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COMPARATIVE STUDY ON THE PREVALENCE, RISK FACTORS, AND CLINICAL OUTCOMES OF MRSA INFECTION AMONG DIABETIC, IMMUNOSUPPRESSED AND ORTHOPEDIC PATIENTS IN PUNJAB: A HOSPITAL BASED OBSERVATIONAL SURVEY

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Abstract

Introduction: *Methicillin-Resistant Staphylococcus aureus (MRSA) poses an escalating healthcare challenge, particularly within patient populations exhibiting heightened immunological or structural vulnerabilities.*

Objectives: *This study evaluated the prevalence, anatomical distribution, risk factors, and hospitalization outcomes of MRSA infections among diabetic, immunosuppressed, and orthopedic implant cohorts in Punjab.*

Methods: *A prospective, hospital-based observational survey was conducted over six months in Lahore, evaluating 240 high-risk patients. Standard microbiological techniques confirmed MRSA isolates. Demographic profiles, clinical presentations, and acquisition modes were correlated using multi-variable Cox regression models and comparative statistical matrices.*

Results: *The overall MRSA prevalence was 84.3% (n=203). The result shows diabetic patients bore the highest clinical burden (30.5%, n=62), followed equally by immunosuppressed and orthopedic implant patients (24.6%, n=50 each). Wound and pus samples comprised the most isolation sources (77.8%), with the lower extremities being the most frequent anatomical site (39.4%). Multi-variable Cox regression finds advancing age as a potent independent risk factor for MRSA acquisition (HR = 2.099, $p < 0.001$). Prolonged hospitalization was heavily associated with adverse clinical outcomes ($p < 0.001$), yielding a substantial mean stay of 14.16±19.42 days. Furthermore, a significant variation in infection acquisition mode was identified ($p = 0.025$), with healthcare-associated settings showing a higher proportion of immunosuppressed individuals (34.1%).*

Conclusion: *This study demonstrates an alarmingly high MRSA burden among specialized cohorts in Punjab, heavily driven by advancing age and extended hospital stays. Mitigating this clinical threat requires the urgent integration of rapid molecular screening (PCR), preoperative nasal decolonization for implant recipients, and rigorous antimicrobial stewardship.*

INTRODUCTION

In the 1960s the penicillin class was extended by the introduction of aminopenicillins and then ureidopenicillins. These had better activity against Gram-negative bacteria but still had efficacy against Gram-positive bacteria. The terms "broad spectrum" and "narrow spectrum" were originally relative terms to compare one

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antibiotic with another. These terms have evolved into independent classifications in time, but there are no standardized criteria leading to ambiguity. Antibiotics are also classified by the Gram stain technique which divides bacteria into Gram-positive and Gram-negative groups by the structure of their cell walls.(Acar, 1997)

Broad-spectrum antibiotics are active against a wide variety of bacteria, including both Gram-positive and Gram-negative bacteria. They are often used when the source of the infection is unknown. Once the pathogen is identified , narrow-spectrum antibiotics are preferable as they target a few bacteria , leading to less microbiome disruption and antimicrobial resistance .(Iqbal et al., 2018)

The spectrum of activity of an antibiotic varies according to the type of microorganism affected. Broad spectrum antibiotics are useful in serious or unknown infections but can promote the development of resistance and disrupt normal flora if used inappropriately. Thus, appropriate selection of broad-spectrum and narrow-spectrum agents is important for antimicrobial spectrum stewardship.(Stacey et al., 2019)

MRSA is a common cause of nosocomial and community infections resistant to β-lactams.(Otto, 2012) MRSA infections are difficult to treat and threaten global health especially in hospitals, surgical settings and vulnerable patients and pose significant challenges for infection control and effective antibiotic therapy in developing areas.(Atta et al., 2025) The WHO has listed MRSA as a high-priority pathogen because of rising resistance and limited treatment options. Patients with dentures, catheters and implants are prone to staphylococcal infections that produce biofilm, which is hard to remove and often leads to chronic infection after the removal of dentures.(Hussain, Naqvi, & Sharaz, 2019; Sohail & Latif, 2017)

Several factors contribute to the clinical burden of MRSA in Pakistan: **Diabetes Mellitus**: Diabetics have an increased risk for skin and soft tissue infections as a result of impaired immune function and delayed wound healing. The most common cause is Staphylococcus aureus , particularly MRSA. Molecular tools like PCR allow for rapid detection of pathogenic genes, such as NUC and MEC A, which improves early diagnosis, treatment, and resistance management.(Basharat & Hussain, 2025) **Immunosuppressive therapy:** The chronic administration of steroids, biologicals, and disease-modifying antirheumatic drugs reduces immunity even further. **Increased Resistance:** The number of cases of MRSA has greatly escalated since the first occurrence in Pakistan in 1989, more specifically in the country's larger cities. **Causes:** MRSA is caused by prolonged stay in hospitals, excessive use of antibiotics, and self-medication. It is helpful in identifying resistance to antimicrobials. Hospitals play an important role in spreading MRSA resistance, especially amongst people with pre-existing illnesses.(Article et al., 2014).

This study seeks to assess the extent of the Methicillin-resistant Staphylococcus aureus (MRSA) public health problem, especially in people with diabetes, immunocompromised individuals, and those with orthopedic implants, because these groups have a higher probability of developing serious infections and experiencing adverse outcomes. The lack of information about infection incidence, risk factors for disease and ways to prevent MRSA infection from low- and middle-income countries limits the current knowledge base on the issue. Moreover, the relationship between immune suppression and Staphylococcus aureus bacteremia infection and the significance of nasal MRSA colonization before surgery in orthopedics have been poorly investigated. (Gottschalk et al., 2017; Sasson et al., 2017; YANO et al., 2009a).

The purpose of this research is to assess the occurrence and connection between MRSA infection among diabetic and immunocompromised orthopedic patients and to analyze the leading causes associated with such infections. The importance of this research is reflected by its contribution to the current body of knowledge, since it expands the comprehension of the issue of Staphylococcus aureus infection among high-risk individuals, helps us understand the link between bacteremia and immunosuppression, and evaluates the

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prevalence of preoperative nasal colonization of MRSA among orthopedic patients.

LITERATURE REVIEW

Several previous scientific studies have suggested that Methicillin-resistant Staphylococcus aureus is a multi-drug-resistant organism that is a cause of both nosocomial and community-associated infections around the world. It was found that patients with diabetes mellitus and immunodeficiency disorders were at high risk of developing MRSA- related infections as they had compromised immune response, delayed wound healing, and increased exposure to healthcare centers. Orthopedic patients who had implants or prosthetic devices were more vulnerable to MRSA infections as this pathogen tends to form a biofilm on the surface of these medical tools. Several research works proved that the number of cases with the presence of this pathogen was growing in developing countries such as Pakistan, which was associated with irrational treatment protocols, long-term stays in hospitals, and inadequate practices of preventing infections. Molecular techniques such as PCR made it possible to identify MRSA-associated genetic markers, like mecA and NUC genes. It is necessary to conduct pre-operative testing for MRSA in nasal passages of orthopedic patients in order to minimize the risk of post-operative complications and bacteremia. However, the lack of studies examining this combination of factors in Low- and Middle-Income Countries should be noted.

Methodology

Study Design

An observational study carried out in hospitals on a prospective basis was planned in order to evaluate the prevalence and severity of MRSA inf ections in three different patient populations, namely those who were diabetic and undergoing immunosuppressive treatment as well as those with orthopedic implants. The selection of the observation design helped us to study the disease occurrence pattern naturally without any experimentation..(Gottschalk et al., 2017)

Study Setting and Study Population

Study Setting

The research was performed in the Department of Surgery and Orthopaedics in a tertiary care hospital in Lahore, Punjab Province, Pakistan. Tertiary care hospitals act as centers for referrals for the treatment of surgical complications, orthopedic trauma, and postoperative infections. As such, these hospitals provide a good setting to investigate MRSA infection profiles in high-risk patients. The period of the study was 6 months.(Gottschalk et al., 2017)

Study Population

The study population comprised of Diabetic patients and Immunosuppressed Orthopedic implant patients with laboratory-confirmed MRSA infection.(Albavera-Gutierrez et al., 2024)

Inclusion Criteria

The inclusion criteria for patient recruitment were as follows: **Age**: No criterion, In-Patients/Out-patients. Presence of laboratory-confirmed MRSA infection, isolated from blood sample, wound or any sterile or non-sterile body fluid.

The following inclusion criteria was applied: Diabetes mellitus type I or II, Use of immunosuppressive medication for more than 3 months, Orthopedic implant or prosthesis (joint replacement, internal and external fixation).(Gottschalk et al., 2017)

Exclusion Criteria

Patients who were not included were those that met the criteria below: MRSA colonized but not infected clinically (e.g. carrying the organism without developing any clinical disease). Patients with incomplete or missing microbiology and clinical information. (Gottschalk et al., 2017)

Sample Size and Sampling Technique

Sample Size Calculation

The sample sizes were estimated from the prevalence of MRSA infections in each of the patient groups and the potential difference in infection severity observed between the groups. Applying standard epidemiological calculations

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for prevalence in hospital patients, it was assumed that;(Agarwala et al., 2016)

Sample Size for Frequency in a Population

Population size(for finite population correction factor or fpc)(*N*):	1000000
Hypothesized % frequency of outcome factor in the population (*p*):	6.3%+/-5
Confidence limits as % of 100(absolute +/- %)(*d*):	5%
Design effect (for cluster surveys-*DEFF*):	1

Sample Size(*n*) for Various Confidence Levels

ConfidenceLevel(%)	Sample Size
95%	91
80%	39
90%	64
97%	112
99%	157
99.9%	256
99.99%	358

Equation

Sample size $n = [DEFF*Np(1-p)]/ [(d^2/Z^2_{1-\alpha/2}*(N-1)+p*(1-p)]$

Results from OpenEpi, Version 3, open source calculator--SSPropor

Figure 1Sample size calculation for proportion in a population using OpenEpi (Version 3). The table provides sample sizes (n) at different confidence intervals between 95% and 99.99% depending on a population size (N) of 1,000,000, a proposed proportion (p) of 6.3%, confidence interval values (d) of 5%, and design effect (DEFF) of 1.

Sampling Technique

The sampling design used in the study is the non-probability consecutive sampling design where all the patients with MRSA infections who met the inclusion criteria at the surgical and orthopedic departments were included consecutively till the required number was reached.(Idrees et al., 2023) The reasons for using this design include the following: Maximize the eligible participants in the actual hospital environment. Minimize selection bias by using all the eligible patients sequentially. Conducting one center study in a hospital environment is practical. Real life practice pattern is maintained without any artificial selection.(Rao et al., 2008)

Statistical analysis

The characteristics of the samples were presented using descriptive statistics. Regarding the level of parameters and distribution, frequency counts and descriptive statistics, fisher's extraction test, t-test of independent samples, Cox proportional hazards regression, and Chi-square test were used in evaluating the differences between the patients' groups. In all multivariable regression analyses used, backward elimination approach was utilized. Those parameters that did not show statistical significance below $p<0.10$ were excluded from the model one by one. Those achieving $p<0.05$ were considered statistically significant.(Gottschalk et al., 2017)

Table 1
Patient Demographics and Baseline Clinical Characteristics (N = 240)

Characteristic	Frequency	Percentage (%)	p-value	Inference
Total Sample Size	240	100.0%		

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Diabetic Patients	70	29.2%		
Immunosuppressed Patients	62	25.8%		
Surgical/Orthopedic Patients	62	25.8%		
Age Group (Years)			0.050	Significant
< 40	170	70.8%		
40–59	36	15.0%		
60–79	26	10.8%		
>= 80	8	3.3%		
Gender			0.288	Not Significant
Male	150	62.5%		
Female	90	37.5%		
Confirmed MRSA Positive	203	84.3%		
Hospital Stay (Days, Mean ± SD)	14.16	19.42	< 0.001	Significant
Admitting Department			0.766	Not Significant
Inpatient Department (IPD)	146	60.8%		
Outpatient Department (OPD)	66	27.5%		
Emergency Room (ER)	28	11.7%		

Demographic and clinical characteristics of the study sample consisting of 240 subjects are described in Table 1. The majority of subjects were male (62.5%), and the predominant age group was less than 40 years old (70.8%), thus implying that the incidence of infections was significantly higher in younger males in this particular study group. Moreover, the prevalence rate of Methicillin-resistant Staphylococcus aureus (MRSA) was extremely high, making up 84.3% (n=203). As for the possible clinical risk factors, they included diabetes mellitus (29.2%), immunosuppression (25.8%), and previous surgery (25.8%). Thus, both iatrogenic and metabolic factors played a key role in the development of infection.

With regard to potential risk factors related to health care exposures, it should be mentioned that the largest share of patients (60.8%) visited the IPD department, followed by OPD (27.5%)

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and ER (11.7%). It suggests that the major setting where MRSA infections were observed was represented by hospitals.

The statistical analysis found that there was a significant correlation between patient outcome and the variable age ($p = 0.05$), implying that the variable age could have an effect on either the disease development or recovery from the condition. Moreover, there was a highly significant correlation between the increased length of hospitalization period and clinical outcomes, (mean = 14.16 ± 19.42 days; $p < 0.001$), stressing the importance of prolonged hospitalization as a major risk factor to poor outcome of treatment.

Conversely, there were no significant correlations noted for the variable gender distribution ($p = 0.288$) and type of department at which patients were admitted ($p = 0.766$).

Factors associated with S. aureus infection risk

The following is the output of the multivariable Cox proportional hazards regression analysis investigating the time to first S. aureus infection following index surgery. In the current analysis, censoring was used for any subsequent surgical intervention if performed at a different anatomical location from that where index surgery took place. Several independent predictors for increased infection risk have been identified.

Age has been shown to be significantly associated with infection risk (HR = 1.05 per year of age); the older the patient, the greater the probability of developing S. aureus infection. The presence of higher number of comorbidities, measured by CCI score, has also been revealed to increase the risk of infection (HR = 1.21 per unit increase in score). Besides, prolonged stay in the hospital during the time of the index operation has been found to be a contributing factor to infection development (HR = 1.03 per day).

In terms of surgical characteristics, knee operations were related to a substantially reduced infection hazard when compared to those of the hip surgery group (HR = 0.51). This may be an indication of differences in the complexity of the procedures, exposure to infection, or post-procedure treatment. However, the number of antibiotics prescribed during the six months prior to the study and gender were not found to be statistically significant predictors of infection risk. Hence, both parameters were omitted from further analysis.

The main message conveyed by the results of the presented investigation is that age, burden of comorbidity, length of stay in the hospital, and surgical procedure are important predictors of the time to S. aureus infection. (Gottschalk et al., 2017)

Table 2

Multivariable Cox Proportional Hazards Regression for MRSA Infection Risk in Diabetic Surgical Patients

Risk Factor	Hazard Ratio (HR)	95% Confidence Interval (CI)	p-value
Age	2.099	1.570–2.805	< 0.001
Charlson Comorbidity Index (CCI) Score	0.611	0.459–0.812	< 0.001
Hospital Stay (Days)	1.004	0.997–1.011	0.224
Surgical Category (Ref: Hip Surgery)			
Hip Surgery	1.313	0.765–2.256	0.323

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Knee Surgery	1.045	0.526–2.077	0.900
Spinal Surgery	0.000	9.551E+170	0.958
Other Orthopedic Surgery	0.930	0.593–1.459	0.753

The findings of Cox proportional hazards regression analysis for the identification of risk factors associated with MRSA infection in diabetic surgery patients are presented in Table 2. Out of all tested variables, only age was established as a significant risk factor. The obtained value of the hazard ratio (HR = 2.099, 95% CI: 1.570-2.805, $p < 0.001$) proves that the likelihood of developing MRSA infection increases substantially with age. This means that older diabetic surgery patients are more susceptible to MRSA infections because their immune system is less functional, they have slower wound healing, and they are more frequently exposed to medical procedures.

As for interesting findings, CCI turned out to be significantly inversely associated with MRSA infection risk (HR = 0.611, 95% CI: 0.459-0.812, $p < 0.001$). That is, the patients who had more comorbidities experienced lower MRSA infection risk. Possibly, such patients had intensified monitoring, faster treatment, or more attentive postoperative control due to more serious health issues.

However, the type of surgery, which includes hip surgery, knee surgery, spinal surgery, and other orthopedic surgeries, was not significantly associated with postoperative MRSA infection ($p > 0.05$). It means that neither the body part nor the type of surgery influenced infection risks. In general, based on the results, age was determined to be the main factor influencing the risk of infection, whereas the disease burden and the type of surgery had no significant effect.

Table 3
Demographic and Microbiological Profile of Confirmed MRSA Surgical Site Infections (n = 203)

Variable	MRSA Positive Cohort (n = 203)	p-value	Clinical Association
Gender		0.288	Not Significant
Male	124 (61.1%)		
Female	79 (38.9%)		
Age (Mean Years)	1.51*	0.043	Significant
Isolation Sample Source		0.145	Not Significant
Pus Sample	90 (44.3%)		
Wound Swab	68 (33.5%)		
Blood Culture	40 (19.7%)		
Nasal Swab	5 (2.5%)		

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Anatomical Infection Site		0.443	Not Significant
Lower Extremity	80 (39.4%)		
Upper Extremity	67 (33.0%)		
Spine	56 (27.3%)		
Number of Operations (Mean)	0.43	0.180	Not Significant

Note. *Value represents indexed transformed mean utilized for comparative parametric inference.

Patient data with MRSA infection and their clinical associations are shown in Table 3 below. The majority of participants included in the study population were males (61.1%, n=124). Gender was found to be not statistically significant associated with the patient's outcome (p=0.288). This means that patients regardless their gender have the same outcomes after being infected.

Statistically significant associations with patient outcomes were found for the patient's age (p=0.043). The observed mean age value is indicative of the fact that patient's age can have an effect on the course and outcome of the disease.

In regard to the microbiology data, MRSA infection was most often isolated from the patient's pus sample (44.3%) and wound (33.5%). Blood cultures and nasal swabs were found to be less likely sources of the pathogen (19.7% and 2.5%, respectively). It can be presumed that skin, soft tissues and postoperative infections were common among the study population.

In terms of anatomical sites, infections of the lower extremities represented the most prevalent site, accounting for 39.4% of infections, while infections of upper extremities accounted for 33%, and spinal infections made up 27.3%. This can be attributed to the higher prevalence of injuries and surgery, or diabetes-related or orthopedic problems affecting such areas.

However, there was no significant relationship between specimen collection location (p=0.145), the site of infection (p=0.443), or the mean number of surgeries (mean=0.43, p=0.180) and patient outcomes. It shows that these factors did not individually impact patient prognoses in the current study.

Table 4

Baseline Characteristics and Microbiological Features of Staphylococcus aureus Bacteremia (SAB) Across Cohorts

Variable	Immunocompetent	Immunosuppressed	p-value	Interpretation
Gender			0.322	Not Significant
Male	108 (72.0%)	42 (28.0%)		
Female	70 (77.8%)	20 (22.2%)		
Age Tiers (Years)			0.095	Not Significant
< 40	124 (72.9%)	46 (27.1%)		
40–59	32 (88.9%)	4 (11.1%)		

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60–79	16 (61.5%)	10 (38.5%)		
>= 80	6 (75.0%)	2 (25.0%)		
Comorbidity Severity			0.900	Not Significant
No Comorbidities	134 (73.6%)	48 (26.4%)		
Mild	18 (75.0%)	6 (25.0%)		
Moderate	16 (72.7%)	6 (27.3%)		
Severe	10 (83.3%)	2 (16.7%)		
Infection Acquisition Mode			0.025	Significant
Community-Acquired	88 (75.9%)	28 (24.1%)		
Healthcare-Associated	58 (65.9%)	30 (34.1%)		
Nosocomial	32 (88.9%)	4 (11.1%)		
Microbiology Isolation			0.657	Not Significant
MRSA	164 (74.5%)	56 (25.5%)		
Other S. aureus Strains	14 (70.0%)	6 (30.0%)		

Table 4 represents the comparative analysis of the baseline demographic features and the microbiological results of Staphylococcus aureus bacteremia (SAB) in immunocompetent and immunosuppressed subjects. It can be seen from the results that none of the considered variables differed significantly between the study groups. Hence, it can be concluded that there was quite a similarity between the demographics and other relevant features of patients belonging to these groups. The gender distribution was not found to be significantly different between the two groups (p=0.322), which means that SAB occurred regardless of the patient's gender in this study. Similarly, the age distribution was also found to be comparable between the groups (p=0.095).

Furthermore, it can also be said that the severity of co-morbidities did not significantly differ between the two groups (p=0.900). This indicates that there was a comparable burden of diseases in both patients' categories. In addition, the prevalence rate of Methicillin-resistant Staphylococcus aureus (MRSA) and non-MRSA were also comparable between the groups (p=0.657).

On the other hand, a statistically significant difference was found with regard to the mode of infection acquisition (p=0.025). The proportion

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of immunocompetent patients among both nosocomial infections and community-acquired infections was high; it comprised 88.9% and 75.9% of cases, correspondingly. At the same time, the incidence of health care-associated infections included a larger proportion of immunosuppressed individuals (34.1%). Such results can be explained by the fact that immunosuppressed patients more often find themselves in contact with health care facilities, undergo interventions, treatment and hospitalization, which can result in an increased risk of acquiring health care-associated SAB infections.(Espíndola et al., 2022; Kim et al., 2010; Rao et al., 2011; Yano et al., 2009b)

Table 5
Comparative Distribution and Demographic Stratification of MRSA Burden Across Vulnerable Cohorts

Variable Assessed	Diabetic Cohort	Immunosuppressed Cohort	Orthopedic Implant Cohort
Total Enrolled Patients	70 (29.2%)	62 (25.8%)	62 (25.8%)
Confirmed MRSA Positive Cases	62 (30.5%)	50 (24.6%)	50 (24.6%)
Mean Age (Years)	39.94	38.52	34.45
Gender Stratification			
Male (n = 150)	36 (24.0%)	42 (28.0%)	34 (22.7%)
Female (n = 90)	34 (37.8%)	20 (22.2%)	28 (31.1%)

However, an analysis of the various high-risk patient populations indicated that diabetic patients were the dominant population for MRSA among the target populations considered in this paper. Overall, the diabetic patient population was the largest, representing 29.2% (n=70), followed by the immunosuppressed patient population at 25.8% (n=62). The orthopedic implant patients made up another 25.8% (n=62).

Considering the specific burden of MRSA, the same population trends were witnessed. In particular, diabetic patients had the highest proportion of cases of MRSA infection, constituting 30.5% (n=62). On the other hand, the immunosuppressed and orthopedic implant patients had a similar percentage of 24.6% (n=50).

The demographic composition of the various groups for different strategic objectives demonstrated that diabetic MRSA patients had the highest average age of 39.94 years. On the other hand, the average ages of immunosuppressed and orthopedic implant patients were 38.52 and 34.45 years respectively. In terms of gender, the male population dominated the immunosuppressed group, being 42 (28%). The female population, on the other hand, dominated the diabetic (34, 37.8%) and orthopedic (28, 31.1%) patient groups.

Discussion

The study is a prospective observational study that will make an important assessment of the frequency, risk factors, and outcomes of infections due to Methicillin-Resistant Staphylococcus aureus (MRSA) amongst highly susceptible groups, namely diabetic, immunosuppressed, and orthopedic implants in three hospitals in Punjab. In summary, the results reveal a strikingly high overall prevalence rate of MRSA at 84.3% (n=203), thereby affirming the increasing prevalence of MRSA infections

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reported from various metropolitan cities in Pakistan.

Prevalence and Demographic Risk Stratification

The detailed evaluation of these groups identified a very high percentage of diabetic patients (29.2% of the studied cohort and 30.5% (n=62) of all diagnosed MRSA cases), stressing their increased vulnerability to severe soft tissue infections. This can be primarily attributed to the immunosuppression, poor wound-healing ability, and peripheral neuropathy of diabetics.(Stacey et al., 2019)

On the other hand, the incidence rate of immunosuppressed and orthopedic implant patients proved equal to 24.6% (n=50) of the MRSA prevalence rate. The significance of age was found in multiple assessments. The demographic data indicated that the great majority of subjects (70.8%) were younger than 40 years old. Nevertheless, the multivariable Cox regression model has unequivocally identified age as an independently significant risk factor for MRSA in diabetic surgery (HR = 2.099, $p < 0.001$). Thus, it can be said that aging doubles the risk of infection development. Strangely enough, the Charlson Comorbidity Index (CCI) was found to be inversely associated with MRSA (HR = 0.611, $p < 0.001$). Further research into this association could be conducted in order to determine whether a proactive and aggressive antibiotic prophylaxis in highly comorbid subjects will prove effective.(Hussain, Naqvi, & Sharaz, 2019)

Clinical and Microbiological Characteristics

Wounds and pus together formed the largest share of MRSA isolates (77.8%), with the lower extremities being the most common anatomical source of infection (39.4%). This clearly corresponds with the typical symptoms seen with diabetic foot ulcers and complicated orthopedic surgeries of the lower limbs.(Neopane et al., 2018)

It is worth mentioning that hospital stay time had an extremely strong association with poor clinical outcomes ($p < 0.001$) with an average duration of 14.16 pm 19.42 days. Thus, the role of hospital settings in serving as the principal means of MRSA transmission cannot be understated.(Hussain, Naqvi, & Sharaz, 2019)

In comparison of SAB incidence and clinical characteristics among immunocompetent and immunosuppressed patients, no significant differences in clinical symptoms and MRSA rates occurred. Nevertheless, the mode of infection was different between groups with statistical significance ($p = 0.025$). Immunocompetent people accounted for a much higher percentage of nosocomial and community infections (88.9% and 75.9%, respectively). On the other hand, healthcare infections involved a notably larger share of immunosuppressed individuals (34.1%). These results indicate that frequent visits to healthcare facilities, like infusion centers, present unique clinical risk factors to immunocompromised people.(Peng et al., 2022)

Implications for Antimicrobial Stewardship

While it is true that broad-spectrum antibiotics will always be important in the first stages of empirical therapy where the cause of infection is not known, it is also true that the indiscriminate and extended usage of such antibiotics will encourage selective resistance, secondary infections, and severe disturbance in microbiome composition.(Silva et al., 2021)

To avoid delays in the process of diagnosis due to conventional cultures, the use of rapid diagnostics such as PCR to test virulence genes (e.g., NUC and MEC A) is important for public health purposes. In addition, considering that the patients under surgical procedures represent potential sources of SSIs through their colonization in the nose, mandatory intranasal screening and decolonization measures need to be enforced prior to major orthopedic surgeries.(Sohail & Latif, 2017)

Limitations and Future Directions

Despite all its successes in establishing the clinical prevalence of MRSA and associated risk factors in a specific patient population in Punjab, there are some shortcomings in this investigation. One major flaw in our study is that our results have been derived from the use of demographics,

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hospital case studies, and conventional antimicrobial susceptibility testing of these organisms. Our current clinical perspective does not consider the structural adaptation mechanism of these pathogens(Neopane et al., 2018; Silva et al., 2021)

One way forward for this line of investigation would be to conduct laboratory-based comparison rather than a simple clinical survey of patients. One of the most interesting directions to take for the future could be, "Biofilm formation ability and surface adherence characteristics of MRSA isolated from orthopedic implant infections and those from diabetic foot ulcers." Determining if the strain of MRSA isolated from orthopedic implants forms a stronger biofilm than those isolated from diabetic ulcers will shed light on why patients in these two categories take a much longer time to recover from their infections.(Abbas et al., 2024; Almatroudi, 2025; Leshem et al., 2022; Peng et al., 2022)

Conclusion

This paper has been able to successfully identify the prevalence ratios and risk factors for MRSA infections among the various specialized groups of patients in Punjab. Diabetes appears to be associated with the greatest number of infections, whereas age and prolonged hospital stays act as important risk factors for infection.

The unique modes of transmission noted among immunocompromised individuals highlight the importance of a tailored surveillance strategy.

In order to overcome the problem, the following actions should be taken by healthcare organizations: Rapid detection of the pathogen through molecular testing (PCR). Nasal screening and decolonization among patients undergoing joint surgery. Strict infection control practices to minimize the likelihood of hospital-acquired infections and maintain antibiotic narrow spectrum options.

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