



(RESEARCH ARTICLE)



## STAPHYLOCOCCUS AUREUS ISOLATES AND METHICILLIN RESISTANCE AT A MILITARY HOSPITAL IN MARRAKECH, MOROCCO (2017-2025)

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### ABSTRACT

**Background:** Methicillin-resistant *Staphylococcus aureus* (MRSA) is an important antimicrobial-resistance concern. This study describes the distribution and antimicrobial susceptibility of *S. aureus* clinical isolates at Avicenne Military Hospital, Marrakech, Morocco.

**Methods:** A retrospective descriptive analysis covered 1 July 2017 to 31 October 2025. Non-duplicate clinical *S. aureus* isolates from routine microbiology samples were identified using conventional methods and BD PHOENIX M50 and/or API STAPH systems. Susceptibility testing followed the laboratory's contemporaneous CA-SFM/EUCAST procedures; methicillin resistance was screened using a 30-µg cefoxitin disk.

**Results:** Among 8,787 bacterial isolates, 727 (8.27%) were identified as *S. aureus*. Male patients accounted for 558/727 isolates (76.7%). Surgical wards contributed 256 (35.2%) isolates and intensive care 222 (30.5%). The leading specimens were pus or skin/soft-tissue samples (265; 36.4%) and respiratory samples (177; 24.3%). MRSA accounted for 92/727 isolates (12.7%). Reported resistance proportions among MRSA isolates were 50% to fusidic acid, 49% to kanamycin, 48% to erythromycin, and 45% to tetracycline. The source report described 100% susceptibility to vancomycin and 99% to linezolid, although antibiotic-specific denominators were unavailable.

**Conclusion:** *S. aureus* was frequently recovered from surgical and critical-care specimens in this hospital-based collection. MRSA accounted for approximately one in eight *S. aureus* isolates and exhibited substantial co-resistance to several non-beta-lactam agents. Consistent specimen-based surveillance and locally informed antimicrobial stewardship are warranted.

**Keywords:** *Staphylococcus aureus*; Methicillin-Resistant *Staphylococcus aureus*; Antimicrobial Resistance; Hospital Microbiology; Morocco; Retrospective Surveillance.

### 1 INTRODUCTION

*Staphylococcus aureus* is a major cause of skin and soft-tissue infections, bloodstream infection, osteoarticular disease, pneumonia, and device-associated infection. The clinical consequences of *S. aureus* are amplified by antimicrobial

resistance and by the vulnerability of hospitalized patients [1]. The World Health Organization classifies methicillin-resistant *S. aureus* (MRSA) among high-priority antibiotic-resistant bacterial pathogens [2].

Methicillin resistance is principally associated with altered penicillin-binding protein activity linked to *mec* determinants carried in staphylococcal cassette chromosome *mec* elements. The epidemiology and associated non-beta-lactam co-resistance patterns of MRSA vary across settings, so antimicrobial treatment and infection-prevention priorities benefit from locally representative laboratory data [3,4].

This study aimed to describe the proportion of *S. aureus* among bacterial isolates, the demographic and specimen distribution, the proportion classified as MRSA, and reported antibiotic-resistance patterns in a single military hospital laboratory in Marrakech during 2017-2025. As annual isolate counts were not supplied, the analysis is descriptive and does not attempt to quantify year-on-year trends.

## 2 MATERIALS AND METHODS

### 2.1 Study design and setting

This retrospective, descriptive, single-centre laboratory study used microbiology data from Avicenne Military Hospital, Marrakech, Morocco, spanning 1 July 2017 to 31 October 2025 (8 years and 4 months). The unit of analysis was a non-duplicate *S. aureus* clinical isolate. The source report stated that repeat isolates from the same patient and infectious episode were excluded.

### 2.2 Sample processing and identification

Samples were obtained during routine clinical care, from inpatients and patients assessed through other hospital services. *S. aureus* identification relied on colony characteristics, Gram stain, catalase and coagulase reactions and was supported by the BD PHOENIX M50 automated system and/or API STAPH biochemical identification panels. The original dataset summary did not specify how many isolates were processed by each method.

### 2.3 Antimicrobial susceptibility and MRSA classification

Antimicrobial susceptibility was assessed by automated testing and/or agar disk diffusion according to the CA-SFM/EUCAST guidance in use during the corresponding year. A 30-µg cefoxitin disk was used for phenotypic screening of methicillin resistance. The original summary did not provide cefoxitin zone diameters, drug-specific testing denominators, or MIC distributions. Therefore, the reported susceptibility percentages should not be interpreted as MIC-based susceptibility distributions [5].

### 2.4 Analysis

Results are summarized as counts and proportions using the reported totals. No inferential tests, patient-level outcomes, annual trend estimates, or between-ward resistance comparisons were performed because the necessary individual-level data were not available in the source report. Descriptive observational reporting was informed by STROBE principles where supported by the available material [6].

## 3 RESULTS

### 3.1 Isolate frequency and demographic profile

During the study period, the laboratory recorded 8,787 bacterial isolates, of which 727 were identified as *S. aureus* (8.27%). Among the *S. aureus* isolates, 558 (76.7%) originated from male patients and 169 (23.3%) from female patients, corresponding to a male-to-female ratio of approximately 3.3:1. The distribution of patients by age was not supplied.

### 3.2 Clinical services

The largest groups of *S. aureus* isolates were contributed by surgical services (256; 35.2%) and the intensive care unit (222; 30.5%). Medical wards accounted for 133 (18.3%) isolates, while the combined category of emergency department and outpatient consultations comprised 116 (16.0%) isolates (Table 1). The source document also described 97% of isolates as inpatient-derived, but did not provide a breakdown allowing that classification to be independently reconciled with the combined emergency/outpatient category.

**Table 1: Distribution of *S. aureus* isolates by referring service (n = 727).**

| Hospital service                                  | Isolates (n) | Share (%) |
|---------------------------------------------------|--------------|-----------|
| Surgical services                                 | 256          | 35.2      |
| Intensive care                                    | 222          | 30.5      |
| Medical services                                  | 133          | 18.3      |
| Emergency and outpatient consultations (combined) | 116          | 16.0      |
| Total                                             | 727          | 100.0     |

### 3.3 Specimen types

Pus and skin/soft-tissue samples accounted for 265 isolates (36.4%), followed by respiratory specimens (177; 24.3%) and blood cultures (102; 14.1%). All reported specimen categories sum to 727 isolates (Table 2). A specimen category should not be interpreted as proof of clinical infection without patient-level context.

**Table 2: Distribution of *S. aureus* isolates by specimen type (n = 727).**

| Specimen type                                              | Isolates (n) | Share (%) |
|------------------------------------------------------------|--------------|-----------|
| Pus and cutaneous/mucosal specimens                        | 265          | 36.4      |
| Respiratory specimens                                      | 177          | 24.3      |
| Blood cultures                                             | 102          | 14.1      |
| Urine                                                      | 58           | 8.0       |
| Prosthetic material and catheters                          | 49           | 6.7       |
| Other biological fluids (including joint, pleural and CSF) | 76           | 10.5      |
| Total                                                      | 727          | 100.0     |

### 3.4 Methicillin resistance and co-resistance

A total of 92/727 *S. aureus* isolates were classified as MRSA (12.7% by conventional rounding); the remaining 635 were methicillin susceptible (MSSA). In the MRSA group, the report described approximately half of isolates as resistant to fusidic acid (50%), kanamycin (49%), and erythromycin (48%), and 45% as resistant to tetracycline. Comparator percentages recorded for MSSA were 9%, 17%, 17%, and 31%, respectively (Table 3). Penicillin G resistance was reported in 95% of MSSA isolates.

**Table 3: Reported antibiotic-resistance percentages in MSSA and MRSA isolates.**

| Antibiotic   | MSSA resistant (%) | MRSA resistant (%) |
|--------------|--------------------|--------------------|
| Fusidic acid | 9                  | 50                 |
| Kanamycin    | 17                 | 49                 |
| Erythromycin | 17                 | 48                 |
| Tetracycline | 31                 | 45                 |
| Penicillin G | 95                 | 100*               |

The original narrative reported 100% penicillin G resistance in MRSA. Drug-specific numbers tested and resistant were not provided; percentages in Table 3 are therefore reported as supplied and were not recalculated from patient-level data.

The source abstract reported full (100%) susceptibility to vancomycin and 99% susceptibility to linezolid. The discussion contained a conflicting statement of 100% linezolid susceptibility; the abstract value is retained here pending confirmation against laboratory records. An exact denominator for either agent was not supplied.

## 4 DISCUSSION

This single-centre surveillance summary shows that *S. aureus* represented 8.27% of all bacterial isolates processed during the study period, with a substantial concentration of isolates originating from surgical and intensive-care settings. These proportions reflect the clinical specimen and hospital-service mix of the institution; they are not community incidence rates, patient-level infection prevalence estimates, or measures of hospital acquisition. The observed male predominance may reflect the patient population served by a military hospital, but occupation and admission-type data were not available to test this explanation.

The reported MRSA proportion, approximately one eighth of *S. aureus* isolates, is a useful local descriptive measure. However, comparisons with other hospitals must account for different definitions of duplicate isolates, clinical case mix, inpatient/outpatient referral patterns, collection periods, and susceptibility methods. The present report contains no yearly counts, and consequently neither an increase nor a decrease in MRSA over the study interval can be inferred. Regional differences in MRSA epidemiology are well documented in the scientific literature [3].

Non-beta-lactam co-resistance in the MRSA subset was most prominent for fusidic acid, kanamycin, erythromycin, and tetracycline. These percentages support continued local antibiogram monitoring; however, the absence of drug-specific denominators and isolate-level susceptibility results limits assessment of testing completeness or multidrug-resistant combinations. The observed rates should not be treated as predictive of a specific patient's treatment response. Phenotypic ceftiofur screening is a practical surrogate for methicillin resistance, but no molecular typing or *mec*-gene data were provided for this series [3-5].

The reported vancomycin susceptibility is potentially reassuring for laboratory surveillance, although it cannot be equated with universal clinical efficacy. Linezolid susceptibility was reported inconsistently in different sections of the source summary (99% versus 100%), and the underlying record should be checked before a definitive numerator and denominator are presented. No clinical outcomes, vancomycin MIC distributions, stewardship interventions, or strain relatedness data were available to support stronger therapeutic or transmission conclusions.

The study has important limitations: it is retrospective and single-centre; testing denominators are unavailable for individual antimicrobial agents; the original summary does not provide patient ages or clinical outcomes; the inpatient designation cannot be fully reconciled from the mixed referral category; and no annual data or molecular characterization are available. Nonetheless, the aggregated results identify specimen and service distributions that may help focus prospective surveillance and targeted infection-prevention auditing. Routine reporting based on consistent laboratory definitions and continued stewardship remain appropriate priorities [2,5].

## 5 CONCLUSION

Across more than eight years of laboratory surveillance at Avicenne Military Hospital in Marrakech, 727 of 8,787 bacterial isolates were identified as *S. aureus*. MRSA accounted for 92 isolates, approximately 12.7% of *S. aureus*, with relatively high reported resistance to fusidic acid, kanamycin, erythromycin, and tetracycline. The findings support continued standardized microbiological surveillance, infection prevention and context-specific antimicrobial stewardship. Detailed annual and isolate-level datasets would be needed to study trends and treatment implications.

## STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

### *Disclosure of conflict of interest*

The authors declare no conflicts of interest.

### *Statement of ethical approval*

This retrospective analysis reports aggregated results from routine diagnostic microbiology. No direct patient identifiers are presented. The study was conducted in accordance with applicable institutional data-governance requirements.

### *Statement of informed consent*

Only retrospective, aggregated, non-identifiable laboratory data are reported; no individual patient information or identifiable images are included.

### *Authors' contributions*

All five authors contributed to the work, reviewed the manuscript and approved the final submitted version.

### *Data availability*

The article reports aggregated laboratory data only. The underlying records are not included in the submission. Any permitted access to de-identified supporting data is subject to institutional rules and must be confirmed by the data custodian.

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