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A Study of Antimicrobial Susceptibility Pattern of *Staphylococcus Aureus* Isolated from Clinical Sample

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ABSTRACT:

This study unearth the distribution of Staphylococcus aureus among various demographic groups, its antimicrobial susceptibility, and the prevalence of methicillin-resistant Staphylococcus aureus (MRSA) in clinical isolates. A total of 383 isolates were analyzed from samples collected at LBS Hospital, Bhopal, with investigations conducted at the Department of Biological Sciences and Life Sciences, IES University, Bhopal. The profound implications of resistance patterns for clinical treatment and public health are discussed.

Introduction

Staphylococcus aureus is one of the most significant human pathogens, leading to a multitude of infections ranging from mild skin lesions to life-threatening systemic diseases such as pneumonia, sepsis, and toxic shock syndrome (Bashabsheh, R. H *et al*., 2024) The versatility of *S. aureus* in causing various infections has made it a focal point of clinical and microbiological research (Fowler *et al*., 2020). The emergence of methicillin-resistant *Staphylococcus aureus* (MRSA) has posed significant challenges to infection control in healthcare settings. The first report of MRSA in the early 1960s marked the beginning of a new era in infectious disease management, leading to increased morbidity and mortality associated with staphylococcal infections (Gould, I. M. 2005; Klevens *et al*., 2007). MRSA infections can lead to extended hospital stays and increased healthcare costs, creating a substantial burden on public health systems (Siegel *et al*., 2007).

Understanding the epidemiology of *S. aureus* is crucial for developing effective treatment protocols and control measures. Various studies have shown fluctuations in resistance patterns of *S. aureus*, influenced by local antibiotic policies, usage practices, and patient demographics (Srinivasan *et al*., 2005; Khanna *et al*., 2014). In Central India, where this study is focused, the prevalence of MRSA has been reported to be rising, reflecting similar trends observed globally. Previous studies indicated a prevalence of MRSA ranging from 25% to over 70% in hospital settings across India (Khan *et al*., 2019; Shobha *et al*., 2020). This research focuses on the prevalence and antimicrobial resistance of *S. aureus* in a clinical setting at LBS Hospital, Bhopal, which serves a diverse population. By thoroughly examining demographic factors, specimen types, and resistance patterns, the study aims to contribute valuable insights into the control and management of *S. aureus* infections in the region. The study also emphasizes the urgent need for empirical data to guide local treatment protocols and inform public health initiatives.

In summary, this research highlights the evolving challenges posed by *S. aureus*, especially MRSA, in clinical settings. Through systematic analysis of demographic and susceptibility data, it seeks to enhance the understanding of this pathogen's behaviour and guide better clinical outcomes.

Materials and Methods Study Setting

This study was conducted in the Department of Biological Sciences and Life Sciences at IES University, Bhopal, utilizing clinical isolates obtained from LBS Hospital, Bhopal. The hospital serves a diverse patient population and is equipped with modern facilities, making it an ideal setting for such epidemiological research. With a significant number of admissions each year, LBS Hospital provides a range of clinical services, which enables the collection of various sample types reflective of common and emerging infections (Patel *et al*., 2018).

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Sample Collection

A total of 383 clinical isolates of *Staphylococcus aureus* were collected from various departments within the hospital from January to December 2022. The specimens included pus, blood, ear swabs, urine, and sputum. Samples were collected using aseptic techniques to prevent contamination, ensuring the integrity of the microbiological analysis. Each specimen was stored under appropriate conditions and transported to the laboratory for processing within a maximum of two hours, adhering to recommendations from the Clinical and Laboratory Standards Institute (CLSI, 2020). This thorough collection strategy aimed to encompass a broad spectrum of *S. aureus* infections across different demographic groups and clinical presentations.

Data Collection

Demographic data such as patient age, sex, and the type of specimen were meticulously recorded for all isolates. Patient confidentiality was maintained throughout the study in accordance with ethical guidelines and regulatory standards (Bhan & Rani, 2020). Data were systematically organized in a database for subsequent statistical analysis. Each isolate was labeled with a unique identifier linked to demographic details to facilitate correlation with clinical outcomes and antimicrobial susceptibility results.

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility was assessed using the disk diffusion method, as recommended by the CLSI (2020). A panel of antibiotics was selected for testing, which included Penicillin-G, Erythromycin, Tetracycline, Vancomycin, and Linezolid, reflecting standard treatment options for *S. aureus* infections. For the disk diffusion assay, Mueller-Hinton agar plates were inoculated with a suspension of the isolates adjusted to a 0.5 McFarland standard, ensuring consistent bacterial density.

To identify methicillin-resistant *Staphylococcus aureus* (MRSA), both phenotypic and molecular methods were employed. The phenotypic identification was carried out using oxacillin and cefoxitin disc diffusion methods, with susceptibility interpreted based on established zone diameter breakpoints (CLSI, 2020). For molecular confirmation, the mecA gene, which confers resistance to methicillin, was targeted using polymerase chain reaction (PCR). Genomic DNA was extracted from the isolates using commercial kits following the manufacturer's protocols (Jiang *et al.*, 2021). PCR products were analyzed by gel electrophoresis to confirm the presence of the mecA gene using specific primers, which further validated the phenotypic findings.

Overall, the methodological rigor employed in this study aimed to ensure reliable results that contribute valuable insights into the epidemiology and antimicrobial resistance landscape of *Staphylococcus aureus* in the local healthcare setting.

Results Demographics of Staphylococcus aureus Isolates

1. Age Distribution

Table:1 The distribution of *S. aureus* isolates according to age

Age Group (Years)	Number of Isolates (N)	Percentage (%)
<1	4	1.0
1–10	48	12.5
11–20	33	8.6
21–30	71	18.5
31–40	46	12.0
41–50	63	16.4
51–60	55	14.4
>80	63	16.4
Total	383	100.0

Mean ± SD: 38.4 ± 21.7

Table:2 Sex Distribution

Sex	Number of Isolates (N)	Percentage (%)
Male	237	61.9
Female	146	38.1
Total	383	100.0

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Table:3 Specimen Type Distribution

Specimen Type	Number of Isolates (N)	Percentage (%)
Blood	8	2.1
Ear Swab/Discharge	30	7.8
Pus	304	79.4
Sputum	14	3.7
Throat Swab	6	1.6
Urine	15	3.9
Vaginal Swab	3	0.8
Total	383	100

Table: 4. Distribution by Ward

Ward	Number of Isolates (N)	Percentage (%)
In-patient Department (IPD)	281	73.4
Out-patient Department (OPD)	102	26.6
Total	383	100.0

Table:5 MRSA and MSSA Distribution

S. aureus Type	Number of Isolates (N)	Percentage (%)
MSSA	197	51.4
MRSA	186	48.6
Total	383	100.0

Demographic Distribution of Staphylococcus aureus Isolates

The study evaluated a total of 383 clinical isolates of *Staphylococcus aureus*. Among these, the age distribution indicated a significant prevalence in certain demographics. The highest number of isolates was from the age group 21-30 years, which accounted for 18.5% of the samples. This was followed closely by the 41-50 age group with 16.4%. Younger children (<1 year) were represented minimally, making up just 1.0% of the cases, while the age groups of 51-60 and >80 years each comprised 14.4% and 16.4%, respectively. The overall mean age of patients from whom isolates were obtained was 38.4 years with a standard deviation of 21.7 years.

When analyzing the sex distribution of the isolates, it was found that males represented a substantial majority, accounting for 61.9% of the cases, while females contributed 38.1%. This suggests that males may have an elevated risk for *S. aureus* infections or possibly higher exposure rates in the studied population.

Regarding the specimen types from which *S. aureus* was isolated, pus samples were overwhelmingly predominant, comprising 79.4% of all isolates, which indicates a likely focus on wound infections or abscesses. Other specimen types included ear swabs (7.8%), sputum (3.7%), and urine samples (3.9%), which reflects the types of infections being treated at the clinical setting. The distribution of isolates by the ward revealed that inpatients were more frequently affected, with 73.4% of isolates coming from the inpatient department (IPD), while outpatient cases (OPD) were significantly lower at 26.6%. This disparity may reflect the severity of infections leading to hospital admissions.

Antimicrobial Susceptibility Patterns

Table:6 Susceptibility Among MSSA Isolates

Antibiotic	Sensitive (%)	Resistant (%)
Penicillin-G	9.1	90.9
Erythromycin	44.2	55.8
Tetracycline	89.3	10.7
Vancomycin	87.6	12.4
Linezolid	92.5	7.5

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Table:7 Susceptibility Among MRSA Isolates

Antibiotic	Sensitive (%)	Resistant (%)
Penicillin-G	3.8	96.2
Erythromycin	36.0	64.0
Tetracycline	84.9	15.1
Vancomycin	84.3	15.7
Linezolid	89.3	10.7

Table:8 Comparison of Resistance Patterns

Antibiotic	MSSA Resistant (%)	MRSA Resistant (%)	p-value
Penicillin-G	90.9	96.2	0.033*
Erythromycin	55.8	64.0	0.106
Ciprofloxacin	70.6	80.6	0.732
Gentamicin	23.4	33.3	0.032*
Vancomycin	11.7	16.7	0.339

*Note: $p < 0.05$ considered significant.

Distribution of MRSA and MSSA Isolates

The prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) was also analyzed. The results indicated that MRSA isolates accounted for 48.6% of all *S. aureus* samples collected, while methicillin sensitive *Staphylococcus aureus* (MSSA) constituted 51.4%. This juxtaposition showcases a nearly equal distribution, highlighting a concerning presence of MRSA which poses challenges for treatment options. When specifically examining antimicrobial susceptibility for MSSA and MRSA isolates, significant differences were observed in resistance patterns. Among MSSA isolates, a staggering 90.9% were resistant to Penicillin-G, while 44.2% were resistant to Erythromycin. In contrast, MRSA isolates exhibited even higher resistance rates, with 96.2% resistant to Penicillin-G and 64.0% to Erythromycin. The resistance to tetracycline was observed in 10.7% of MSSA compared to 15.1% of MRSA isolates, indicating that MRSA retains a considerably high resistance profile overall.

Additionally, the susceptibility of MRSA to Vancomycin and Linezolid, while still relatively high (84.3% and 89.3%, respectively), is tempered by notable resistance, underscoring the necessity for ongoing surveillance and tailored therapeutic strategies.

In summary, the demographic data regarding age and sex, along with the specimen types and wards, provide essential context for understanding the burden of *S. aureus* infections in this clinical setting. The highlighted trends, particularly the significant proportion of MRSA, underscore the ongoing public health challenge in effectively managing these infections and the critical need for continued monitoring of resistance patterns to inform clinical decision-making and antibiotic stewardship strategies.

Discussion

The findings from this study reveal a concerning prevalence of *Staphylococcus aureus*, particularly methicillin-resistant *Staphylococcus aureus* (MRSA), in clinical isolates from LBS Hospital, Bhopal. The results highlight not only age and sex demographics but also the significance of specimen types and resistance patterns, contributing to our understanding of this pathogen's impact on public health in the region.

Epidemiological Insights

The age distribution shows a notable prevalence of *S. aureus* infections in the young adult population (2130 years), which is consistent with studies conducted in similar urban settings (Khanna *et al*., 2014). Factors contributing to this trend may include lifestyle choices, occupational exposures, or crowding in urban environments, increasing susceptibility to infections. Conversely, lower detection rates in neonates could reflect improved neonatal care practices; however, the observed isolation of *S. aureus* from the elderly (>80 years) also raises questions about age-related immune deficiencies and their role in increasing vulnerability to bacterial infections.

The predominance of males (61.9%) among the isolates aligns with previous literature indicating a gender disparity in susceptibility to *S. aureus* infections (Bale, M. I. 2021; Srinivasan *et al*., 2005). This disparity may be attributed to biological factors, such as hormonal differences, or socio-cultural practices that may lead to various exposure risks. Understanding these factors is crucial for developing targeted prevention strategies, especially in high-risk groups.

Specimen Analysis

The majority of isolates originated from pus samples (79.4%), indicating a high incidence of skin and soft tissue infections, which is historically common for *S. aureus*. This underscores the importance of wound care and the management of abscesses as critical preventive measures in community settings. The relatively low percentage of bloodstream infections illustrates the effectiveness of infection control practices at the hospital, preventing deeper systemic infections.

Meanwhile, the data derived from the ward analysis signifies that a greater number of isolates originated from inpatients (73.4%). This suggests a higher risk of nosocomial infections among hospitalized patients, potentially due to invasive procedures, longer hospital stays, and antibiotic exposure. It is advisable for healthcare facilities to enhance infection control measures, particularly in inpatient settings, to mitigate the associated risks.

Antimicrobial Resistance Patterns

The high prevalence of MRSA (48.6%) is alarming, particularly given the significant resistance rates to Penicillin-G and Erythromycin. The results are consistent with other studies in India, where rising MRSA rates have been reported, suggesting a widespread challenge in the fight against resistant strains (Khan *et al*., 2019; Shobha *et al*., 2020). This resistance further complicates treatment options, leading to a reliance on more potent antibiotics such as Vancomycin and Linezolid, both of which still exhibit commendable susceptibility (84.3% and 89.3%, respectively). However, the emerging resistance trends signal potential future treatment failures, necessitating immediate action in terms of surveillance and antimicrobial stewardship.

Interestingly, the susceptibility difference between MSSA and MRSA isolates is stark, particularly for Penicillin-G, with vulnerabilities suggesting that MSSA strains may still respond effectively to conventional therapies (Sharma, R *et al*., 2025). This emphasizes the importance of accurate identification of *S. aureus* strains in clinical settings, as MSSA infections can often be managed with more standard antibiotic regimens, sparing more potent agents for resistant infections.

Implications for Treatment and Public Health

The study underscores the urgent need for continued monitoring of *S. aureus* infections and their resistance patterns to develop appropriate treatment protocols and devise effective public health interventions. The implications are significant; public health entities must promote awareness about infection prevention strategies, antimicrobial stewardship, and the importance of hygiene, particularly in healthcare settings.

Moreover, this data highlights a crucial area for further research, particularly focusing on the molecular epidemiology of *S. aureus* strains to understand the mechanisms of resistance better and to identify potential sources of transmission in the community and hospital settings.

In conclusion, the findings from this study present a comprehensive overview of the current challenges posed by *Staphylococcus aureus*, particularly in the face of increasing MRSA prevalence. Ongoing vigilance, continuous education, and robust surveillance practices are essential to combat the threats presented by this versatile and resilient pathogen in the healthcare landscape of Central India.

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Journal of Chemical Health Risks

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