groups.

The highest proportions of resistant phenotypes were observed in the age groups 30-39 (13.69%), 60-69 (13.69%), and 70-79 (11.64%). This suggests a significant presence of resistant MRSA strains across a wide range of adult age groups. The age groups 0-1 and 10-19 also showed notable proportions of resistant phenotypes (8.90% each) (Table 2).

The p-value analysis indicates that the only age group with a statistically significant difference in the distribution of resistant phenotypes is the 40-49 age group, with a p-value 0.0064, indicating a higher prevalence of resistant phenotypes (Table 2). The other age groups do not show statistically significant differences, as their p-values are above the threshold for significance (0.05).

Antibiotic susceptibility of MRSA clinical strains

Antimicrobial susceptibility profiles were obtained for 361 MRSA clinical isolates (Figure 1). The susceptibility was highest for Vancomycin (VAN), Linezolid (LZD), Rifampicin (RIF), and Teicoplanin (TEC) show 100% sensitivity, indicating they are highly effective against MRSA strains. Trimethoprim/Sulfamethoxazole (STX) and Clindamycin (DA) also exhibit high sensitivity rates (78.11% and 75.34%, respectively), Erythromycin (ERY) demonstrates moderate sensitivity (64.81%) and (35.18%) showed resistant MRSA strains. Oxacillin (OX) shows 100% resistance, confirming that MRSA strains are inherently resistant to this antibiotic. Nitrofurantoin (NF) shows very low sensitivity (2.77%), indicating it is not effective against MRSA.

Discussion

The present findings represented several important aspects of the distribution of MRSA resistant phenotypes among different age groups and comparison of demographic characteristics of patients with resistant phenotypes of MRSA clinical strains based on gender. The data also revealed critical insights into the antibiotic resistance profiles of MRSA clinical strains.

In our study, gender distribution analysis revealed predominance of MRSA resistant phenotypes among males compared to females, it was found to be consistent across both MDR and R resistant phenotypes. In contrast to the other studies, gender attributed to various factors, including gender-specific behaviors, exposure to healthcare environments, and possible biological differences that could influence susceptibility to antibiotic resistance [14-16].

Gender/Site of swab	Resistant Phenotypes	
	MDR	R
(Gender)	n = 93	n = 268
Male	52 (55.91%)	148 (55.22%)
Female	41 (44.08%)	120 (44.77%)
(Site of swab)	n = 93	n = 268
Sputum	43 (46.23%)	89 (33.20%)
Wound	12 (12.90%)	53 (19.77%)
Throat	10 (10.75%)	20 (7.46%)
Miscellaneous	28 (30.10%)	106 (39.55%)

Table 1: Comparison of demographic characteristics of patients with resistant phenotypes of MRSA clinical strains.

(MDR- multidrug resistant; R- Resistant).

The site of swab analysis demonstrates significant variation in the distribution of resistant MRSA clinical strains. From the Sputum samples highest MDR strains were obtained followed by miscellaneous sites. The resistant strains in sputum samples could be due to the respiratory tract frequent exposure to antibiotics and pathogens, which leads to prevalence of MDR strains in sputum sample as reported in the later study [17].

In our present study we found higher prevalence of MRSA-MDR phenotypes among middle-aged (40-49 yrs) and older adults (50-59, 80-89) which may be attributed to factors such as increased healthcare exposure, underlying health conditions, and higher antibiotic as compared with previous study reports, MRSA-MDR strains was found to be 77.78% [18,19]. In contrast lower prevalence of MRSA-MDR phenotypes were obtained in younger age groups (10-19 yrs), which might reflect lower healthcare exposure and antibiotic use in these populations as reported in previous reports [8,20].

Age group (Years)	Male		Female		
	MDR (n = 52)	R (n = 146)	MDR (n = 40)	R (n = 123)	P value
0-1	2 (3.84%)	13 (8.90%)	3 (7.5%)	7 (5.69%)	0.357
2-5	2 (3.84%)	10 (6.847%)	4 (10%)	7 (5.69%)	0.370
6-9	5 (9.61%)	11 (7.53%)	4 (10%)	8 (6.50%)	>0.9999
10-19	0 (0%)	13 (8.90%)	5 (12.5%)	13 (10.56%)	0.0580
20-29	2 (3.84%)	12 (8.21%)	4 (10%)	10 (8.13%)	0.6483
30-39	7 (13.46%)	20 (13.69%)	6 (15%)	16 (13.00%)	>0.9999
40-49	11(21.15%)	13 (8.90%)	1 (2.5%)	10 (8.13%)	**0.0064
50-59	7 (13.46%)	10 (6.84%)	4 (10%)	19 (15.44%)	0.1530
60-69	4 (7.69%)	20 (13.69%)	5 (12.5%)	13 (10.56%)	0.4620
70-79	5 (9.61%)	17 (11.64%)	0 (0%)	12 (9.75%)	0.1366
80-89	7 (13.46%)	6 (4.10%)	2 (5%)	7 (5.69%)	0.2031
90-110	0 (0%)	1 (0.68%)	2 (5%)	1 (0.81%)	>0.9999

Table 2: Comparison of resistant phenotypes of MRSA clinical strains with gender and age groups.

(MDR- multidrug resistant; R- Resistant).

We observed the high sensitivity with VAN, LZD, RIF, and TEC antibiotics, which suggests their importance as first-line treatments for MRSA infections. However, the moderate resistance observed in ERY and the high resistance in OX and NF might underscore the necessity for accurate susceptibility testing and the careful selection of antibiotics [21,22]. Our data also emphasizes the ongoing need for antibiotic stewardship programs to preserve the efficacy of these critical drugs and to prevent the further spread of resistance.

Conclusion

This study reveals significant differences in the distribution of MRSA resistant phenotypes (MDR and R) across various age groups and genders. Males demonstrated higher resistance rates, likely due to specific behaviors and increased healthcare exposure. Sputum samples exhibited the highest rates of MRSA-MDR strains, highlighting the need for targeted respiratory infection control measures. Middle-aged and older adults showed a higher prevalence of MRSA-MDR strains, while younger individuals had a lower prevalence of MRSA infections.

The high sensitivity to Vancomycin (VAN), Linezolid (LZD), Rifampicin (RIF), and Teicoplanin (TEC) confirms their effectiveness as first-line treatments for MRSA infections. Conversely, the moderate resistance to Erythromycin (ERY) and high resistance to Oxacillin (OX) and Nitrofurantoin (NF) emphasize the need for precise susceptibility testing and careful antibiotic selection. These findings underscore the critical importance of antibiotic stewardship programs to preserve antibiotic effectiveness and combat resistance.

Limitations and Future Directions

Our study has limitations that may restrict the generalizability of the findings. Specifically, it was conducted solely at KFMC hospital. To obtain a more comprehensive understanding, data should be collected from other hospitals and regions across Saudi Arabia, encompassing a larger and more diverse population.

Future efforts should focus on strengthening antibiotic stewardship programs to mitigate the development of antibiotic resistance. This includes continuous monitoring of MRSA resistance patterns, personalized treatment plans based on specific resistance profiles, and public education on the judicious use of antibiotics. By addressing these areas, we can enhance our ability to manage and treat MRSA infections effectively, ultimately improving patient outcomes and preserving antibiotic efficacy.

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Conflict of Interest

The authors have no conflict of interest.

Authors Contribution

Conception and design of the study was carried out by Reem Hamoud Alrashoud, acquisition of data, analyses, and interpretation was Ayesha Mateen and Rugiah Alsghair critical revision of the manuscript was done by Ahmad S. AlYami and Seham Mohamed Hassan Elbih.

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