PREVALENCE AND ANTIBIOTIC SUSCEPTIBILITY PATTERN OF MRSA AMONG PEDIATRICS AND YOUNG ADULT PATIENTS

Alina Syed[1], Alishba Ikhlaq[2], Maryam Salman[3], Zahra Batool[4], Haleema Sadia[5], Dr Areeba Ikhlaq[6]

1Faculty of Rehabilitation and Allied Health Sciences, Riphah International University Gulberg Green Campus, Rawalpindi
2,3,4,5Riphah International University Gulberg Green Campus, Rawalpindi
6Foundation University Islamabad

ABSTRACT

Introduction: *Staphylococcus aureus* is a grampositive bacteria which causes various infections both in children and adults. Methicillin-resistant strains (MRSA) are a major health risk because they are resistant to antibiotics, mostly because of changes in β-lactamase enzymes and penicillin-binding proteins.

Objective: To determine the prevalence of MRSA infection in Pediatric and young Adult patients and to study the antibiotics susceptibility pattern of MRSA among the isolates from population.

Methodology: A cross-sectional study using convenience sampling was conducted in Rawal General Hospital Rawalpindi. The study size include total 107 participants divided in 2 groups children (0-12 years) and young adults (12-30 years), Samples were examined using microbiological techniques, including bacterial culture, Gram staining, and biochemical tests. Antibiotic susceptibility testing was carried out using the Kirby-Bauer method. Data analysis was done through SPSS software version 25.

Result: Our study showed high MRSA prevalence in children with higher rates in females. MRSA was common in blood specimens of children and pus specimens of adults. Staphylococcus aureus in adults and paeds showed highest sensitivity to cefoxitin (100%) tigecycline, chloramphenicol, and linezolid. High resistance was observed to penicillin and erythromycin in both groups. MRSA isolates in adults and pediatric patients showed 100% resistance to cefoxitin, confirming methicillin resistance. High resistance was observed to penicillin, ciprofloxacin, and erythromycin, while linezolid, chloramphenicol, and doxycycline showed notable sensitivity. These

findings highlight limited antibiotic options, with linezolid and chloramphenicol emerging as the most effective treatments.

Conclusion: Our study shows a higher prevalence of MRSA in children, especially around 1 month of age, and more in females. In adults, pus was the main source, while in children it was blood. Doxycycline was more effective in adults. Linezolid and chloramphenicol were effective in both groups.

1. INTRODUCTION:

A gram-positive commensal bacterium called *Staphylococcus aureus* (*S. aureus*) colonizes different areas of the body in 30% of healthy individuals (1). It is a naturally occurring flora that is regularly carried and has no harmful effects on the skin (2). It was first identified in 1880 by Scottish surgeon Sir Alexander Ogston, who isolated them from surgical abscess fluid. (1).A facultative anaerobe, *Staphylococcus aureus* is neither motile nor spore-forming. It usually appears as an irregular cluster that looks like grapes on blood agar that contains 5% sheep or horse blood, either singly or in pairs. The smooth, elevated colonies are hemolytic and range in color from yellow to golden (3).Transmission happens following contact with an infected person or subject, and sometimes after consuming contaminated food. Open wounds on the skin, common diseases, implanted devices, and prolonged hospitalization are the main risk factors (5). The presence of many virulence factors, including as surface proteins, biofilms, exoenzymes, exotoxins, and exfoliative toxins, is linked to *S. aureus* ability to cause a variety of illnesses (6). *S. aureus* infections can range in severity from mild skin infections to serious necrotizing pneumonia. It can lead to infections related to devices, osteoarticular, skin and soft tissue, and pleuropulmonary (7). Infections of Soft Tissue and Skin Numerous infections of the skin and soft tissues are associated with *S. aureus*, including folliculitis, cellulitis, carbuncles, furuncles, hidradenitis suppurativa, and impetigo. The consequences of *S. aureus* bacteremia can include sepsis, infective endocarditis, and metastatic foci of infection. One of the most important phenotypic traits used to classify staphylococci is their capacity to manufacture coagulase. Since *Staphylococcus aureus* is catalase-positive, the catalase test can be used to distinguish staphylococci from enterococci and streptococci (1).Additionally, the DNase test can be used to differentiate *S. aureus* from other staphylococci species. Cell division appears as bluish grape-like colonies on gram staining because it occurs at different planes (6). *S. aureus* are best treated with a semi-synthetic penicillin (e.g., intravenous nafcillin, oxacillin [Bactocill], or oral dicloxacillin [Dynapen]). The most effective medicines for severe MSSA infections like endocarditis or infections of the bones and joints are still penicillinaseresistant penicillins (dicloxacillin and flucloxacillin). For less severe MSSA infections, like skin and soft tissue infections, or in patients with penicillin hypersensitivity, first-generation cephalosporin's (cefazolin, cephalothin, and cephalexin), clindamycin, lincomycin, and erythromycin play crucial therapeutic roles(4). With bacteriostatic action against *S. aureus*, linezolid is authorized to treat pneumonia in children and adults as well as complex skin and soft tissue infections. *S. aureus* possesses the remarkable ability to rapidly evolve resistance. DNA damage, cell membrane rupture, and environmental factors can all hasten the development of antibiotic resistance (8). One of the most important clinical aspects is its resistance to β-lactam antibiotics, the drug of choice for treating staphylococcal infections (9). One particular strain of *S. aureus*, known as MRSA, is resistant to methicillin and all βlactam antibiotics (10). The term MRSA has endured

and can be considered to refer to resistance to almost all β-lactam antibiotics, even if methicillin is no longer manufactured. Nowadays, cefoxitin and/or oxacillin are commonly used in susceptibility testing. Bacterial cell lysis results from B-lactams' inhibition of peptidoglycan crosslink production and binding to the penicillin-binding proteins (PBP), which are necessary for cell wall building. The staphylococcal cassette chromosome (SCCmec), a mobile genetic element that carries the mecA gene, which encodes an altered PBP called PBP2a/PBP2′ that has a lower affinity for β-lactam antibiotics, is what gives MRSA its resistance to β-lactams (11).The acquisition of the mecA gene, which is found in the mobile element known as the staphylococcal cassette chromosome mec (SCCmec), causes methicillin resistance in *S. aureus* (12*).*Therefore, even when β-lactam antibiotics are present at otherwise inhibitory levels, MRSA strains continue to produce cell walls (11). Community-acquired methicillin-resistant *Staphylococcus aureus* (CA-MRSA) in adults increases the risk of bacteremia, necrotizing pneumonia, and increased mortality. Adults seem to be more susceptible to urinary tract infections, pneumonia, skin and soft tissue infections, intra-abdominal infections, infective endocarditis, bacterial meningitis, TB, and herpes zoster (13). Infected wound, abscess, cellulitis are major causes of MRSA n children (14). MRSA's multidrug resistance (MDR) poses a severe risk that renders efforts at control and treatment futile. MRSA is considered a potentially lethal bacteria for humans and animals since it developed new, effective defenses against modern antibics. Both the frequent and negligent use of antibiotics and the encoding of specific antibiotic resistance genes are commonly blamed for the MDR phenomenon. Penicillin, methicillin, oxacillin, cefoxitin, amoxicillin-clavulanicacid, amoxicillin-sulbactam, quinolones, macrolides, cephalosporin's, tetracycline, and chloramphenicol are among the antimicrobial medications that are consistently resistant to MRSA. The first line of antibiotic treatment usually has no effect on MDR-MRSA, according to numerous studies, and MRSA is resistant to new drug generations such as vancomycin, linezolid, and daptomycin (15). Vancomycin is the standard option for the initial treatment of MRSA bacteremia and endocarditis, especially when sepsis is not life-threatening. Vancomycin is the standard option for the initial treatment of MRSA bacteremia and endocarditis. Depending on the local resistance profiles of clinical MRSA isolates, the Infectious Disease Society of America (IDSA) recently released guidelines that recommend vancomycin or daptomycin for bacteremia and endocarditis (along with rifampicin for infections of prosthetic valves) and vancomycin, Linezolid, or clindamycin for HA-MRSA or CAMRSA pneumonia. Vancomycin, linezolid, daptomycin, telavancin (not yet available in Europe), or clindamycin are options for empirical treatment in hospitalized patients (17).In susceptible MRSA infections, clindamycin may be preferred over macrolides due to its potential for improved absorption and decreased resistance; however, we were unable to locate sufficient trials. For mild MRSA infections, oral tetracyclines might be advised (16).

Between January 2015 and December 2020 (6 years), 1,668 *S. aureus* strains were recovered from 1,657 patients with a variety of diseases, 191 (11.5%) of which came from patients with ocular infections. *S. aureus* samples from 176 patients totaled 177 distinct isolates. Among them were 132 (74.6%) MSSA and 45 (25.4%) MRSA. Of them, 75 (42.4%) were female and 102 (57.6%) were male. 48 (27.1%) isolates were acquired from patients aged 1–18 years, and 119 (72.9%) isolates were obtained from individuals younger than 1 year (18). According to estimates, AMR caused 1.27 million fatalities worldwide in 2019, and MRSA was directly responsible for more than 100,000 deaths (19). According to reports, the death rate for MRSA infections was 64% greater than that of antibiotic-susceptible infections. Specifically, those who

contract invasive or bloodstream MRSA infections were more at risk for poor health outcomes and elevated death rates (20).

2. MATERIALS & METHODS

The study design used for this research was cross sectional study. A total 107 participants were included in our study, divided in 2 groups Paeds (0-12 years) and young adults (12-30 years). The study was conducted in Railway General Hospital Rawalpindi and Rawal General Hospital. We included patients of specific age group with known staphylococcus aureus infection and available medical and laboratory data. Patients outside the specified age group, with infection other than *staphylococcus aureus,* and incomplete medical record or laboratory data were excluded. Firstly we isolate bacteria from various sources including nasal swab, pus swab and blood samples then we conducted bacterial culturing on both blood and MacConkey agar. Once the culture were prepared we performed Gram staining to confirm the presence of staphylococcus aureus which appear as gram positive under microscope. For further confirmation we proceed with series of biochemical test that include catalase, coagulase and DNase. Lastly we conducted antibiotic susceptibility testing using disc diffusion method

3. RESULTS

This study has been conducted to determine the prevalence and antibiotic Susceptibility pattern among Paeds and young adult patient in Tertiary Care Hospitals of Rawalpindi and Islamabad. A total of 107 samples have been examined, including children and young adults. In the study group, 55 are children (n=55) and 52 are Adults (n=52). The pie chart illustrates the patient's distribution of the study population indicating the predominance of children patients over young adult's patients.
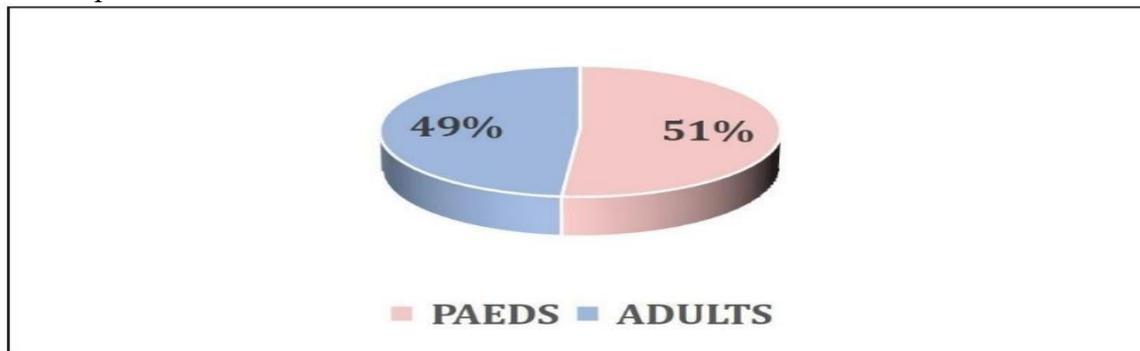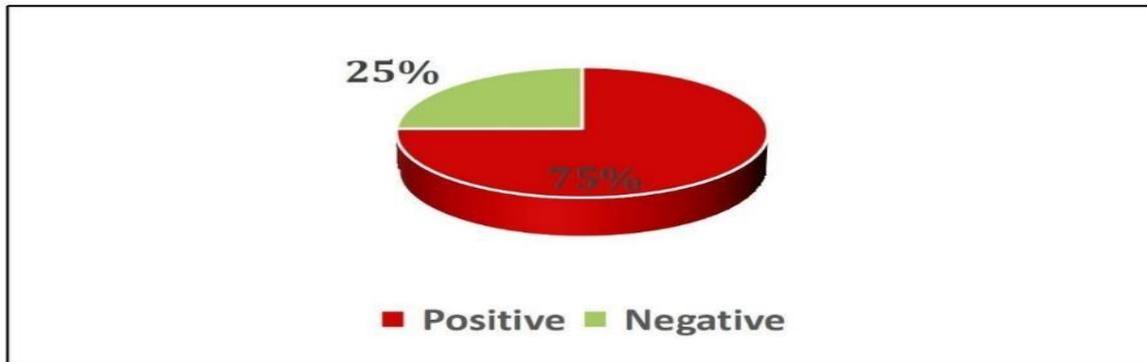

Figure 4.1: Distribution of patients

Table 4.1: Prevalence of MRSA in Adults.

Parameter	Frequency		Percentage	
MRSA in adults				
	Positive	39	Positive	75
	Negative	13	Negative	25

The pie chart indicate that 75% of the adult tested were positive for MRSA while 25% tested negative. The 75% positive rate suggests a high prevalence of MRSA in the study adult population.
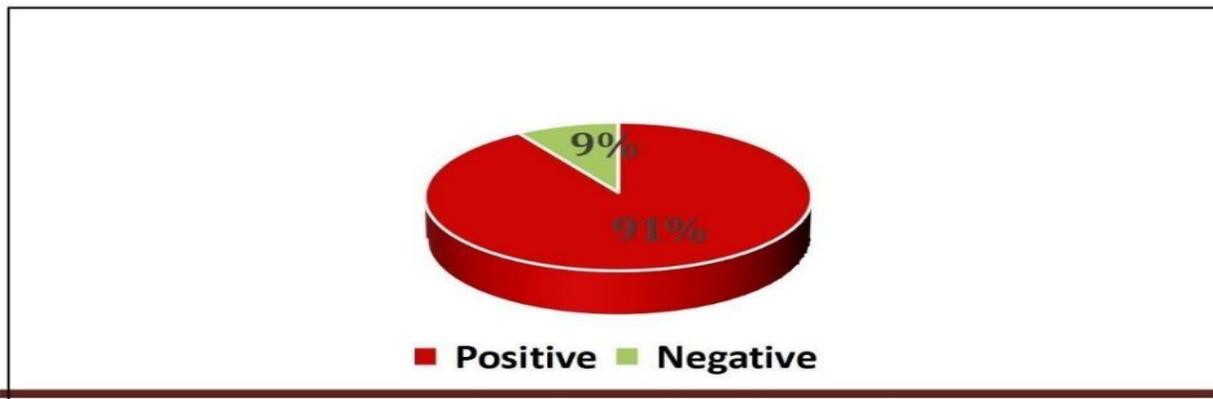
Figure 4.2: Prevalence of MRSA in young Adult patients

**Table 4.1: Prevalence of MRSA in Paediatric patients.**

Parameter	Frequency		Percentage	
MRSA in children	Positive	50	Positive	**91**
	Negative	5	Negative	**9**

The pie chart illustrate the prevalence of Paediatrics patients with 91% testing positive and 9% testing negative. The 91% positive rate indicates a significant burden of MRSA among the children studied. This is notably higher than the global pooled estimated prevalence of 5 % in the Paediatric population.

Figure 4.3: Prevalence of MRSA in Paediatric patients

 Patients of children and young adult age groups are included in the study, approximately 1 day to 30 years. This histogram illustrates that the highest frequency of Individuals is observed in the youngest age group near 1 month. Their appear to be smaller peaks in frequency around the 20-30 year age range, suggesting a secondary concentration of individuals in this age group.
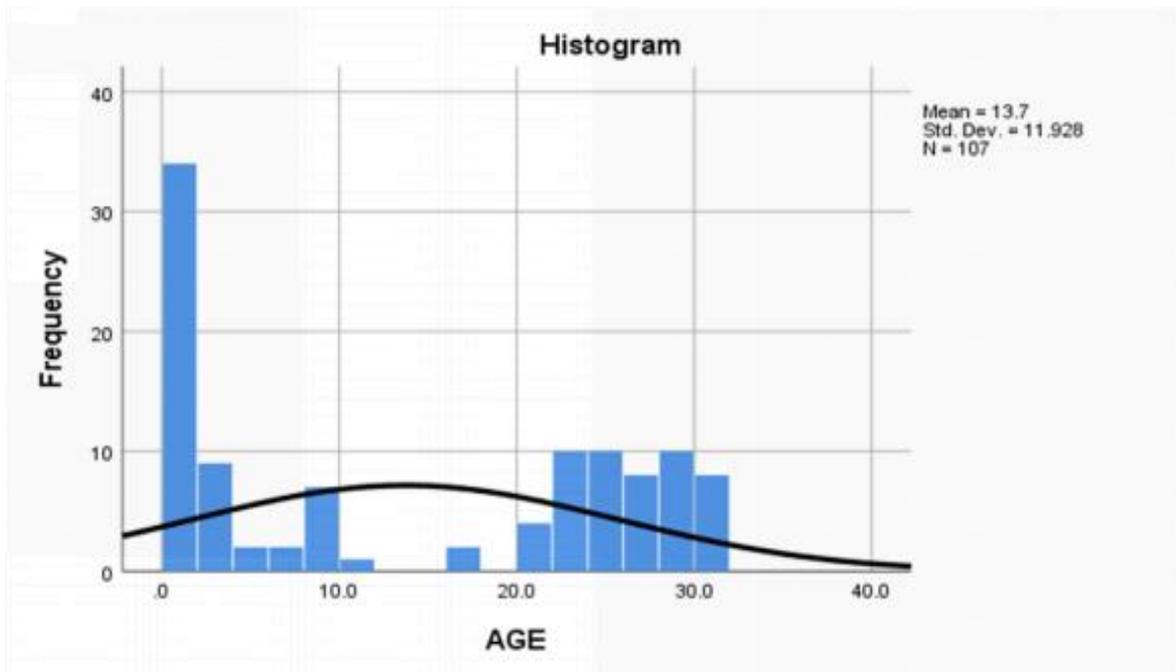
Figure 4.4: Age-wise distribution of MRSA

Table 4.2: Comparison of MRSA among male and female in young adult patient.

Parameter	Frequency		Percentage	
MALE:				
	Positive	11	Positive	64.7
	Negative	6	Negative	35.3
FEMALE:				
	Positive	28	Positive	80
	Negative	7	Negative	20

The graph present data on the number of positive and negative MRSA cases among adult males and females. This indicates that total of 52 cases 17 are males and 35 are female from which 35.3% males and 20% female are negative and 64.7% males and 80% females are positive. This indicates that the number of positive MRSA cases in females are higher than the males in our studied young adult patients.
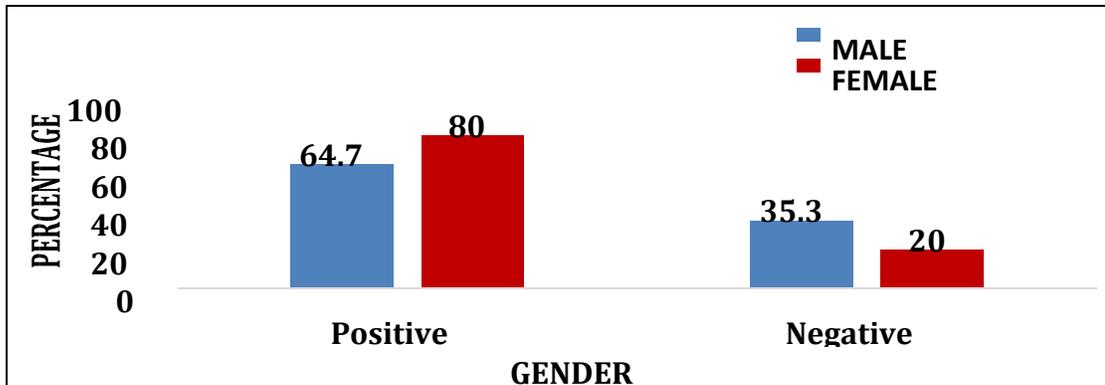
Figure 4.5: Gender distribution in young Adult patients
Table 4.3: Comparison of MRSA among male and female in Paediatric patients.

Parameter	Frequency		Percentage	
MALE:				
	Positive	23	Positive	85.2
	Negative	4	Negative	14.8
FEMALE:				
	Positive	27	Positive	96.4
	Negative	1	Negative	3.6

The graph present data on the number of positive and negative MRSA cases among children males and females. This indicates that total of 55 cases 27 are males and 28 are female from which 14.8% males and 3.6% females are negative and 85.2% males and 96.4% females are positive. This indicates that the number of positive MRSA cases in females are higher than the males in our studied children patients.

Figure 4.6: Gender distribution in Paediatric patients
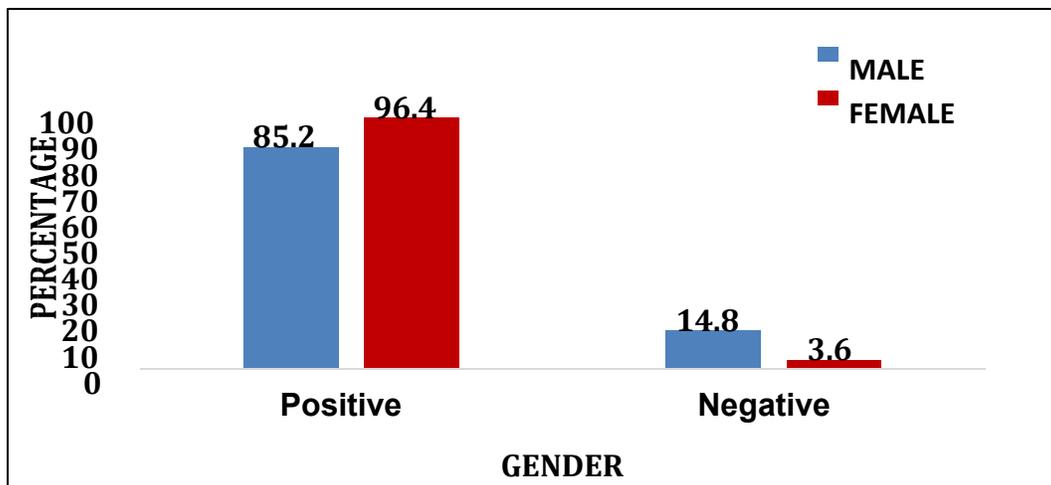
Table 4.4: Specimen isolated from adult patients.

Parameter	Frequency		Percentage	
Blood				
	Positive	11	Positive	21.2
	Negative	5	Negative	9.6
Urine				
	Positive	6	Positive	11.5
	Negative	1	Negative	1.92
Pus				
	Positive	14	Positive	26.9
	Negative	3	Negative	5.8
Fluid	Positive	1	Positive	1.92
	Negative	1	Negative	1.92
HVS	Positive	7	Positive	13.4
	Negative	2	Negative	3.8
Sputum	Positive	0	Positive	0
	Negative	1	Negative	1.9

The graph shows the percentage of MRSA isolated from various specimens. The highest percentage of MRSA was found in pus 26.9%, followed by blood 21.2% and HSV 13.4%. Urine showed 11.5%, while fluid and sputum had the lowest percentages 1.92% each. The high prevalence of MRSA in pus and blood suggests that these are significant sites of infection in young adults.
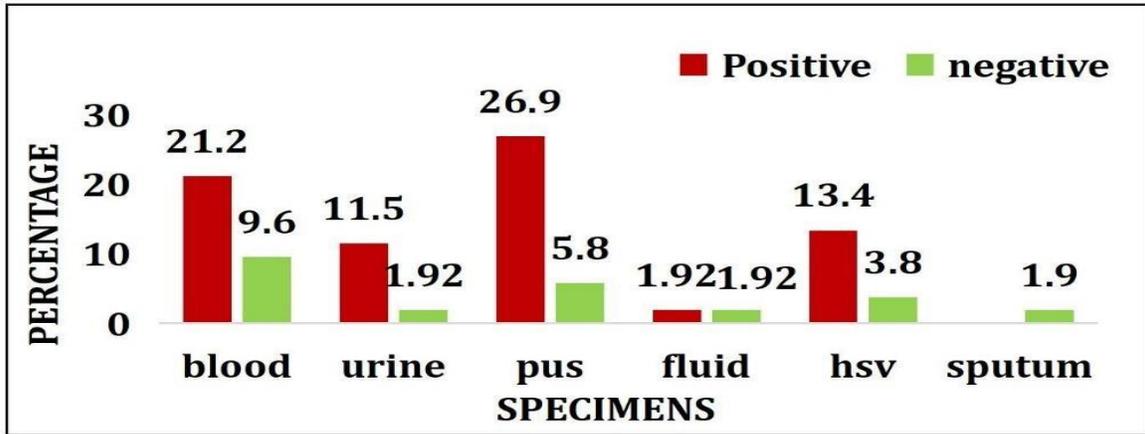
Figure 4.7: Specimen of MRSA isolated from young adult patients

Table 4.5: Specimen isolated from Paediatric patients.

Parameter	Frequency		Percentage	
Blood				
	Positive	45	Positive	81.8
	Negative	5	Negative	9.09
Urine				
	Positive	2	Positive	3.64
	Negative	0	Negative	0
Pus				
	Positive	1	Positive	1.82
	Negative	0	Negative	0
Fluid	Positive	2	Positive	3.64
	Negative	0	Negative	0
HVS				
	Positive	0	Positive	0
	Negative	0	Negative	0
Sputum				
	Positive	0	Positive	0
	Negative	0	Negative	0

The graph illustrates the distribution of MRSA in different specimens collected from pediatric patients. A striking observation is the high prevalence of MRSA in blood samples, with 81.8% positive cases, contrasting sharply with only 9.09% negative cases. This indicates a significant presence of MRSA in the bloodstream of the tested pediatric population. In other specimens, the prevalence of MRSA is considerably lower. Urine and fluid samples show a similar distribution, with 3.64% positive and negative results, respectively. Pus samples have a marginal presence of MRSA, with 1.82% positive cases. Notably, HVS and sputum samples show no presence of MRSA.
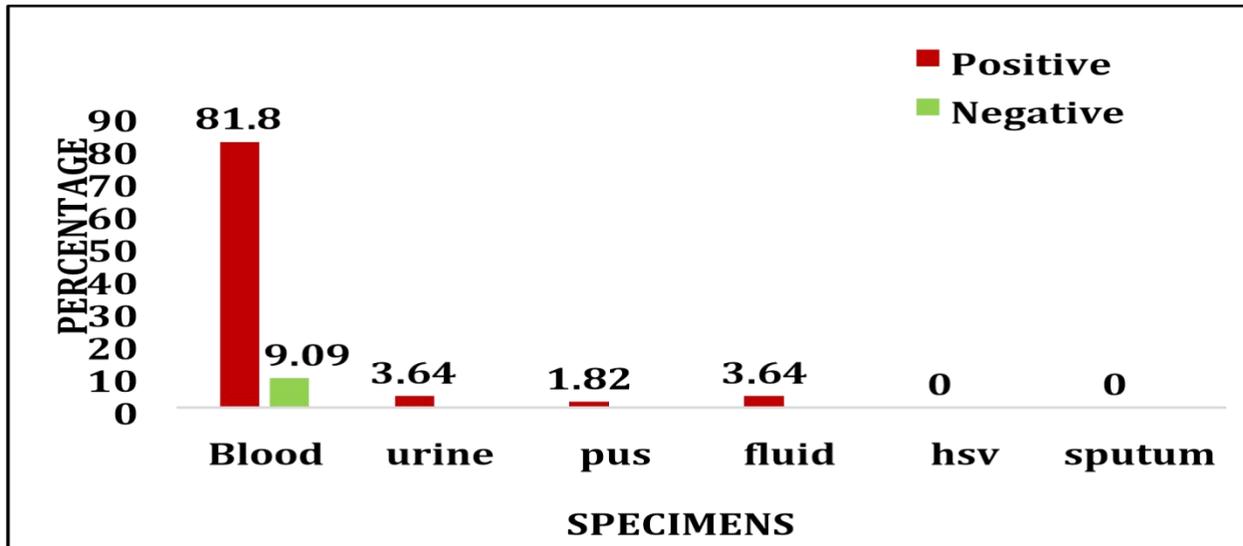

Figure 4.8: Specimen of MRSA isolated from Paediatric patients
Table 4.6: Comparison of Antimicrobial susceptibility pattern of *S. aureus* in adults and Paeds.

Antibiotic	Adult Resistant %	Adult Sensitive %	Children Resistance %	Children Sensitive %
Cefoxitin	0	100	0	100
Clindamycin	30.8	23.1	60	40
Gentamycin	23.1	69.2	20	80
Tigecycline	23.1	77	0	100
Erythromycin	84.6	7.7	60	40
Chloramphenicol	15.4	84.6	0	100
Linezolid	15.4	84.6	0	100

Co-trimoxazole	61.5	38.5	20	80
Ciprofloxacin	92.3	7.7	40	60
Doxycycline	30.8	69.2	20	80
Penicillin	7.7	92.3	40	60

The antimicrobial susceptibility patterns of *Staphylococcus aureus* isolates differed between adult and children populations. In adults, cefoxitin exhibited 100% sensitivity, followed closely by ciprofloxacin (92.3% each). Among adults, chloramphenicol, linezolid, and penicillin showed particularly high sensitivity. Erythromycin and ciprofloxacin show resistance in adults.

In contrast, children isolates showed 100% sensitivity to cefoxitin, tigecycline, chloramphenicol, and linezolid. Gentamycin, co- trimoxazole and doxycycline also displayed high sensitivity rates (80% each), while penicillin showed moderate sensitivity (60%). On the other hand, resistance was comparatively low in children group. Gentamycin, co-trimoxazole, showed 20% resistance, while penicillin and ciprofloxacin exhibited slightly higher resistance rate of 40%. Erythromycin and clindamycin show higher resistance of (60%) in children. Overall the most antibiotics remain effective against s. aureus in children patients, with minimal resistance observed.
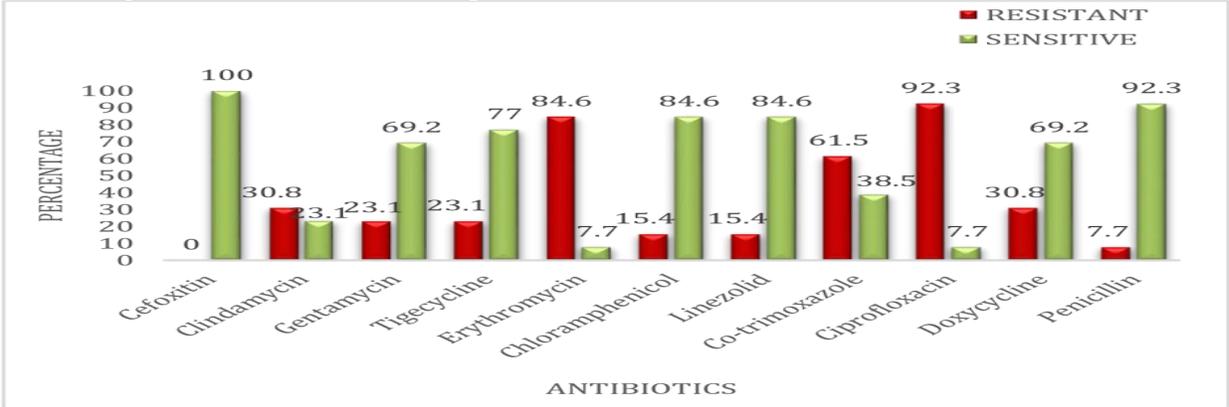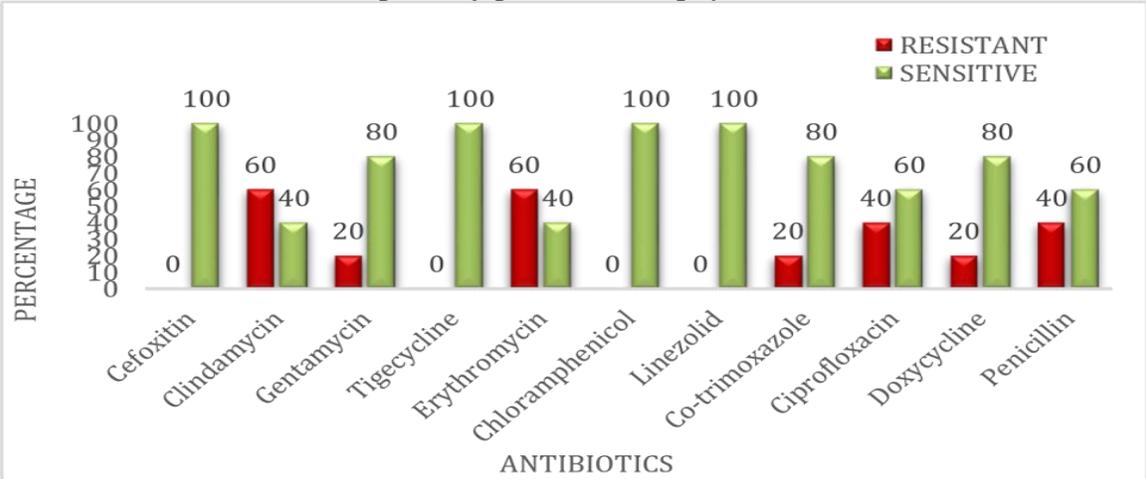

Figure 4.9: Antimicrobial susceptibility pattern of *Staphylococcus aureus* in adults.


151

Figure 4.10: Antimicrobial susceptibility pattern of *Staphylococcus aureus* in Paeds .
Table 4.7: Comparison of Antimicrobial susceptibility pattern of MRSA in adults and Paeds.

Antibiotic	Adult Sensitive %	Adult Resistant %	Children Sensitive %	Children Resistant %
Cefoxitin	0	100	0	100
Clindamycin	22	48	17.9	64.1
Gentamycin	48	46	51	49
Tigecycline	66	28	51	49
Erythromycin	12	80	10.3	79.6
Chloramphenicol	74	22	77	18
Linezolid	76	20	76	24
Co-trimoxazole	40	56	20	80
Ciprofloxacin	38	56	12.8	84.6
Doxycycline	84	14	62	33
penicillin	4	96	2.4	97.6

MRSA isolates in both adults and children patients showed 100% resistance to cefoxitin, confirming methicillin resistance. Penicillin exhibit the highest resistance rates 96%, indicating that these antibiotics are largely ineffective against the tested bacteria. Similarly, Erythromycin shows a high resistance rate of 80%, with only 12% sensitivity. In contrast, antibiotics such as Doxycycline (84%), Linezolid (76%), and Chloramphenicol (74%) show high sensitivity, making them more effective treatment options. Gentamycin displays a nearly balanced profile with 46% resistance and 48% sensitivity. Moderate resistance is seen in Clindamycin (48%), Co-trimoxazole (56%), and Ciprofloxacin (56%), with varying degrees of sensitivity.

In contrast, Aantibiotics with high resistance rates included penicillin (97.6%), ciprofloxacin (84.6%), erythromycin (79.6%), and co-trimoxazole (80%), indicating that these drugs are largely ineffective against MRSA in this population. Moderate resistance was seen with clindamycin (64.1%), gentamycin (49%), tigecycline (49%), and doxycycline (33%). On the other hand, the highest sensitivity was observed with linezolid (76%) and chloramphenicol (77%), suggesting these are among the most effective treatment options. Doxycycline also showed promising results with a sensitivity rate of 62%.
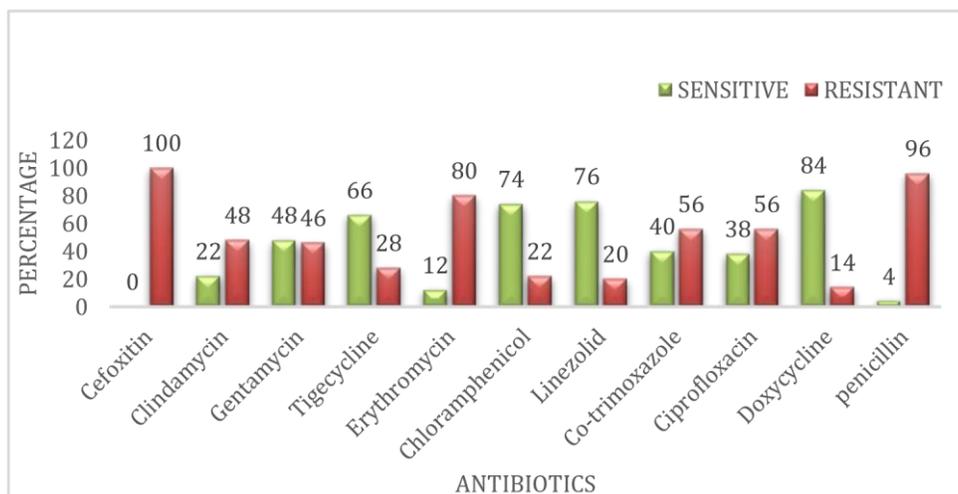
Figure 4.11: Antimicrobial susceptibility pattern of MRSA in adults.
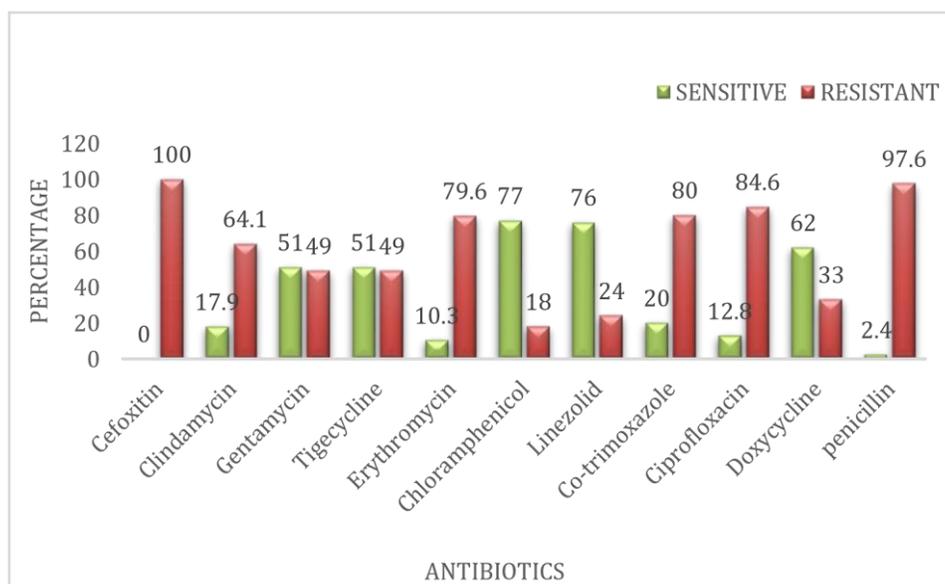
Figure 4.12: Antimicrobial susceptibility pattern of MRSA in Paeds.

4. DISCUSSION

This study targeted to analyze the prevalence and antibiotic susceptibility pattern of MRSA among Paediatrics and young adult patient. In this research, a total of 107 samples with specific age group from 1 month to 30 years were collected and analyzed, in this research there is predominance of children over young adult patients(28)This study supports the findings of Hadiah Almutairi et al. 2024, which show the distribution of MRSA in children by age group. Children under one year old had a higher number of MRSA cases than children older than one year (15). In our study, 25% of people had negative MRSA tests and 75% had positive ones. This study contrasts with one by Jann-Tay Wang et al. 2009, which found that 3.8% of Taiwanese adults had MRSA colonization 119/3,098 (27). There are 91% positive and 9% negative samples in children. Regarding the Antibiotic Susceptibility Pattern of *Staphylococcus Aureus* with reference to MRSA isolates from paeds patients, Raja Ram Gurung et al. 2020 found that the frequency of MRSA was 75% (5).

The demographic characteristics of MRSA cases showed a much greater proportion of MRSA cases in females than in males, which is consistent with Hadiah Almutairi et al., 2024 (15).

Our study reported the higher isolation of *S.aureus* from blood 81.8% in children. These study align with the Daniel B Gregson et.al 2011 which represent *Staphylococcus aureus* is the most commonly isolated blood culture organism in the Paeds (21). Also in our study, in adults the highest percentage is isolated from pus 26.9.These study align with a Pandey et al., 2006, which reported the higher isolation of *S. aureus* from pus and wound (22). In our study, the antimicrobial susceptibility pattern of *Staphylococcus aureus* isolated from adults reveals high sensitivity to penicillin 92.3%, chloramphenicol and linezolid both 84.6%, gentamycin 69.2% and clindamycin 23.1%.Similarly to the study of Nauman Khalid et al. 2023 *Staphylococcus aureus* showed a highly sensitivity to penicillin 100%, linezolid 98% and chloramphenicol 89.5%.While high levels of resistance to ciprofloxacin 92.3%, erythromycin 84.6%,co-trimoxazole 61.5% and chloramphenicol 15.4% (23).These findings differ from study EA Tobin et al. 2021 which showed high resistant rate to co-trimoxazole 93.1%,erythromycin 68.1% and chloramphenicol 30.8% (24). In the present study, *Staphylococcus aureus* isolates from paeds patients demonstrated high sensitivity to cefoxitin, tigecycline, linezolid, and chloramphenicol, each showing 100% sensitivity. Conversely, the highest resistance was observed against penicillin and erythromycin 60%, followed by clindamycin and gentamycin 40%. These findings are in line with multiple international studies. For instance, a study conducted in Tehran, Iran, by Jomehzadeh et al. 2019 revealed that children MRSA isolates exhibited high resistance to erythromycin 62% and clindamycin 71%, with all isolates remaining susceptible to vancomycin (25). A comparison between our study of MRSA in adult and a study A.A. Shah et al. 2020 reveals both alignment and contrast in antibiotic sensitivity and resistance patterns. For Chloramphenicol, there is strong alignment, with our study showing 74% sensitivity and 22% resistance, closely matching the comparable study's findings of 73.33% sensitivity and 26.67% resistance. Similarly, Erythromycin demonstrates consistency, with both studies reporting 80% resistance. However, a significant contrast is observed in Doxycycline. Our study reports a much higher sensitivity rate of 84% compared to only 57.78% in the comparable study. Ciprofloxacin also shows a notable gap, our study shows 38% sensitivity, while the comparable study reports only 17.78%. In the case of Gentamicin, our study reports nearly equal sensitivity and resistance (48% and 46%, respectively), whereas the comparable study suggests higher resistance at 62.22% and lower sensitivity at 37.78%. For Co-trimoxazole, the contrast is minor; our study shows 40% sensitivity and 56% resistance, which is comparable to the comparable study's 45.56% sensitivity and 54.44% resistance (26). When it comes to drugs like erythromycin and clindamycin, the study of X Wu, C. Wang, et al. 2023 agrees regarding the antibiotic susceptibility pattern of MRSA in children. According to the study, erythromycin resistance can range from 62% to 92.7%; our results, which demonstrate 79.6% resistance, are in good agreement. Comparably, the study's clindamycin resistance ranged from 50% to 60%, whereas ours is 64.1%, indicating strong alignment. In both investigations, ciprofloxacin 84.6 likewise exhibits high resistance (29). There are some distinctions, though. For gentamicin, the study shows only 24% resistance, but our study shows 49%, which is much higher. For TMP-SMX (co-trimoxazole), the study reports resistance between 3% and 24%, but out study shows a high 80% resistance, which is a big contrast. The largest mismatch is with linezolid the study says 0% resistance 100% sensitive, but our study shows 24% resistance (5).

5. CONCLUSION

This study aimed to analyze the prevalence and antibiotic resistance pattern of MRSA among Paeds and young adult patients. Our findings indicate that, MRSA is more common in children near 1month than adults. In both children and adults, females are more affected with MRSA than males. In children the highest percentage of MRSA is found in blood as compared to adults, the highest percentage of MRSA is found in pus specimen. There is a clear difference in the antibiotic susceptibility pattern of MRSA between adult and paediatric patients, as shown in the graphs. Doxycycline demonstrates higher sensitivity in adults 84% compared to children 62%, indicating better effectiveness in adults. Ciprofloxacin and Co-trimoxazole is significantly more resistant in pediatric patients 80% compared to adults 56%. Chloramphenicol and Linezolid have relatively similar effectiveness in both groups, with slight variations. Erythromycin and Penicillin show high resistance in both populations, making them largely ineffective.

6. RECOMMENDATION:

In order to control and monitor the usage of antibiotics and make sure they are not marketed without a legitimate prescription, strict regulations must be put in place. It is crucial to regularly monitor MRSA strains, resistance profiles, and genetic testing in children settings. The data acquired in this study is limited to a specific area. For better results, future studies should concentrate on a wider geographic area. Steer clear of overusing broad range antibiotics to stop the emergence of resistance. In a hospital setting, strictly enforce hygiene, contact restrictions, and decolonization procedures.

ETHICAL APPROVAL:

Conflict of interest: There are no conflict of interest.

Data availability statement: Data will be available upon request.

Funding: The current study didn't received any funding.

REFERENCES

1. Rasheed NA, Hussein NRJEJoM, Medicine C. Staphylococcus aureus: an overview of discovery, characteristics, epidemiology, virulence factors and antimicrobial sensitivity. 2021; 8 (3):1160-83.

2. Cheung GY, Bae JS, Otto MJV. Pathogenicity and virulence of Staphylococcus aureus. 2021; 12 (1):547-69.

3. Bitrus A, Peter O, Abbas M, Goni MDJVSR, Reviews. Staphylococcus aureus: A review of antimicrobial resistance mechanisms. 2018; 4 (2):43-54. Rayner C, Munckhof WJImj. Antibiotics currently used in the treatment of infections caused by Staphylococcus aureus. 2005; 35:S3-16.

4. Oliveira D, Borges A, Simões MJT. Staphylococcus aureus toxins and their molecular activity in infectious diseases. 2018; 10(6):252. Jubeh B, Breijyeh Z, Karaman RJM. Resistance of gram-positive bacteria to current antibacterial agents and overcoming approaches. 2020; 25(12):2888.

5. Harris LG, Foster S, Richards RGJECM. An introduction to Staphylococcus aureus, and techniques for identifying and quantifying S. aureus adhesins in relation to adhesion to biomaterials: review. 2002; 4(3):100-20.

6. Gurung RR, Maharjan P, Chhetri GGJFsO. Antibiotic resistance pattern of Staphylococcus aureus with reference to MRSA isolates from pediatric patients 2020;6 (4):FSO464.

7.	Rasheed NA, Hussein NRJEJoM, Medicine C. Staphylococcus aureus: an overview of discovery, characteristics, epidemiology, virulence factors and antimicrobial sensitivity. 2021;8(3):1160-83.

8.	Rayner C, Munckhof WJImj. Antibiotics currently used in the treatment of infections caused by Staphylococcus aureus. 2005;35:S3-16.

9.	Gurung RR, Maharjan P, Chhetri GGJFsO. Antibiotic resistance pattern of Staphylococcus aureus with reference to MRSA isolates from pediatric patients. 2020;6(4):FSO464.

10.	Rasmi AH, Ahmed EF, Darwish AMA, Gad GFMJBid. Virulence genes distributed among Staphylococcus aureus causing wound infections and their correlation to antibiotic resistance. 2022;22(1):652.

11.	Gould IM, David MZ, Esposito S, Garau J, Lina G, Mazzei T, et al. New insights into meticillin-resistant Staphylococcus aureus (MRSA) pathogenesis, treatment and resistance. 2012;39(2):96-104.

12.	Watkins RR, David MZ, Salata RAJJomm. Current concepts on the virulence mechanisms of meticillin-resistant Staphylococcus aureus. 2012;61(9):117993. 28. McDevitt D, Francois P, Vaudaux P, Foster TJMm. Molecular characterization of the clumping factor (fibrinogen receptor) of Staphylococcus aureus. 1994;11(2):237-48.

13.	Kang C-I, Song J-H, Ko KS, Chung DR, Peck KR, Diseases ANfSoRPSGJIJoI. Clinical features and outcome of Staphylococcus aureus infection in elderly versus younger adult patients. 2011;15(1):e58-e62.

14.	Nathwani D, Davey PG, Marwick CAJBCE. MRSA: treating people with infection. 2010;2010:0922.David MZ, Daum RSJCpr. Update on epidemiology and treatment of MRSA infections in children. 2013;1:170-81.

15.	Gherardi GJIjoms. Staphylococcus aureus infection: pathogenesis and antimicrobial resistance. MDPI; 2023. p. 8182.

16.	Lowy FDJTJoci. Antimicrobial resistance: the example of Staphylococcus aureus. 2003;111(9):1265-73.

17.	Stefani S, Goglio AJIJoID. Methicillin-resistant Staphylococcus aureus: related infections and antibiotic resistance. 2010;14:S19-S22.

18.	Immergluck LC, Jain S, Ray SM, Mayberry R, Satola S, Parker TC, et al. Risk of skin and soft tissue infections among children found to be Staphylococcus aureus MRSA USA300 carriers. 2017;18(2):201.

19.	Zheng X-Y, Choy BNK, Zhou M-M, Zhao Z-YJFip. Antibiotic resistance pattern of Staphylococcus aureus isolated from pediatrics with ocular infections: A 6year hospital-based study in China. 2021;9:728634.

20.	Pereira MFB, Bando SY, Sasagawa SM, da Silva CB, Mimica MJ, Berezin ENJTPIDJ. Panton-valentine positive Staphylococcus aureus in communityacquired and hospital-acquired pediatric infections. 2019;38(10):1068-70.

21.	Humphreys H, Fitzpatick F, Harvey BJJCID. Gender differences in rates of carriage and bloodstream infection caused by methicillin-resistant Staphylococcus aureus: are they real, do they matter and why? 2015;61(11):1708-14. 52. Vanderkoo OG, Gregson DB, Kellner JD, Laupland KBJP, health c. Staphylococcus aureus bloodstream infections in children: a population-based assessment. 2011;16(5):276-80.

22. Taj Y, Abdullah FE, Kazmi SUJJCPSP. Current pattern of antibiotic resistance in Staphylococcus aureus clinical isolates and the emergence of vancomycin resistance. 2010;20(11):728-32.

23. Khalid N, Akbar Z, Mustafa N, Akbar J, Saeed S, Saleem ZJFiA. Trends in antimicrobial susceptibility patterns of bacterial isolates in Lahore, Pakistan. 2023;2:1149408.

24. Tobin E, Samuel S, Inyang N, Adewuyi G, Nmema EJNJoCP. Bacteriological Profile and Antibiotic Sensitivity Patterns in Clinical Isolates from the OutPatient Departments of a Tertiary Hospital in Nigeria. 2021;24(8):1225-33.

25. Samadi R, Ghalavand Z, Mirnejad R, Nikmanesh B, Eslami GJI, Resistance D. Antimicrobial resistance and molecular characteristics of methicillinresistant Staphylococcus aureus isolates from children patients in Iran. 2019:3849-57.

26. Shah AA, Ali Y, Maqbool A, Abbasi SAJJTJotPMA. Antimicrobial susceptibility pattern of Methicillin-resistant Staphylococcus Aureus isolates in Fauji Foundation Hospital Rawalpindi. 2020;70(9):1633-5.

27. Gravenkemper CF, Brodie JL, Kirby WMJJob. Resistance of coagulasepositive staphylococci to methicillin and oxacillin. 1965;89(4):1005-10. Alrabiah K, Al Alola S, Al Banyan E, Al Shaalan M, Al Johani SJIJop, medicine a. Characteristics and risk factors of hospital acquired–methicillin-resistant Staphylococcus aureus (HA-MRSA) infection of pediatric patients in a tertiary care hospital in Riyadh, Saudi Arabia. 2016;3(2):71-7.

28. Ashfaq, M.H., et al., *REVOLUTIONIZING REHABILITATION: THE ROLE OF ARTIFICIAL INTELLIGENCE IN MODERN PHYSIOTHERAPY.* Journal of Medical & Health Sciences Review, 2025. **2**(2).

29. Kumar, S., et al., *BLOCKCHAIN IN HEALTHCARE: INVESTIGATING THE APPLICATIONS OF BLOCKCHAIN TECHNOLOGY IN SECURING ELECTRONIC HEALTH RECORDS. A BIBLIOMETRIC REVIEW.* Cuestiones de Fisioterapia, 2024. **53**(03): p. 429-456.