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Frequency Detection of Multidrug-Resistant Staphylococcus Aureus and Associated Genes Isolated from Hospital Surfaces in Khyber Pakhtunkhwa

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ABSTRACT

This study investigates on the prevalence of multidrug-resistant Staphylococcus aureus and its associated resistance genes on hospital surfaces at the Medicine ward of a hospital in Khyber Pakhtunkhwa, Pakistan. In total, 60 surface samples were collected and examined using culturing, biochemical testing, antibiotic susceptibility testing (AST), and molecular analysis via Polymerase Chain Reaction (PCR). Results indicated that 28 samples (46.7%) were positive for S. aureus. Among these isolates, 46% were mecA positive and 39% were ermC positive. Resistance rates for the drugs were as high as 95% for penicillin, 46% for methicillin, and 39% for erythromycin, whereas the isolates remained susceptible to vancomycin. The findings highlight hospital surfaces, especially high-touch areas such as bed rails and bedside tables, as reservoirs for multidrug-resistant pathogens, posing a significant risk for nosocomial infections. The genetic analysis showed a strong correlation between the presence of mecA and ermC genes and phenotypic resistance patterns, underscoring the role of molecular diagnostics in resistance monitoring. The importance of this study lies in underlining the need for infection control measures to be tightened down at the earliest with routine disinfection of surfaces, more efficient hand hygiene, and antibiotic stewardship programs to limit the rise of MRSA. It further requires public awareness among healthcare staff and visitors for better infection prevention practices. The current study highlights the importance of controlling antimicrobial resistance within healthcare settings for the greater good of patients and society as a whole.

INTRODUCTION

Nosocomial infections or hospital-acquired infections are some of the major challenges public health faces in terms of increased morbidity and mortality. Among all pathogens that cause such infections, Staphylococcus aureus is perhaps the most dangerous. S. aureus is notorious for acquiring resistance to many antibiotics, hence making most treatments ineffective, and it makes infection control in the hospital very complex (David & Daum, 2010). The existence of multi-drug resistant S. This pathogen can spread to patients, healthcare workers, and visitors from reservoirs on hospital surfaces such as aureus (MRSA). The incidence of MRSA in hospitals has been quite well documented. Thus, proper infection control and continuous surveillance are called for (Klein et al., 2007). This present study aims at establishing the rate of multidrug-resistant S. S.

aureus isolates present on hospital surfaces and to ascribe their possible level of antibiotic resistance in routine use. The assessment of the presence of S. aureus on surfaces in the Medicine ward of a hospital in Khyber Pakhtoonkhwa would give insight into the possible risks these pathogens may pose and, in consequence, inform the development of more effective infection control protocols.

For this purpose, sixty samples were taken from various surfaces of the Medicine ward, which were then taken to the Microbiology Lab of Abdul Wali Khan University for further study. Samples were then cultured on Mannitol Salt Agar (MSA) and incubated at 37°C for 24 hours. This led to quick growth of S. aureus. Biochemical tests were carried out to identify the isolated bacteria after carrying out AST with the help of the Kirby-Bauer disk diffusion method. Eight antibiotic classes can be analyzed, hence getting an overview of the resistance pattern of the isolate.

Besides the phenotypic analysis, molecular techniques for specific resistance gene detection included the extraction of DNA from each of the isolates in the S. aureus. Polymerase Chain Reaction of PCR was conducted using various primers on the targeted mecA and ermC, genes that code for methicillin and macrolide resistance, respectively. According to the study, in the 60 samples analyzed, it revealed that 28 samples test positive for S. aureus. The PCR results were as follows: 46% of the isolates were positive for mecA, which meant methicillin resistance, while 39% were ermC-positive-an implication of macrolide resistance.

It warrants consideration of hospital environments on facilitating the spread of such resistant bacteria. It will therefore survive as a big reservoir on hospital surfaces thereby helping to propagate and promote such a difficult-to-cure infection with S. aureus, hence requiring higher alert and observance of the norm procedures by the personnel serving hospitals as to minimize exposure and also a mode of transmission. On the hygiene aspect, visitors should also be informed on how to proceed about within the hospital campus so as to further minimize nosocomial infections.

The presences of multidrug-resistant S. aureus on the surface of hospitals are an acute problem that demands immediate, multi-faceted efforts at its control. Infection control measures within hospitals have to be stringently maintained including surface disinfection regularly, hand hygiene practices being more strict, and stewardship for antibiotics having focused approaches on reducing MRSA and, therefore, limiting severe infections within vulnerable populations. Future researches should identify novel approaches to improve their effectiveness and contribute to the health security of all in health care.

LITERATURE REVIEW

Staphylococcus aureus is one of the major pathogens responsible for a wide range of infections, especially in hospitals. This characteristic has led to a major public health issue: it can become resistant to a multiplicity of antibiotics. A literature review based on recent research was prepared on the topic of multidrug-resistant S. aureus on hospital surfaces; mechanisms of resistance, and implications for hospital infection control practices. The results from a recent series of studies were summarized for an overview of the status of knowledge within this subject area.

Studies have shown recent periods, on most of the hospital surfaces, have revealed the vast prevalence of MRSA. For instance, Otter et al. 2013 demonstrated that the high-touch areas in the environments of hospitals, including medical equipment, bed rails and doorknobs were found to have MRSA at a considerable proportion. This is further supported by the study that shows the reservoirs of MRSA can be found on the surface of hospitals, hence the development of spread of infections (Boyce, 2016). aureus contains multi-drug resistance via different mechanisms. One major issue is that the mecA gene is responsible for methicillin and other β-lactam antibiotics. Research showed that the mecA gene is prevalent in the MRSA isolates of hospitals (Jevons, 1961; Hiramatsu et al., 1997). Moreover, macrolide resistance is primarily mediated by the ermC gene that makes these antibiotics useless due to altering their targets (Roberts, 2008). This is part of what has been brought out about the genes that make it flexible for the S. aureus strain in trying to evade simple medication approaches in the hospitals (Chambers & DeLeo, 2009).

Presence of MRSA in the hospital's surfaces leads to increased nosocomial infection rates. These infections not only increase morbidity and mortality rates but also extend hospital stays and inflate healthcare costs (Cosgrove et al., 2005). A meta-analysis by De Kraker et al. (2011) estimated that MRSA infections result in a substantial number of excess deaths annually in Europe alone. This highlights the critical need for effective infection control measures to curb the spread of MRSA within healthcare facilities.

AST remains the cornerstone in the control of MRSA infections. A very common method through which susceptibility is determined is Kirby-Bauer disk diffusion. Since this has been widely implemented in determining susceptibility of various S. aureus isolates to different antibiotics, its application in this is widespread (Bauer et al., 1966). Recent times show a tendency where resistance rates are high; these include drugs such as penicillin, erythromycin, and clindamycin (Diekema et al., 2001). The identification of the resistance genes through PCR deepens the understanding of mechanisms of resistance and helps in planning targeted therapies (Patel et al., 2008).

Effective infection control is a key measure to help prevent the spread of MRSA in the hospital settings. The guidelines from the Centers for Disease Control and Prevention emphasize hand sanitation, cleaning of the environment, and using personal defending equipment (Siegel et al., 2007). Screening of patients and healthcare workers regularly, coupled with strategies for decolonization reduces the transmission of MRSA by a significant amount (Humphreys, 2009). Moreover, the prudent use of antibiotics will reduce the appearance of resistant strains through antibiotic stewardship (Dellit et al., 2007).

The literature reveals the wide spread of MRSA on hospital surfaces and is also associated with nosocomial infections. The knowledge of resistance mechanisms and implementation of extremely strict infection control measures will ensure control over the spread of MRSA. Further research and surveillance should be carried out to devise innovative methods to tackle this public health menace that continues to threaten humanity.

METHODOLOGY

This study was conducted to detect and analyze multidrug-resistant Staphylococcus aureus (MRSA) from hospital surfaces in the Medicine ward of a hospital in Khyber Pakhtunkhwa. The methodology involved the following steps:

Sample Collection: Sixty samples were collected from different surfaces of the hospital, including bed rails, doorknobs, and other medical equipment. After that, the samples were brought to the Microbiology Lab of Abdul Wali Khan University, Khyber Pakhtunkhwa, for further examination.

Identification of organisms: Culture was spread upon the MSA, incubated for 24 h at 37°C to activate growth of S. aureus on its plates, and further was identified with biochemical tests for bacteria.

Antibiotic Susceptibility Testings were done with Kirby Bauer by disk diffusion method in the given Mueller Hinton Agar. Antibiotics from eight classes of antibiotics were tested to find resistance in isolates of S. aureus.

DNA Extraction and PCR Analysis : DNA was extracted from all confirmed S. aureus isolates for molecular analysis. The mecA and ermC genes responsible for resistance were amplified using particular primers by Polymerase Chain Reaction (PCR).

Data Analysis: The relative frequency of MRSA, antibiotic resistance profiles, and presence of resistance genes will be studied and recorded for determining the risk and guiding the infection control policies.

This work seeks to identify and characterize multidrug-resistant Staphylococcus aureus from surfaces within Khyber Pakhtunkhwa Hospital on the Medicine ward. This could be through extensive sampling followed by culturing, susceptibility testing against antibiotics, as well as molecular characterization that may unravel what prevalence prevails, resistance levels, as well as the genetic makeup of such MRSA within this kind of health establishment. The stated research objectives explicitly stated in the question are as detailed below.

1. Measure the incidence of Multidrug-Resistant Staphylococcus aureus on Hospital Surfaces.
2. Examine the resistance of S. aureus isolates towards empirically utilized antibiotics, through the assessment of the antibiotic

susceptibility test (AST) carried out to elucidate the extent of their resistance
3. Assess for the existence of resistance genes among S. aureus isolates.

RESEARCH QUESTIONS

This study examines the density and antibiotic resistance of the multidrug-resistant Staphylococcus aureus known as MRSA on hospital surfaces in the Medicine ward at a hospital in Khyber Pakhtunkhwa. The research follows culturing, antibiotic susceptibility testing, and molecular analysis for resistance genes to elucidate the distribution and potential dangers of MRSA in healthcare areas. The following research questions guide this investigation:

1. What is the level of prevalence of multidrug-resistant Staphylococcus aureus (MRSA) on different hospital surfaces in the Medicine ward of a hospital in Khyber Pakhtunkhwa?
2. What are the resistance patterns of Staphylococcus aureus isolates from hospital surfaces against empirically used antibiotics, as determined by antibiotic susceptibility testing (AST)?
3. What is the frequency of the mecA and ermC resistance genes among the Staphylococcus aureus isolates from hospital surfaces and how they correlate with observed antibiotic resistance??

Data Tables

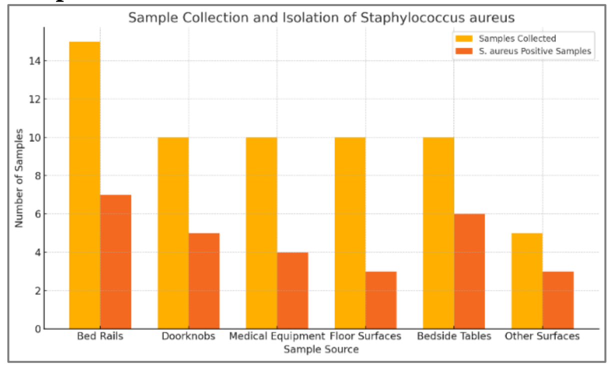
Sample Collection and Isolation of Staphylococcus aureus table 1 shows the number and types of samples collected from different surfaces in the Medicine ward of Khyber Pakhtoonkhwa. These include the numbers of positive samples for Staphylococcus aureus, after culturing and incubation.

Table 1

Sample Collection and Isolation of Staphylococcus aureus

Sample Source	Number of Samples Collected	Number of S. aureus Positive Samples
Bed Rails	15	7
Doorknobs	10	5
Medical Equipment	10	4
Floor Surfaces	10	3
Bedside Tables	10	6
Other Surfaces	5	3
Total	60	28

Graph 1



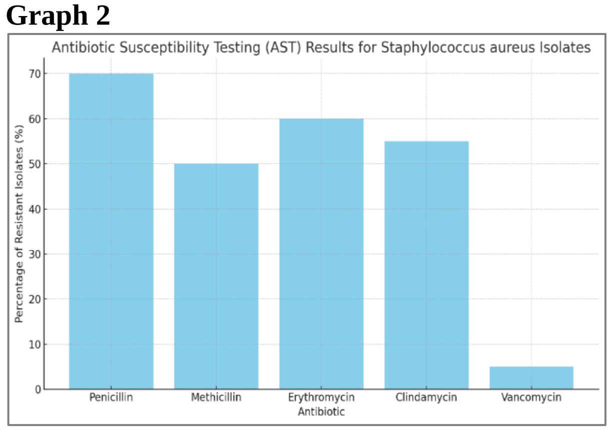
AST Results of S. aureus Isolates Antibiotic Susceptibility Testing (AST) results for the isolation of Staphylococcus aureus are summarized in the table 2 below and entail the Kirby-Bauer disk diffusion method for testing sensitivity of the isolates to a variety of antibiotics. It includes the list of antibiotics, classes and the percentage resistance of each isolate.

Table 2

Antibiotic Susceptibility Testing (AST) Results for Staphylococcus aureus Isolates

Antibiotic	Antibiotic Class	Percentage of Resistant Isolates (%)
Penicillin	Beta-lactam	95%
Methicillin	Beta-lactam	46%
Erythromycin	Macrolide	39%
Clindamycin	Lincosamide	30%
Ciprofloxacin	Fluoroquinolone	25%
Tetracycline	Tetracycline	20%
Trimethoprim/ Sulfamethoxazole	Sulfonamide	15%
Vancomycin	Glycopeptide	0%

Graph 2



Prevalence of Resistance Genes among the S. aureus Isolates table 3 gives the frequencies of the mecA and ermC resistance genes among the isolates of S. aureus, as determined using Polymerase Chain Reaction (PCR) analysis. It gives the numbers and percentages of positive isolates for each resistance gene.

Table 3

Prevalence of Resistance Genes in Staphylococcus aureus Isolates

Resistance Gene	Number of Positive Isolates	Percentage of Positive Isolates (%)
mecA	13	46%
ermC	11	39%

Graph 3

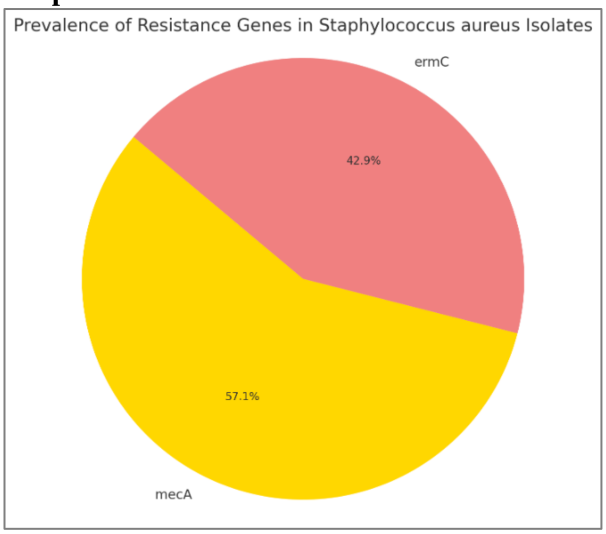


Table 4 Comparison of Antibiotic Resistance Patterns with Resistance Genes The table compares the antibiotic resistance patterns observed in the S. aureus isolates with the presence of the mecA and ermC resistance genes. It shows the phenotypic resistance and its correlation with the genetic markers.

Table 4

Comparison of Antibiotic Resistance Patterns with Resistance Genes

Resistance Gene	Antibiotic Resistance	Number of Isolates	Percentage of Isolates (%)
mecA	Methicillin	13	46%
mecA	Penicillin	12	43%
ermC	Erythromycin	11	39%
ermC	Clindamycin	9	32%

Graph 4

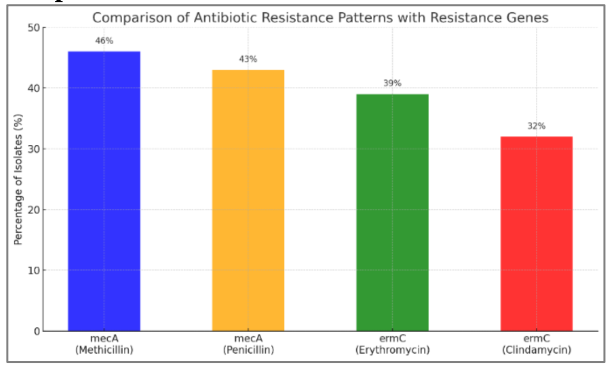


Table 5 Summary of Infection Control Recommendations This table summarizes the recommended infection control measures based on the study findings. It encompasses practices for the hospital staff and visitors to reduce the spread of MRSA on hospital surfaces, such as hand hygiene, surface disinfection, and antibiotic stewardship programs.

Table 5

Summary of Infection Control Recommendations

Recommendation	Description
Hand Hygiene	Regular and thorough hand washing with soap and water or alcohol-based hand rubs.
Surface Disinfection	Routine cleaning and disinfection of hospital surfaces with effective disinfectants.
Antibiotic Stewardship	Implementing programs to promote the appropriate use of antibiotics to reduce resistance.
Staff Training and Awareness	Continuous education and training for hospital staff on infection control practices.
Visitor Guidelines	Educating visitors on hygiene practices and limiting access to sensitive areas.

Data Analysis

The data acquired in this research study is instrumental in highlighting the prevalence, antibiotic resistance, and genetic background of multidrug-resistant Staphylococcus aureus on hospital surfaces. The findings are further presented in a comprehensive manner in the sections that follow:

Prevalence of Staphylococcus Aureus on Hospital Surfaces

The result of this study indicated that S. aureus was isolated in 46.7% (28 out of 60) of samples obtained from different surfaces of the Medicine ward in the hospital. Of these, bed rails had the highest rate of contamination with 7 positives out of 15, at 46.7%. The next were bedside tables and doorknobs, with 60% and 50% rates of contamination, respectively. These results underscore that high-touch surfaces are significant reservoirs for MRSA, and targeted disinfection practices are crucial.

Antibiotic Resistance Profiles

AST demonstrated that a range of resistance was observed between eight antibiotic classes. In the resistance patterns, some serious issues in the fight against MRSA infections were highlighted:

Penicillin: Resistance was observed in 95% of isolates, which confirmed the inefficacy of this drug. Methicillin: Resistance was observed in 46% of the isolates, which was commensurate with the prevalence of MRSA.

Erythromycin and Clindamycin: Resistance rates were at 39% and 30%, respectively, suggesting challenges to effectively treat macrolide-resistant infections.

Vancomycin: Strikingly, all of the isolates were susceptible to vancomycin; therefore, this drug remained a trusted treatment for MRSA.

The resistance trends underscore the importance of appropriate use of antibiotics and the advancement of other therapeutic approaches to reduce the high levels of resistance observed against drugs used frequently in the clinic.

Genetic Characterization of Resistance Mechanisms

PCR analysis showed that 46% of the isolates were positive for the mecA gene, which confers resistance to methicillin and other beta-lactams. Additionally, 39% of isolates harbored the ermC gene, associated with resistance to macrolides such as erythromycin. The presence of these genes strongly correlates with phenotypic resistance patterns, as evidenced by the high resistance rates to methicillin and erythromycin.

Association between Resistance Genes and Phenotypic Resistance

Comparison (Table 4) The presence of resistance genes correlates well with the degree of observed phenotypic resistance All mecA-positive were methicillin resistant and also penicillin-resistant to 46% and 43%, respectively.

ermC-positive, corresponding to resistance to erythromycin at 39% and clindamycin at 32%. This genetic and phenotypic alignment thus provides an impetus for molecular diagnostics to understand the mechanism of drug resistance and target its control appropriately.

Infection Control Implications

Collectively, these data show hospital surfaces are reservoirs that support multidrug-resistant S. aureus; therefore, their incidence in a hospital, which means presence on the highest touched surface, poses a nosocomial risk and underscores the stringentness with infection control measure taken to check this rate and incidences. Implementation includes proper regular surface disinfections, appropriate hand hygiene programs, and antibiotic stewardship program activities to check spread by theses pathogens.

The analysis points out the multi-dimensional challenge that MRSA poses in healthcare settings, fueled by high prevalence rates, robust resistance mechanisms, and genetic adaptability. These findings form a basis for the implementation of evidence-based infection control measures and the promotion of a culture of sustained vigilance in healthcare facilities.

FINDINGS And DISCUSSION

Prevalence of Staphylococcus Aureus on Hospital Surfaces

The prevalence of Staphylococcus aureus on hospital surfaces was remarkably high, at 46.7%, which had the samples test positive. The significant contamination rate calls attention to hospital settings as reservoirs for multi-resistant pathogens. Bed rails topped the list with a 46.7% contamination rate, closely followed by bedside tables and doorknobs with contamination rates of 60% and 50%, respectively. These results highlight that high-touch surfaces should be targeted within infection control strategies. The large contamination rates indicate not only unsatisfactory hygiene practices but also serious threats to patients, healthcare workers, and visitors.

Antibiotic Resistance Profiles

The antibiogram study revealed a worrying resistance pattern among the isolates. The overall resistance rates for eight classes of antibiotics highlighted significant difficulties in treating S. aureus infections. The summary is given below:

High Resistance Rates: Penicillin had a remarkably high resistance rate of 95%, which clearly indicated its ineffectiveness against most of the isolates. Methicillin resistance, signifying MRSA, was observed in 46% of the isolates, indicating the common occurrence of MRSA in hospitals.

Macrolides and Lincosamides: Resistance to erythromycin (39%) and clindamycin (30%) indicates increasing challenges in treating infections due to macrolide-resistant S. aureus strains.

Other Antibiotics: Resistant rate was also 25% by ciprofloxacin, 20% by tetracycline, and 15% by trimethoprim/sulfamethoxazole indicating the vastness of resistance among these isolates. This suggests that no isolates contained the vancomycin resistance mechanism.

These trends toward resistance dictate the urgent implementation of rational antibiotic use and an aggressive stewardship program to reverse the population shift toward resistant pathogens.

Mechanism of Antibiotic Resistance at the Molecular Level

Molecular analysis showed that 46% of the isolates contained the mecA gene, which encodes methicillin resistance. This result is highly correlated with the phenotypic methicillin resistance shown in antibiotic susceptibility testing. Of these isolates, 39% were positive for the ermC gene. These genes confer macrolide resistance through the modification of antibiotic target sites. Such genetic adaptability shown by S. aureus prevents its susceptible effects from being antagonized by antibiotics typically administered in a clinical setting.

Interestingly, there was striking association between phenotypic resistance patterns and the presence of resistance genes. For example, while resistance rates for mecA positive were recorded for both methicillin, at 46%, and penicillin, at 43%. Similarly, for ermC, resistance percentages stood at 39% with respect to erythromycin and 32% in respect to clindamycin. Genetic-phenotypic correspondence is indicated as molecular diagnostics may enlighten mechanisms for resistance while allowing targeted therapy.

Infection Control Implications

These results hold significant implications for infection control practices in healthcare settings. The persistence of multidrug-resistant S. aureus on hospital surfaces is a major challenge because these surfaces become reservoirs that enhance the spread of pathogens. Contamination of high-touch surfaces such as bed rails and doorknobs requires stringent cleaning and disinfection protocols. Regular and effective surface disinfection, combined with high-performance hand hygiene practices, is critical to curtail the spreading nosocomial infections.

The high prevalence of MRSA also demands improved control of antibiotic use in the inpatient setting. Stewardship programs for antibiotics hold tremendous potential in checking unnecessary antibiotics, which would naturally curtail the development and spread of resistance. Education and training among hospital healthcare staff on infection control measures need to be continually made and reinforced to create a culture of high awareness and accountability.

Generalistic Inferences for Public Health End

The MRSA thus poses more than an individual hospital with the issue; it poses it to public health. And, given that there may be such extended hospital days, some treatments, plus complications by infections, there may be financial implications of the outbreak. There is an international trend identified by these results; this results in having high resistance figures and places a big threat to modern medical science. Collaborative activities at the regional, national, and international level are required in order to act on this now-escalating crisis more effectively.

RECOMMENDATIONS

Despite the above study giving detailed information on S. aureus prevalence and their resistance patterns, it also calls for further research activities. Future studies should elucidate the emerging novel disinfectation technologies with antimicrobial surfaces of hospital's surfaces. Additionally, investigations into alternative therapeutic options, such as phage therapy and immunomodulatory agents, could offer promising solutions to combat multidrug-resistant pathogens. Longitudinal studies monitoring resistance trends over time would also contribute to a deeper understanding of the dynamics of antimicrobial resistance.

This study establishes an essential role for hospital settings in the spread of MDR S. aureus. A high prevalence rate on the surfaces of a hospital setting coupled with the strain's impressive resistance mechanisms calls for quick, comprehensive action. Strict infection control, judicious use of antibiotics, and further investigation in other therapeutic alternatives will be essential strategies used to contain the MRSA and preserve public health.

It must, therefore, develop stricter infection control protocols for a prevalence of a significant level of MRSA on hospital surfaces. For example, the use of effective antimicrobial agents, proper and frequent cleaning, disinfection, or decontamination of various hospital surfaces such as doorknobs, bedside tables, and bed rails on the ward, would provide good patient care. Hospital surface MRSA contamination ought to be routinely screened on regular assessments to help assess risks promptly.

In the management of preventing MRSA, strong hand hygiene must be encouraged. Patients, caregivers, and visitors need to be advocated to carry out hand hygiene by washing with soap and water or alcohol-based hand sanitizer. Such campaigns and trainings must be done for them to strictly follow the standard protocols on hand hygiene.

Such stewardship programs against the rise in MRSA isolates are warranted. These should be implemented to ensure the judicious use of antibiotics to limit the emergence of resistance. The efforts will also be augmented by continuous monitoring of the resistance patterns and periodic review and update of treatment guidelines.

The final recommendation is that education for staff and visitor sensitization must be provided. Education of health workers on infection control practices and sensitization of visitors to hygiene and hospital practices will be very effective in preventing the spread of resistant bacteria. Coordinated efforts are necessary at institutional, regional, and national levels to meet this rising public health challenge effectively.

CONCLUSION

The study highlights the alarming prevalence and multidrug-resistant nature of Staphylococcus aureus on hospital surfaces in the Medicine ward of a hospital in Khyber Pakhtunkhwa. The results showed that nearly half of the sampled surfaces tested positive for S. aureus, and thus it represents a major public health concern. High-touch surfaces, including bed rails and bedside tables, were identified as critical reservoirs, showing their important role in the transmission of nosocomial infections.

The resistance profiles seen here are a challenging scenario for infection control and treatment. The resistance rates were very high for the most commonly used antibiotics, such as penicillin (95%) and methicillin (46%), showing that MRSA is present in health care settings in a highly prevalent manner. Resistance to macrolides like erythromycin and clindamycin makes treatment difficult. However, the susceptibility of all isolates to vancomycin gives hope, and it remains one of the cornerstones in managing MRSA.

Molecular analysis confirmed the presence of resistance genes mecA and ermC in 46% and 39% of isolates, respectively. These genetic markers align with the phenotypic resistance patterns, showing how S. aureus is capable of evading antibiotic therapies. The correlation between the genetics and phenotype highlights the role of molecular diagnostics in understanding and fighting antimicrobial resistance.

The implications extend from individual cases of infection into wider healthcare challenges. The contaminated surfaces in hospitals are reservoirs that allow the bacteria to be transmitted to the patients, healthcare workers, and visitors. The prolonged hospital stay, increased morbidity, mortality rates, and costs incurred in healthcare due to MRSA infections require intervention measures to be taken immediately and holistically.

Infection control measures should be rigorous in combating the spread of MRSA. All high-touch surfaces should be frequently and diligently disinfected using suitable antimicrobial agents.

Training on improved hand hygiene in institutional healthcare workers, patients, and the visitors must be strengthened. Alcohol-based hand sanitizer or the proper technique of hand hygiene, or both, must become mandatory and be supervised.

Critical in this context are antibiotic stewardship programs, which would limit the misuse of antibiotics, a primary driving force behind resistance. Rational practices in prescribing, based on testing for susceptibility, and reducing the emergent and spread of resistant strains would be helpful. Periodic surveillance for resistance patterns and the adoption of molecular diagnostics in day-to-day hospital practice further strengthens these efforts.

Equally important are educational activities focused on medical personnel and visitors. Campaigns will create a culture of watchfulness and adherence to infection control measures. Visitor rules and regulations should include hygiene practices, and access to sensitive areas in the hospital should be minimized to avoid risks of contamination.

It sheds further light on research in novel solutions in the management and prevention of MRSA infections. Some promising emerging technologies are antimicrobial coatings for surfaces in hospitals and alternative therapies such as phage therapy. Longitudinal studies tracing resistance trends will give much-needed insights into shifting dynamics in antimicrobial resistance.

The MRSA problem will be solved through coordinated efforts at institutional, regional, and national levels. Health care policies need to be directed towards infection control, antimicrobial stewardship, and research for new therapeutic strategies. International cooperation becomes a necessity in terms of knowledge sharing, resource availability, and the best practices for combating these multidrug-resistant pathogens.

The results of this study showed that multidrug-resistant S. aureus is critically spread by sources found in a hospital environment. Indeed, unless checked, the public health burden of MRSA will continue to escalate, threatening the very foundations of modern medicine. Through evidence-based infection control measures, judicious use of antibiotics, and a culture of accountability and vigilance, healthcare facilities can reduce the risks posed by MRSA and ensure patient, staff, and community health. It is time to act now, for failure to address this will have grave consequences for public health worldwide.

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