International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(RESEARCH ARTICLE)

Check for updates

Staphylococcus aureus infections and antibiotic resistance patterns at the Department of Infectious Diseases of Ibn Rochd University Hospital, Casablanca: A three-year retrospective study

K. SANHAJI [1, 3, *], A. KETTANI [1, 2], K. ZEROUALI [1, 2] and M. SOUSSI ABDELLAOUI [1, 2]

[1] *Department of Bacteriology, Virology and Hospital Hygiene, Ibn Rochd University Hospital, Casablanca, Morocco.*
[2] *Faculty of Medicine and Pharmacy of Casablanca, Hassan II University, Morocco.*
[3] *Faculty of Medicine and Pharmacy of Agadir, Ibn Zohr University, Morocco.*

International Journal of Science and Research Archive, 2023, 08(01), 1159-1166

Publication history: Received on 17 December 2022; revised on 24 January 2023; accepted on 29 January 2023

Article DOI: https://doi.org/10.30574/ijsra.2023.8.1.0094

Abstract

Staphylococcus aureus is one of the most frequent bacterial pathogens involved in both community-acquired and healthcare-associated infections. The emergence of methicillin-resistant strains (MRSA) is a major public health concern, especially in high-risk hospital wards. In Morocco, local data remain limited and the surveillance is not standardized at the national level. This study concerned patients followed at the Department of Infectious Diseases of Ibn Rochd University Hospital, in whom *S. aureus* was isolated at the Bacteriology Laboratory of the same hospital. 59 isolates from 42 patients were compiled over a three-year period (January 2019 to December 2021). The mean age was 46 years, with a male predominance (sex ratio 2.2). MRSA was identified in 15.3% of samples. The most active antibiotics were rifampin (5% resistance), clindamycin (7%), gentamicin (8%) and trimethoprim-sulfamethoxazole (9%). The highest resistance rates were observed for tetracycline (50%) and fusidic acid (44%). MRSA isolates showed substantially higher co-resistance rates than MSSA, particularly for tetracycline (100% vs 44%), fusidic acid (86% vs 33%) and chloramphenicol (80% vs 12%). All MRSA strains were isolated from non-sterile sites; no MRSA was detected in sterile-site samples. Our findings are consistent with recent Moroccan data, lower than figures reported in some Tunisian centers, and within the range observed in southern European countries.

Keywords: *Staphylococcus aureus*; MRSA; Antibiotic resistance; Antibiogram; Infectious diseases; Ibn Rochd UHC; Casablanca

1. Introduction

Staphylococcus aureus is a Gram-positive coccus belonging to the Staphylococcaceae family. It colonizes the nasopharyngeal mucosa and moist skin areas in approximately 30% of the general population as a healthy carrier state. This asymptomatic carriage represents a permanent reservoir and promotes person-to-person transmission, mainly through direct contact and hand carriage [1].

Clinically, *S. aureus* is responsible for a wide spectrum of infections. Superficial suppurative lesions such as folliculitis, furuncles and anthrax are the most common, but the bacterium can cause severe deep infections, including septicemia, endocarditis, necrotizing pneumonia, meningitis and septic arthritis. In the hospital setting, *S. aureus* is one of the leading agents of nosocomial infections, often associated with iatrogenic portals of entry such as vascular catheters, surgical wounds and implanted medical devices [2].

* Corresponding author: K. SANHAJI

The global emergence of methicillin-resistant *S. aureus* (MRSA) since the 1960s has profoundly modified the management of staphylococcal infections. Methicillin resistance is mediated by the mecA gene, which encodes the modified PBP2a protein, and confers resistance to all beta-lactams. It is frequently associated with multiple co-resistances, which considerably reduces the available therapeutic options [3]. While MRSA was initially confined to the hospital environment, community-acquired MRSA strains — often carrying the Panton-Valentine leukocidin — now constitute an additional emerging threat [4].

In Morocco, epidemiological data on *S. aureus* infections remain fragmented and mainly derived from single-center studies. The Ibn Rochd University Hospital in Casablanca, as a major referral center receiving a mixed population, represents an ideal sentinel site to describe the local profile of this pathogen.

The objective of our study is to describe the epidemiological, clinical and bacteriological characteristics of *S. aureus* infections at the Department of Infectious Diseases of Ibn Rochd UHC over a three-year period, to analyze the antibiotic susceptibility profile, to compare MRSA and MSSA phenotypes, and to assess the resistance profile according to sample category.

2. Patients and method

This is a retrospective descriptive study, which concerned patients followed at the Department of Infectious Diseases of Ibn Rochd University Hospital in Casablanca, in whom a *S. aureus* strain was isolated at the Bacteriology Laboratory of the same hospital, over a three-year period from January 1, 2019 to December 31, 2021. Data were extracted from two complementary sources: the medical records of patients followed at the Department of Infectious Diseases, and the bacteriological database of the laboratory.

Included are all samples in which *S. aureus* was identified, regardless of the patient's age and sex. All samples whose records were incomplete were excluded from sub-group analyses but kept for global descriptive statistics.

Identification of *S. aureus* was performed according to standardized procedures: direct microscopic examination after Gram staining, culture on Columbia blood agar (35–37°C, 24–48 h), catalase test, free coagulase test on tube and bound coagulase test by slide agglutination. Differentiation between *S. aureus* and coagulase-negative staphylococci was systematically verified.

Antibiotic susceptibility testing was performed by the disk diffusion method on Mueller-Hinton agar (Kirby-Bauer method) according to the recommendations of the Antibiogram Committee of the French Society of Microbiology (CASFM/EUCAST). Methicillin resistance was screened with the cefoxitin disk (30 µg), with an inhibition zone diameter ≤ 21 mm defining MRSA. The antibiotics tested were: cefoxitin (MRSA marker), gentamicin, tobramycin, kanamycin, norfloxacin, ciprofloxacin, levofloxacin, erythromycin, clindamycin, trimethoprim-sulfamethoxazole, fusidic acid, rifampin, chloramphenicol and tetracycline.

Samples were classified according to the REMIC (Référentiel en Microbiologie Médicale) standard into two categories: sterile-site samples (blood cultures, cerebrospinal fluid, pleural fluid, deep tissue biopsies) for which any positive culture is considered significant, and non-sterile-site samples (skin swabs, pus, surgical wounds, drains, catheters, urine, stoma) for which interpretation must take into account the clinical context. A healthcare-associated infection was defined according to ECDC criteria: onset of clinical signs more than 48 hours after admission, in the absence of prior incubation.

After selecting the complete information sheets, we processed the data on Microsoft Excel. We recorded the information in a structured table to facilitate analysis and interpretation. Quantitative variables are expressed as mean ± standard deviation and median. Qualitative variables are expressed as numbers and percentages. Comparisons between subgroups were based on descriptive statistics, using crude percentages and percentage-point differences, given the limited sample size and the descriptive aim of the study.

3. Result

During the period of our study, we collected 59 *S. aureus* isolates from 42 patients at the Bacteriology Laboratory of Ibn Rochd University Hospital, all of which were included. The samples were distributed by year as follows: 9 in 2019, 21 in 2020 and 29 in 2021.

3.1. Demographic and clinical characteristics

The mean age was 46 years (±16.6), ranging from 16 to 84 years, with a predominance of the age group 16–64 years, representing 78.6% of the study population. The male sex was predominant (29 men, 13 women), with a sex ratio of 2.2. Among the 42 patients, 34 (81%) were hospitalized in the Department of Infectious Diseases, of which 2 patients transferred from the intensive care unit and 1 from another internal medicine ward, while 8 (19%) were outpatients. A healthcare-associated origin was retained in 14 patients (36%). The detailed characteristics are summarized in Table 1.

Table 1 Demographic and clinical characteristics of the study population

Characteristic	n	%
Total samples	59	—
Patients	42	—
Hospitalized in Infectious Diseases	34	81.0
Outpatients	8	19.0
Male	29	69.0
Female	13	31.0
Sex ratio (M/F)	2.2	—
Mean age (±SD), years	46 (±16.6)	—
Median age, years	42.4	—
Age 16–64 y	33	78.6
Age ≥ 65 y	4	9.5
Healthcare-associated infection	14	36.0

3.2. Distribution of samples

The distribution of samples according to their nature is shown in Table 2. Blood cultures were the most frequently submitted sample (n=10, 16.9%), followed by skin swabs (n=7, 11.9%), pus (n=6, 10.2%) and surgical wounds (n=5, 8.5%). Sterile-site samples accounted for 15 isolates (25.4%), while non-sterile-site samples accounted for 27 isolates (45.8%). The remaining 17 samples (28.8%) were not categorized due to missing data on sample nature.

Table 2 Distribution of samples by nature and corresponding MRSA rate

Sample type	n	%	MRSA n	MRSA %
Blood culture	10	16.9	0	0.0
Skin swab	7	11.9	2	28.6
Pus	6	10.2	2	33.3
Surgical wound	5	8.5	2	40.0
Cerebrospinal fluid	3	5.1	0	0.0
Soft tissue abscess	2	3.4	0	0.0
Drain	2	3.4	0	0.0
Abscess pus	2	3.4	0	0.0
Other (stoma, biopsy, catheter, pleural fluid, urine)	5	8.5	3	60.0
Not specified	17	28.8	—	—
Total	59	100	9	15.3

MRSA was identified in 9 of the 58 isolates tested with the cefoxitin disk (15.3%). The MRSA rate varied considerably according to sample type: 40% for surgical wounds, 33% for pus, 28% for skin swabs, and 0% for both blood cultures and cerebrospinal fluid. All MRSA strains were recovered from non-sterile sites.

3.3. Antibiotic susceptibility profile

The susceptibility profile of all *S. aureus* isolates is illustrated in Figure 1. Rifampin showed the best overall activity, with only 5% of resistant strains (2 of 44 tested), followed by clindamycin (7% resistance, 3 of 45), gentamicin (8%, 5 of 59) and trimethoprim-sulfamethoxazole (9%, 4 of 47). These four molecules represent first-line therapeutic options in our local epidemiological context.

Conversely, tetracycline showed the highest resistance rate of the series, with 50% of resistant strains (20 of 40 tested). Fusidic acid was also markedly affected, with 44% of resistance (15 of 34). Fluoroquinolones presented moderate resistance: 35% for norfloxacin and 30% for ciprofloxacin. These rates deserve particular attention, since fluoroquinolones are often used as first-line empirical therapy in community-acquired infections.

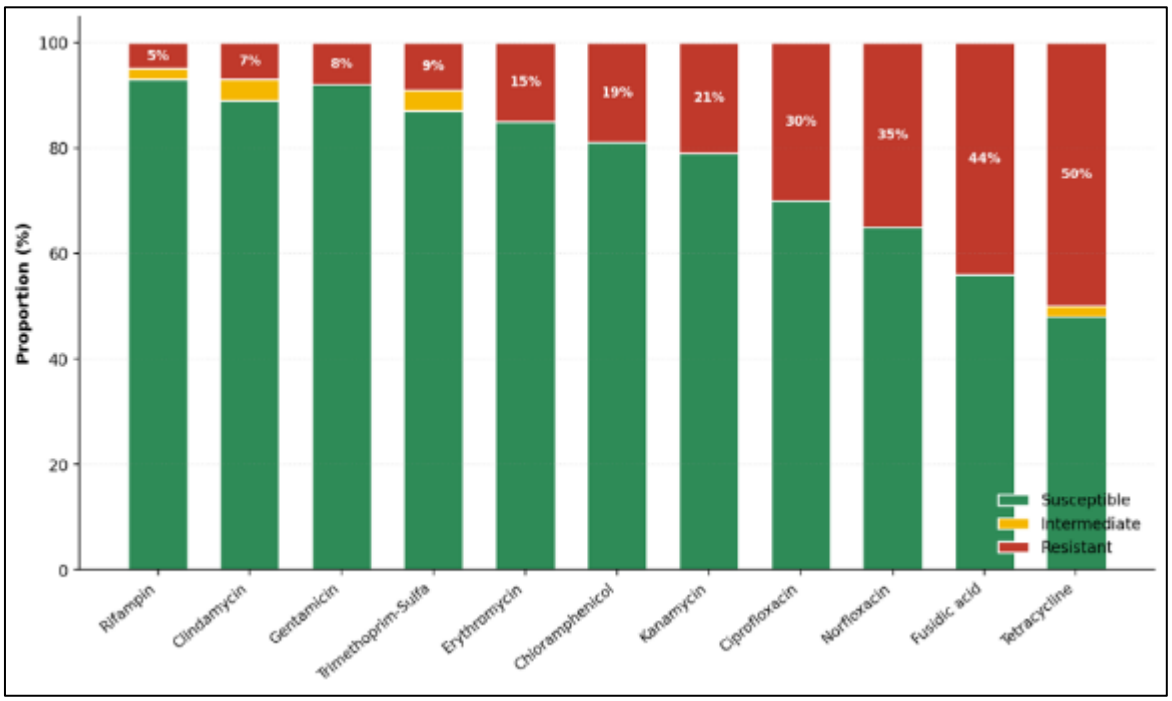

Figure 1 Distribution of susceptible (S), intermediate (I) and resistant (R) phenotypes for each antibiotic tested in our series

3.4. Resistance profile by MRSA status and sample category

Among the 58 isolates tested for cefoxitin, 9 strains (15.3%) were classified as MRSA and 49 (84.7%) as MSSA. The resistance profile of these isolates, both according to methicillin susceptibility and according to the REMIC sample category, is presented in Table 3. MRSA strains presented a markedly higher resistance profile than MSSA for most antibiotics, with the largest differences observed for tetracycline (100% vs 44%), fusidic acid (86% vs 33%) and chloramphenicol (80% vs 12%). Gentamicin and trimethoprim-sulfamethoxazole, which remained globally active, were however resistant in 33% of MRSA isolates.

Distribution of resistance according to the REMIC classification of samples showed a clear gradient between sterile and non-sterile sites. No MRSA strain was identified in the 15 sterile-site samples, whereas 6 of the 27 non-sterile samples were MRSA (22%). Aminoglycoside, fluoroquinolone, macrolide and lincosamide resistance rates were systematically lower in sterile-site samples than in non-sterile samples. Tetracycline was the only antibiotic with comparable resistance rates in both categories (43% in sterile sites vs 43% in non-sterile sites), suggesting a resistance mechanism independent of local selection pressure. A similar pattern was observed for chloramphenicol (21% vs 23%) and fusidic acid (25% vs 50%).

Table 3 Resistance profile of S. aureus isolates according to MRSA status and REMIC sample category

Antibiotic	MRSA R%	MSSA R%	Sterile sites R%	Non-sterile sites R%
Tetracycline	100% (4/4)	44% (16/36)	43% (6/14)	43% (9/21)
Fusidic acid	86% (6/7)	33% (9/27)	25% (2/8)	50% (8/16)
Chloramphenicol	80% (4/5)	12% (5/42)	21% (3/14)	23% (5/22)
Erythromycin	38% (3/8)	11% (5/47)	0% (0/14)	21% (5/24)
Ciprofloxacin	38% (3/8)	29% (14/49)	7% (1/15)	30% (8/27)
Gentamicin	33% (3/9)	4% (2/50)	0% (0/15)	11% (3/27)
Trimethoprim-sulfamethoxazole	33% (2/6)	5% (2/41)	0% (0/8)	4% (1/25)
Norfloxacin	25% (2/8)	37% (17/46)	7% (1/15)	35% (8/23)
Clindamycin	20% (1/5)	5% (2/40)	0% (0/14)	9% (2/22)
Kanamycin	17% (1/6)	21% (10/47)	0% (0/15)	27% (7/26)
Rifampin	0% (0/4)	5% (2/40)	0% (0/14)	11% (2/19)
MRSA prevalence in samples	—	—	0% (0/15)	22% (6/27)

4. Discussion

S. aureus remains one of the most frequent pathogens isolated in clinical microbiology laboratories, with a clinical spectrum ranging from minor skin infections to life-threatening invasive disease. The methicillin-resistant phenotype constitutes the main concern in this group, due to its association with multidrug resistance and increased mortality [3], [5].

The male predominance observed in our series (sex ratio 2.2) is consistent with the literature, *S. aureus* being more frequently isolated in men, possibly in relation with a greater exposure to predisposing factors such as trauma and cardiovascular comorbidities [5]. The mean age of 46 years, with a majority of patients in the active age range (16–64 years), differs from European cohorts in which the population is significantly older [6].

4.1. MRSA rate: comparison with Moroccan data

Our MRSA rate of 15.3% is in line with recent Moroccan data. A multicenter study published in 2026, conducted in a UHC in northern Morocco on 4,561 clinical samples, reported a MRSA rate of 9.8% [7]. The same study mentioned a similar rate of 9.2% at the Mohammed V Military Training Hospital in Rabat, suggesting that around 10% represents a reference threshold in centers with active infection control policies. Our result is slightly higher and must be interpreted with caution: the study was conducted at the Department of Infectious Diseases of Ibn Rochd UHC, a tertiary referral center which receives severe infections transferred from other wards of the hospital and from other hospitals across the country. A selection bias toward more severe and more resistant cases is therefore likely.

A study carried out at Ibn Tofail UHC in Marrakech reported a MRSA rate that rose from 12% in 2010 to a peak of 30% in 2017, before decreasing to 15% in 2019 [7] — a value almost identical to ours over the same period. This convergence between two referral UHCs in different cities and different patient populations strengthens the representativeness of our series and suggests that a national plateau around 15% has been reached in Moroccan university hospital wards after a period of progression in 2015–2017.

In a previous Moroccan urological study at the UHC of Marrakech, ciprofloxacin and gentamicin resistance rates of 50% and 20% respectively were reported [8], higher than our results (30% and 8%), which may be due to the difference in selection pressure between a urology ward and an infectious diseases ward.

4.2. MRSA rate: comparison with regional and international data

Beyond the Moroccan setting, our MRSA rate of 15.3% deserves to be compared with regional Maghreb data and with figures reported from Western European countries close to Morocco. A summary of the most relevant comparisons is presented in Table 4.

In Tunisia, Sakly et al. reported a global MRSA rate of 30% in the burn unit of Sahloul UHC over the period 2012–2018, with a progression from 16% in 2012 to 39% in 2018 [9]. These figures, more than twice ours, reflect the extreme selection pressure of a burn unit. However, the comparison must be interpreted with caution, since the study populations differ radically (severely immunocompromised burn patients versus a mixed infectious diseases cohort). A recent African systematic review and meta-analysis including 16 countries (Azzam et al., 2025) reported a pooled MRSA prevalence of 12.9% in hospitalized patients, with a markedly higher value in North Africa (56.2%) compared to Sub-Saharan Africa (36.7%) [10]. Our rate of 15.3% is very close to the pooled hospitalized prevalence and much lower than the North African pooled figure, which may be partly explained by the fact that Morocco has historically been reported with the lowest MRSA rates of the Mediterranean Maghreb. An earlier multi-country review noted a prevalence of 19% in Morocco, against 45% in Algeria and Tunisia, 31% in Libya and 52% in Egypt [11].

At the European level, ECDC EARS-Net data provide a solid reference frame. In Spain, a single-center study published in 2022 at the Comunidad Valenciana UHC documented a significant decrease of hospital MRSA, from 33% to 18% over the study period, thanks to an active epidemiological and molecular surveillance program [12]. In France, ECDC EARS-Net 2021 data confirmed the continuation of a remarkable MRSA decrease, reaching approximately 12% in invasive infections in 2020–2021 [13], after a peak above 32% in the early 2000s. Portugal, in the same period, showed the highest nosocomial MRSA prevalence in Western Europe (>20%), linked to the dissemination of the EMRSA-15 (ST22) clone [13]. Our rate of 15.3% therefore lies in the median range of southern European countries — between France (12%) and Portugal (>20%) — a region with which Morocco shares similar epidemiological patterns. As mentioned in section 4.1, the location of our study at a tertiary referral center receiving severe cases from other hospitals must be taken into account when interpreting the rate.

Table 4 Comparison of MRSA rates between regional Maghreb studies, Western European studies and our series

EUROPE			**MAGHREB**			**OUR STUDY**
Country / Study	Year	MRSA%	Country / Study	Year	MRSA%	Ibn Rochd UHC, Casablanca — Infectious Diseases
France — ECDC EARS-Net	2021	≈ 12%	Tunisia — Sakly et al. (Sahloul, burn unit)	2018	39%	Year: 2019–2021
Spain — Peral-Castellanos (Valencia UHC)	2022	18%	Africa — Azzam et al. (16 countries, 69 studies)	2025	12.9%	MRSA rate: 15.3%
Portugal — ECDC EARS-Net	2021	> 20%	Morocco — Falagas et al. (multi-country review)	2013	19%	Tertiary referral center receiving severe cases from other hospitals (selection bias)

4.3. Susceptibility profile and therapeutic options

Rifampin (95% susceptibility) and clindamycin (89%) were the most active antibiotics in our series. These results are consistent with international literature. Rifampin remains, however, contraindicated as monotherapy because of the rapid selection of resistant mutants; its use must be considered in combination, particularly for bone and joint infections, endovascular infections or prosthetic material infections [14].

Gentamicin (92% susceptibility) and trimethoprim-sulfamethoxazole (87%) represent valuable alternatives, particularly in MSSA infections. The maintained activity of trimethoprim-sulfamethoxazole is noteworthy and is in line with recent studies showing its interest at high dose for the treatment of MRSA infections, especially skin and soft tissue infections and bacteremia, as an alternative to vancomycin [15].

Conversely, the high resistance rates observed for tetracycline (50%) and fusidic acid (44%) limit their clinical use, despite their oral availability. These findings are consistent with previous Moroccan and North African data reporting

an increasing resistance to fusidic acid, likely related to its widespread use in dermatology, particularly for impetigo and wound infections in outpatient settings [8].

4.4. Co-resistance pattern of MRSA isolates

Our MRSA isolates displayed a substantially higher co-resistance profile than MSSA, with resistance differences of more than 50 percentage points for tetracycline, fusidic acid and chloramphenicol. This confirms that methicillin resistance is rarely an isolated phenomenon, but is most often associated with multidrug resistance, mediated by mobile genetic elements such as SCCmec cassettes and resistance plasmids [16]. The Spanish study by Peral-Castellanos et al. similarly reported a higher erythromycin resistance in MRSA compared to MSSA [12], in line with our 38% vs 11% observation.

The high co-resistance of MRSA to tetracycline, fusidic acid and chloramphenicol observed in our series may correspond to the dissemination of multidrug-resistance plasmids well-described in Mediterranean MRSA clones, such as ST239 and ST22 [17]. Molecular characterization of these isolates remains a priority for future research at our institution.

4.5. MRSA distribution by sample category

All MRSA strains in our series were recovered from non-sterile sites, while sterile-site samples yielded only MSSA. This finding is consistent with the literature: invasive MRSA infections, although associated with high mortality, may be underrepresented in retrospective series due to early empirical therapy modifications that bypass microbiological isolation. The selection pressure exerted on non-sterile sites — through topical antiseptics, local antibiotics and broad-spectrum oral therapies — is naturally higher [18]. Tetracycline and chloramphenicol resistance was however comparable in both sample categories (43% vs 43% and 21% vs 23% respectively), suggesting that resistance to these antibiotics relies on intrinsic plasmid-borne mechanisms rather than on local selection pressure.

Limitations

Our study presents several methodological limitations inherent to its retrospective design. First, the study was conducted at the Department of Infectious Diseases of Ibn Rochd UHC, a tertiary referral center that receives severe infections transferred from other wards of the hospital and from other hospitals across the country. This creates a probable selection bias toward more severe and more resistant cases, which may have contributed to a higher MRSA rate compared with centers using primary-care or community samples. Second, data on patient origin, admission reason and comorbid conditions were incomplete in the laboratory database, which limited multivariate analysis of MRSA risk factors. Third, the total sample size of 59 isolates, although representative of three years of activity in our department, remains limited for subgroup analyses, particularly for the MRSA group (n=9). Fourth, the absence of molecular characterization (SCCmec typing, mecA gene detection by PCR, MLST typing) does not allow formal differentiation between community-acquired and hospital-acquired MRSA. These molecular data would represent a valuable contribution to a future prospective study.

5. Conclusion

S. aureus remains a major pathogen in our Department of Infectious Diseases, with an MRSA rate of 15.3% consistent with recent Moroccan data and within the range of southern European countries. Rifampin, clindamycin, gentamicin and trimethoprim-sulfamethoxazole emerged as the most active antibiotics in our local context, while tetracycline and fusidic acid showed limited usefulness due to high resistance rates.

MRSA isolates demonstrated a markedly higher co-resistance profile than MSSA, particularly for tetracycline, fusidic acid and chloramphenicol, which underlines the importance of antibiogram-guided therapy. The complete absence of MRSA in sterile-site samples — contrasting with a 22% rate in non-sterile sites — constitutes an interesting observation that deserves confirmation in larger series.

These results, although limited by sample size and the retrospective design, provide a useful local reference to adapt empirical antibiotic protocols at the Department of Infectious Diseases of Ibn Rochd UHC. They argue in favor of reinforced bacteriological surveillance, regular updating of empirical guidelines, and the implementation of a prospective study including molecular characterization of MRSA strains.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Bianchi V, El Anbassi S, Duployez N. Bactériologie-Virologie. De Boeck Editions; 2019, pp. 101–102.

[2] Nauciel C, Vildé JL. Bactériologie médicale. 2nd ed. Paris: Masson; 2005, pp. 77–80.

[3] Chambers HF, DeLeo FR. Waves of resistance: *Staphylococcus aureus* in the antibiotic era. Nat Rev Microbiol. 2009;7(9):629–641.

[4] Bassetti M, Nicco E, Mikulska M. Why is community-associated MRSA spreading across the world and how will it change clinical practice? Int J Antimicrob Agents. 2009;34(Suppl 1):S15–19.

[5] Kluytmans J, Van Belkum A, Verbrugh H. Nasal carriage of *Staphylococcus aureus*: epidemiology, underlying mechanisms, and associated risks. Clin Microbiol Rev. 1997;10(3):505–520.

[6] European Centre for Disease Prevention and Control. Annual Epidemiological Report on Communicable Diseases in Europe. Stockholm: ECDC; 2022.

[7] Qannouf S, Lhajoui S, El Amin G, Kabbage S, Maleb A, Frikh M, et al. Epidemiological burden of multidrug-resistant bacteria and carbapenemases in Northern Morocco: a one-year observational study. BMC Infect Dis. 2026;26:418. doi:10.1186/s12879-026-13016-z

[8] Amoch A, Bagueri M, Abourrig A, El Kmichi M, Dahami Z, Moudouni S, et al. *Staphylococcus aureus* in urology: which prevalence, which evolution and which resistance profile? Prog Urol. 2015;25(13):811–812.

[9] Sakly H, Tilouch L, Ben Azaiez M, Boughattas S, Ketata S, Bouallégue O. Susceptibility study of methicillin-resistant *Staphylococcus aureus* in burn patients. Méd Mal Infect. 2020;50(6):S38.

[10] Azzam A, Khaled H, Fayed HM, Mansour Y, Eldalil M, Elshennawy E, et al. Prevalence, antibiogram, and risk factors of methicillin-resistant *Staphylococcus aureus* (MRSA) asymptomatic carriage in Africa: a systematic review and meta-analysis. BMC Infect Dis. 2025;25:474. doi:10.1186/s12879-025-10819-4

[11] Falagas ME, Karageorgopoulos DE, Leptidis J, Korbila IP. MRSA in Africa: filling the global map of antimicrobial resistance. PLoS One. 2013;8(7):e68024. doi:10.1371/journal.pone.0068024

[12] Peral-Castellanos M, Carretero-Leiva G, González-Donapetry P, et al. Molecular epidemiology of methicillin-resistant *Staphylococcus aureus* in a tertiary hospital from the Comunidad Valenciana (Spain). Microb Drug Resist. 2022;28(12):1231–1239.

[13] European Centre for Disease Prevention and Control. Antimicrobial resistance in the EU/EEA (EARS-Net) — Annual Epidemiological Report 2021. Stockholm: ECDC; 2022.

[14] Liu C, Bayer A, Cosgrove SE, et al. Clinical practice guidelines by the Infectious Diseases Society of America for the treatment of methicillin-resistant *Staphylococcus aureus* infections in adults and children. Clin Infect Dis. 2011;52(3):e18–55.

[15] Bowen AC, Lilliebridge RA, Tong SY, et al. Is *Staphylococcus aureus* susceptibility to trimethoprim-sulfamethoxazole increasing? Antimicrob Agents Chemother. 2012;56(11):6384–6386.

[16] Chambers HF. Methicillin resistance in staphylococci: molecular and biochemical basis and clinical implications. Clin Microbiol Rev. 1997;10(4):781–791.

[17] Deurenberg RH, Stobberingh EE. The evolution of *Staphylococcus aureus*. Infect Genet Evol. 2008;8(6):747–763.

[18] Bhattacharya S. MRSA — a critical review. J Assoc Physicians India. 2018;66(12):40–43.