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# THE PREVALENCE OF METHICILLIN-RESISTANT STAPHYLOCOCCUS AUREUS AT ADDINGTON HOSPITAL: A CROSS-SECTIONAL STUDY IN DURBAN, KWAZULU-NATAL.

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## Abstract

### Background

*Staphylococcus aureus* (MRSA) is known to be a prominent public health issue that starts as a nosocomial infection that quickly escalates to catastrophic conditions such as pneumonia, necrotizing fasciitis, endocarditis, etc. The majority of *Staphylococcus aureus* infections among hospitalized patients are caused by methicillin-resistant *Staph. aureus* (HA-MRSA) which attributes 20–50% of *Staph. aureus* infections in South Africa.

### The aim and objectives of the study

This study aims to evaluate the prevalence of *Methicillin-Resistant Staphylococcus aureus* (MRSA) at Addington Hospital and to monitor patterns of different classes of antibiotics tested on MRSA.

### Methodology

This research study used a cross-sectional retrospective design with quantitative research analysis. Samples were tested for Microscopy, Culture, and Antibiotic Susceptibility in the microbiology laboratory from January 2021 to December 2021. The investigation focused on the sample population which tested positive for methicillin-resistant *Staphylococcus aureus*. It was recorded that a positive *Staphylococcus aureus* culture was used for quality control ensuring the accuracy of the results.

### Results

Out of a total of 373 patients with *Staphylococcus aureus* isolates from different clinical specimens, 30(8.04%) were methicillin-resistant and 343 (91.96%) were methicillin-sensitive *Staphylococcus aureus* (MSSA). Antibiotic susceptibility tests showed that all patient samples were susceptible to vancomycin 373(100%).

### Conclusion

The detection of 8.04% of MRSA in a hospital setting indicates that more work needs to be done to control MRSA prevalence.

***Keywords:*** Methicillin Resistant *Staphylococcus Aureus*, Antibiotic Susceptibility Testing, Quality Control.
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## Introduction

Methicillin-resistant *Staphylococcus aureus* (MRSA) infections present as a bloated hot wound filled with pus sores that resemble and feel like spider bites. It also appears as huge, red, painful bumps under the skin (called boils) and fluid-filled blisters (Mayo Clinic, 2022). People can acquire MRSA when they use antibiotics regularly, without a prescription, do not follow the recommendations, stop taking them early, or miss doses (CDC, 2019). MRSA can also be acquired through the sharing of needles, having tubes in your body for medical treatment, and healing from burns or surgery can also contribute to the risks of MRSA (TPCHD, 2018).

MRSA is caused by the bacterium *Staphylococcus aureus* (*Staph. aureus*). *Staph. aureus* is a gram-positive organism that is arranged in a "string of grapes" or appears as clusters when viewed under a light microscope (Sheikh, et al., 2021). It can either be aerobic or anaerobic; and grows best at 37°C at a pH of 7.4 (Edwards and Maseey, 2011). This pathogen is known to cause nosocomial infections, capable of colonizing 30% of healthy persons (Weidenmaier, et al., 2012). It is highly infectious frequently invading the skin, soft tissues, and bloodstreams of humans. It is the type of infection that is highly identified in the hospital setting, particularly with

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patients who have been hospitalized for a longer period (Desai, et al., 2011).

This bacterium causes a broad spectrum of diseases such as septicemia, abscesses, and wound infections producing purulent exudate (Desai, et al., 2011). The *Staph. aureus* is a commensal in the gastrointestinal tract, human skin, and nares however when it enters the bloodstream it can lead to infective endocarditis, sepsis, blisters, cellulitis as well as pneumonia (Kim, Missaiakas, Schneedwind, 2014). Research outcomes on a study conducted in the United States in 2012, predicted a rise in the incidence of *Staph. aureus* bacteremia, ranging from 20 to 50 cases/100,000 per year, with 10% to 30% of these patients dying from the infection (Van Hal, 2012). As MRSA infections rise uncontrollably, this may become a huge health problem and new strains may develop placing a country at risk of failing to control infections (Rasigade and Vandenesch, 2014). This study aimed to evaluate the prevalence of Methicillin-Resistant *Staphylococcus aureus* in a Hospital in a Durban-based hospital.

The MRSA infections are based on the resistance of *Staph. aureus* to certain antibiotics (TPCHD, 2019). Antibiotic resistance occurs when bacteria such as *Staph. aureus* gains the ability to resist the medications designed to kill them. That implies the bacteria are not eliminated and can continue to multiply, resistant infections can be difficult, if not impossible, to treat (WHO, 2019). Since the 1990s, MRSA infection has surged in both healthcare facilities and communities, owing to the emerging MRSA clones, that appear to have acquired phenotypic features that make them more virulent or more able to colonize (David and Danum, 2010) (Otto, 2012). MRSA has a high death rate and can infect almost any part of the body (Lakhundi and Zhang, 2018). The European Union (EU) reported cases, of roughly 150,000 MRSA infections per year, resulting in over 7000 deaths (Cassini, et al, 2015). This has led to MRSA being identified as one of the most dangerous pathogens in a hospital or community (Otto, 2010), This is due to the bacterial infection being resistant to standard medications such as methicillin, amoxicillin, and penicillin (NCI, 2013).

The first line drug of choice for *Staph. aureus* is methicillin but since it is no longer commercially available oxacillin is now used as it is in the same class of drugs with methicillin (CDC, 2019). Oxacillin is a penicillin beta-lactam antibiotic used to treat bacterial infections caused by susceptible, mainly gram-positive organisms. Oxacillin inhibits the third and final stage of bacterial cell wall formation by attaching to certain penicillin-binding proteins (PBPs) found within the bacterial cell wall (Chung, 2008). Cell lysis is then mediated by bacterial cell wall autolytic enzymes such as autolysins (Papich, 2016).

Based on antibiotic susceptibilities, methicillin resistance in *Staph. aureus* is defined by an oxacillin minimum inhibitory concentration (MIC) of 4 g/mL. As a result, whenever oxacillin becomes resistant to *Staph. aureus* is termed Methicillin Resistant *Staph. aureus* (MRSA), and this strain is now further resistant to a large group of antibiotics called beta-lactams, which include penicillin and cephalosporins (Kayastha, 2010). Given that it is resistant to some regularly used antibiotics, it is more difficult to treat than most strains of *Staph. aureus* (WebMed, 2023). Vancomycin is the recommended first-line therapy for MRSA bacteremia, with daptomycin being an effective option (Houbar, et al., 2016). The objective of this study was to evaluate other possible antibiotic treatments that can be used to alleviate the rise of MRSA infections.

Understanding the mechanism of action of antibiotics and the cause of resistance is critical for selecting the optimum antibiotic for the treatment of MRSA (Scudiero, et al., 2020). *Staph. aureus* can develop resistance to any antibiotic that is administered to it. Resistance can arise from horizontal gene transfer mediated by plasmids or other mobile genetic elements, or from chromosomal gene changes (Jenul and Horswill, 2019). MRSA can live for hours, days, or even weeks on surfaces such as towels, razors, furniture, and athletic equipment. It can spread to anyone who comes into contact with a contaminated surface, and MRSA can cause infections if it gets into a cut, scrape, or open wound (CDC,2019).

Considering that MRSA can contaminate the surroundings, it is therefore critical that MRSA-infected patients' rooms must be thoroughly disinfected, including over-bed tables, handrails, floors, and any healthcare equipment used during patient care (Calfee, et al.,2014). Hospital visitors and healthcare personnel who treat patients in hospitals are required to wear protective clothing and adhere to strict hand hygiene protocols (TPCHD, 2019). This is a hospital standard practice intended to reduce infection rates as well as cross-contamination. It is recommended that hospitals with high rates of MRSA infection should undertake an active surveillance program as a stringent measure to monitor the spread of MRSA (TPCHD, 2019). Healthcare personnel can aid in the prevention of MRSA by washing their hands with soap and water or using hand sanitizer before and after each clinical consultation (Calfee, et al., 2014). This study would also assist in the development of infection control programs within the hospital to control the spread of MRSA.

This research was based on the prevalence of MRSA in patients admitted to Addington Hospital in KwaZulu Natal. This research reviewed microbiology findings of antibiotic sensitivity results of *Staph. aureus* to evaluate and determine the threat of MRSA in our public health system.

Data was collected from Addington upon request on AARMS (Academic Affairs and Research Management System) and received in a folder via email. The data included all patients positive for MRSA between January 2021 to December 2021. Results were then recorded as seen

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in Chapter 4. The primary aim of this study was to assess the prevalence of MRSA at Addington Hospital. Additionally, the investigation aimed to monitor the pattern of other tested antibiotics for MRSA.



## Methodology

### Ethical considerations

The Mangosuthu University of Technology research committee provided ethical approval (REF: RD5/05/2023). National Health Laboratory Services (NHLS) was contacted to obtain authorizations to access patient results for the study research. Patient confidentiality was ensured by an academic affairs and research management system. Only the investigator had access to the acquired data. This was important to avoid patient information being misused. Patient records were not disclosed to anybody who was not part of this research investigation.

### Study Design

This research was a cross-sectional retrospective study that used quantitative research analysis. The laboratory results were obtained from the NHLS electronic database at Addington Hospital as per the memorandum of understanding (MOU) between the Mangosuthu University of Technology institution (MUT) and the Department of Health (DOH). The data was used to evaluate the prevalence of MRSA at Addington Hospital from January 2021 to December 2021.

### Study setting and population

This research was conducted using data from Addington Hospital, a hospital located in Durban, KwaZulu-Natal.

### Sampling and sample size

The research investigation was conducted on patients whose biological samples were tested for Microscopy culture and Antibiotic Susceptibility in the Microbiology laboratory from January 2021 to December 2021. These patients were selected by reviewing data obtained from the electronic hospital information system. From the data reviewed, a total of 373 patients who were positive for *Staphylococcus aureus* were received and from this data patients with methicillin-resistant *Staphylococcus aureus* were evaluated.

### Data collection

Retrospective data was retrieved using the Laboratory Information System (TrakCare) of the Addington Hospital Laboratory in Durban, KwaZulu-Natal. Data on MRSA patients was collected and analyzed from January to December 2021.

### Statistical analysis

The data gathered was placed into a Microsoft Excel spreadsheet and examined. Microsoft Excel was used to construct statistical features to aid in the arranging of the data by percentage. Data was used to complete the evaluation and determine the prevalence of MRSA. The spreadsheet contained information about the patient's demographics, the source/specimen of the isolate, the ward, and the antibiotic susceptibility profiles. The number of MRSA isolates was divided by the total number of *Staph aureus* infections identified at the Addington Hospital laboratory to calculate positive rates for MRSA.

### Laboratory Investigation of MRSA

The samples were collected from patients with *Staph aureus-related* infections and sent to a microbiology laboratory to be cultured on a basic and selective medium using the most traditional approach. The culture plates were incubated overnight and observed for the growth of *Staphylococcus aureus*. Resistance to antibiotics like methicillin and oxacillin was identified after growing on simple selective media for +/- 16 hours. Antibiotic susceptibility testing was carried out using Kirby Bauer's disc diffusion technique by Clinical and Laboratory Standards Institute (CLSI) recommendations. This confirmed the presence of MRSA in the clinical samples processed in the laboratory. Quality Control was performed using a positive culture of Staphylococcus aureus to ensure the accuracy of the results.

## Results

### Prevalence of MRSA

The total number of patients positive for *Staphylococcus aureus (Staph. aureus)* was 373. This data was then used for the detection of the prevalence of MRSA in Addington Hospital. *Staph. aureus* isolates resistant to cloxacillin determined methicillin-resistant *Staph. aureus* (MRSA) and susceptibility to cloxacillin determined methicillin-susceptible *Staph. aureus (*MSSA). Of the 373 patients positive for staph aureus, 30 (8.04% were MRSA, and the 343, 91.96% were MSSA in this study.

Figure 1: Bar graph showing the antibiotic susceptibility of Staphylococcus aureus, MRSA having 8.04% and MSSA having 91.96% prevalence.

### Socio-demographic characteristics of patients

Out of the 373 *Staph. aureus* patients' data received a relatively higher percentage of MRSA isolates in males (22, 9.65%) than in females (8. 5.52%). The gender groups had no significant association seen by a p-value of 0.17018, greater than 0.05.

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**Table 1: This table shows the rate of methicillin-resistant Staph. aureus about gender.**

| | MRSA | | MSSA | | Total *Staph. aureus* isolates | P- value |
|---|---|---|---|---|---|---|
| **GENDER** | **N** | **%** | **N** | **%** | **N = 373** | |
| **Females** | 8 | 5.52% | 137 | 94.48% | 145 | 0.17018 |
| **Males** | 22 | 9.65% | 206 | 90.35% | 228 | |

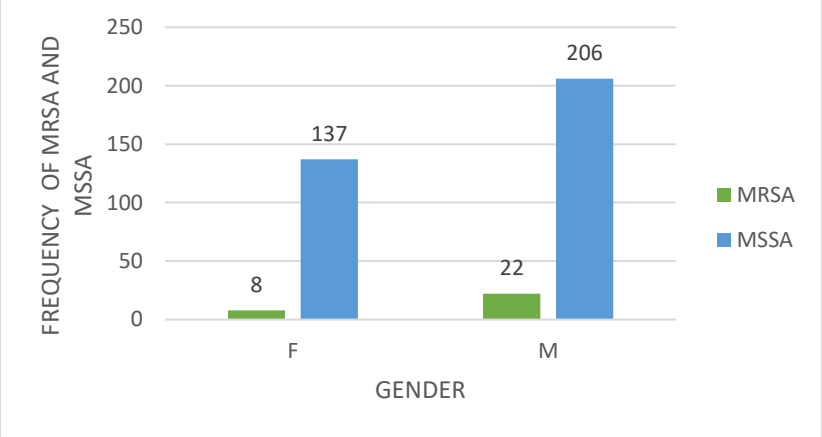


*Figure 2: Bar graph showing the distribution of MRSA and MSSA in males and females.*

In addition, the cases of MRSA (30 patients) were detected highest in the age group 10-29 and 30-49 which reported 9 cases respectively, followed by 50-69 that had 8 cases the rest of the age groups had low to no cases. In MSSA, with 343 cases, the age group with the highest number of isolates were detected in age group 30-49 with 109 cases and the lowest cases in age group 70-89 with 10 cases of MSSA.

The isolation rate of MRSA in relation to age groups was not significantly associated, seen by a p value of 0.49 in the age groups, this is seen by the p values being greater than 0.05.

Table 2: This table shows the rate of methicillin resistant *Staph. aureus* with regard to age.

| | MRSA | | MSSA | | Total *Staph. aureus isolates* | P value |
|---|---|---|---|---|---|---|
| **AGE** | **N** | **%** | **N** | **%** | **N = 373** | |
| <10 | 2 | 0.54% | 63 | 16.89% | 65 | 0.48634 |
| 10-29 | 9 | 2.41% | 93 | 24.93% | 102 | |
| 30-49 | 9 | 2.41% | 106 | 28.42% | 115 | |
| 50-69 | 8 | 2.14% | 59 | 15.82% | 67 | |
| 70-89 | 2 | 0.54% | 10 | 2.68% | 12 | |
| >90 | | 0.00% | 12 | 3.22% | 12 | |

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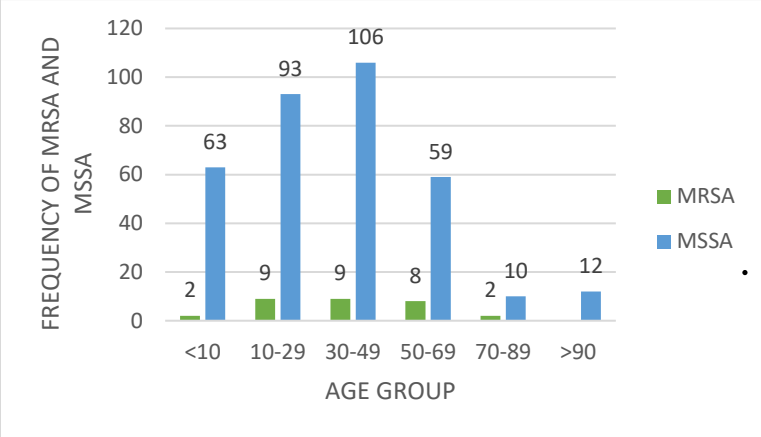


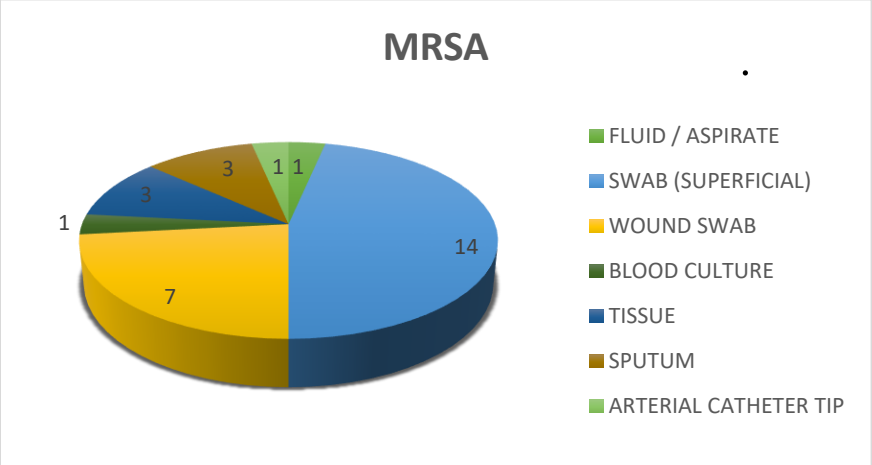

*Figure 1: Bar graph showing the distribution of MRSA and MSSA in different age groups.*

## Prevalence of MRSA in clinical specimens

From the 30 MRSA isolates, MRSA had the highest isolation in superficial swabs with 14 cases followed by wound swabs with 7 cases, tissue and sputum reported 3 cases respectively and fluid aspirate, blood culture and arterial catheter tip reported 1 case respectively. In MSSA superficial swabs had the highest case of 135 cases followed by fluid aspirate with 78 cases and blood culture reported 39 cases of MSSA. The p value was 0.44 (>0.05) hence there was no association between isolation rates of MRSA with any clinical sample

.

**Figure 4: Methicillin resistant Staph. aureus association with different types of clinical specimens**




## Antimicrobial susceptibility pattern of Staph. aureus

The only antibiotics provided were cloxacillin, which had 30 *Staph. aureus* isolates resistant to cloxacillin and 343 (91.96%) susceptible to cloxacillin. All 100% (373) isolates were susceptible to vancomycin including MRSA isolates. This limited information on the antimicrobial susceptibility was derived from the data received.

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**Table 3: Antimicrobial sensitivity patterns of *Staph. aureus*.**

| Antibiotic therapy | Resistance | | Sensitivity | |
|---|---|---|---|---|
| | N | (%) | N | (%) |
| CLOXACILLIN | 30 (8.04) | 8.04% | 343(91.96) | 91.96% |
| VANCOMYCIN | 0 (0) | 0% | 373 (100.00) | 100% |



## Discussion

### The Prevalence of MRSA

MRSA has emerged as a danger to global health. It has increased the burden on patients by extending hospital stays and raising morbidity and mortality rates. The overall prevalence of MRSA in our study was 8.04%. The gender of the patients was not significant with the isolation of *Staph. aureus*, given the reported p-value, was <0.05 for MRSA and MSSA. This was similar to the study conducted in Eritrea (Garoy, et al. 2019). However, the isolation rate in age groups was not significant as well. Moreover, with high isolation rates in superficial swabs (obtaining swabs on the surface of the skin), it is important to note that 1 blood culture patient sample had MRSA from this study as blood should be sterile.

This research study is consistent with a study conducted in a referral hospital in Northeast Ethiopia which reported an MRSA rate of 9.8% (Tsige, et al., 2020). It was also consistent with the MRSA rate reported in Iran, Shahid Sadoughi Hospital with an MRSA rate of (11.92%) whereas nails and nose had the highest isolation rate (Khalili, et al., 2013). The MRSA rate in this study is however lower than a study conducted in KwaZulu-Natal, on a TB ward of the Church of Scotland hospital, which revealed 21% MRSA isolates, and these were more common in patients who were previously hospitalized (Falagas, 2013). It was also reported higher in research conducted at Chris Hani Baragwanath Academic Hospital, South Africa which reported an MRSA rate of 19% in 2013, where admission to the intensive care unit was the only risk factor associated with MRSA (Raphulu et al., 2023). MRSA rate for this study was lower than a study conducted in Nigeria, to investigate the prevalence of MRSA from hospitalized wound patients in a tertiary hospital in Enugu Metropolis, the prevalence was identified to be 22.3%, where more females (12.7%) had MRSA than males (9.6%) (Chukwueze, et al., 2022). From this, it is evident that the prevalence of MRSA in Addington Hospital is fairly low in comparison to the hospitals in South Africa where research on MRSA was conducted (Chukwueze, et al., 2022). This could be due to the implementation of effective control policies in Addington Hospital such as effective personal hygiene, proper wound care, optimum laundry, and cleaning or disinfection of high-touch surfaces.

### Antimicrobial Susceptibility Patterns

Among the 30 MRSA isolates, all 30 (100%) were resistant to cloxacillin, a commonly used antibiotic for the treatment of methicillin-sensitive *Staphylococcus aureus*. These isolates were all reported as sensitive to vancomycin, the first-line drug of choice for MRSA, this is by studies conducted in Pakistan (Hussain, et al., 2019), Jamaica (Gustave, 2020), and Barbados (Gittens, 2020). However, some studies reported vancomycin-resistant *staph, aureus* (VRSA) cases. This is supported by a study conducted in Eritrea, in 2016, investigating the prevalence of MRSA in Asmara, that discovered 15,9% of their isolates were VRSA (Garoy, 2019). VRSA might be due to the unrestricted use of antibiotics resulting in therapeutic failure and hence increasing the mortality of patients (Garoy, 2019). Vancomycin has been used to treat MRSA infections for a long time its side effects like renal impairment and high costs have limited its use. It is likely to maintain its effectiveness as long as vancomycin resistance is controlled (CDC, 2014).

### Limitations

- The first limitation of this study was the lack of data for other tested antibiotics on the *Staph. aureus* to examine other antibiotic-resistant patterns, only cloxacillin and vancomycin were investigated.
- The distinction between HA-MRSA and CA-MRSA could not be ruled out due to no access to patient history, therefore the actual source of infection remains unknown.
- Molecular tests for MRSA were not available as the identification of MRSA has the mecA gene and can be characterized by SCCmec typing.
- During of hospital stay, the majority of the patients did not have a history of antibiotic use.

### Recommendations

- Continued surveillance of MRSA isolates in hospitals across the country is critical for preventing the spread of virulent nosocomial infections and implementing strengthened infection control techniques.

- Further studies can be conducted on Vancomycin-Resistant *Staphylococcus aureus* as has been reported in other studies to implement measures that can be taken to curb its spread.



## Conclusion

In conclusion, out of 373 patients positive for Staph. aureus, 30 (8.04%) were infected with MRSA which was not as high as previous studies. All the MRSA isolates were resistant to cloxacillin for the identification of MRSA and susceptible to vancomycin as the drug of choice for the treatment of MRSA. The low rate of MRSA in this study may be due to an increased awareness of the infection by medical staff where infection control measures are followed to prevent the outbreak of MRSA and other infections.

Regular surveillance and monitoring of antibiotic sensitivity patterns is required to reduce MRSA prevalence in hospitals and other medical settings. The current study reveals that vancomycin remains the first-line therapy for MRSA infection. To maintain its value, vancomycin should only be used when it is needed to prevent vancomycin-resistant strains from forming due to antibiotic misuse and overuse.

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## Conflict of interest

The authors have no competing interests to declare.

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