Alqalam Journal of Medical and Applied Sciences. 2025;8(4):2202-2207
https://doi.org/10.54361/ajmas.258417

Original article

Prevalence of Methicillin-Resistant *Staphylococcus aureus* Among Radiology Technicians in Hospitals in Misurata, Libya.

Mohanned Alwashaish[1]*, Mohamed Almogassbi[2], Elham Elzwawi[2]

[1]*Department of Microbiology, Faculty of Pharmacy, Misurata University, Misurata, Libya.*
[2]*Department of Microbiology, Faculty of Science, Misurata University, Misurata, Libya.*
Corresponding author. mohanad.aloshesh@phar.misuratau.edu.ly

Abstract
Methicillin-resistant *Staphylococcus aureus* (MRSA) is a major cause of healthcare-associated infections, and healthcare workers (HCWs) can serve as potential reservoirs for transmission. Data on MRSA colonization among radiology technicians, particularly in Libya, are limited. To estimate the prevalence of MRSA among radiology technicians in Misurata, Libya, and to describe antimicrobial resistance patterns and potential occupational factors. A cross-sectional study was conducted in two hospitals in Misurata between May and June 2024. Hand swabs were collected from radiology technicians and processed using standard microbiological methods. MRSA identification was based on Clinical and Laboratory Standards Institute (CLSI) guidelines. Data were analyzed using descriptive and inferential statistics with 95% confidence intervals. Of 60 participants, 66.7% carried bacteria; *Staphylococcus aureus* accounted for 85% of isolates, of which 76.5% were MRSA. The overall prevalence of MRSA colonization among radiology technicians was 43.3% (95% CI: 27–61%). Ciprofloxacin resistance was observed in 23.1% of MRSA isolates. Exploratory analyses suggested higher MRSA carriage among less experienced technicians and those working in Computed Tomography (CT), although these associations were not statistically significant. This study provides preliminary evidence of MRSA carriage among radiology technicians in Misurata. While limited by sample size, sampling method, and restricted antimicrobial testing, the findings suggest that radiology departments should be considered in broader infection prevention discussions. Further multicenter and molecular studies are required to confirm these observations and to inform tailored infection control strategies.
Keywords. Methicillin-Resistant *Staphylococcus Aureus*, MRSA, Radiology Technicians, Antimicrobial Resistance, Occupational Health, Infection Prevention.

Introduction

Methicillin-resistant *Staphylococcus aureus* (MRSA) is a significant public health concern globally, responsible for substantial morbidity, mortality, and healthcare costs [1,2]. Healthcare workers (HCWs) may play a dual role in MRSA transmission, serving as reservoirs of the pathogen and as vectors facilitating its spread within healthcare facilities [3,4]. Colonization of HCWs with MRSA has been documented worldwide, with prevalence ranging from 1.8 % in non-outbreak settings to over 20 % in high-burden areas [5,6].

In North Africa, MRSA prevalence remains high. Studies from Tunisia and Egypt report MRSA carriage rates of 39 % and 56 %, respectively [7,8]. In Libya, Doro *et al.* found a nasal MRSA carriage rate of 21.9 % among HCWs in Tripoli [9]. Previous studies have documented that healthcare workers can be colonized with MRSA, with prevalence rates varying across countries and hospital settings [10]. Similarly, high MRSA colonization rates among healthcare workers have been reported in Egypt and Somalia [11,12] and among medical students in Ethiopia and other African countries [13,14], indicating widespread regional MRSA endemicity.

Radiology departments are unique occupational settings within healthcare facilities. Technicians frequently interact with patients and share diagnostic equipment, creating opportunities for the indirect transmission of pathogens [15,16]. *S. aureus* can survive for prolonged periods on surfaces such as X-ray cassettes and CT gantries [17,18], yet MRSA colonization among radiology staff remains under-investigated, particularly in resource-limited settings.

This study is, to our knowledge, the first to specifically investigate MRSA carriage among radiology technicians in Libya, a group often overlooked in infection control policies. By addressing this gap, the study provides novel insights into the occupational risks faced by radiology staff and highlights their potential role as unrecognized reservoirs of MRSA transmission in healthcare facilities.

Methods

Study Design and Setting

A cross-sectional study was conducted between May and June 2024 at Misurata Medical Center (MMC) and the National Institute of Oncology (NIO), two major healthcare facilities in Misurata, Libya. Both hospitals have high-volume radiology departments serving inpatients and outpatients.

Study Population

All radiology technicians working in the two hospitals during the study period were invited to participate. Inclusion criteria included employment as a radiology technician and direct patient contact. Technicians who had taken systemic antibiotics within the previous two weeks or declined to participate were excluded.

***Received**: 04-08-2025 - **Accepted**: 03-10-2025 - **Published**: 11-10-2025*

Data Variables
Data collected included participant demographics (gender, age), years of professional experience, radiology subspecialty: X-ray, CT, and Magnetic Resonance Imaging (MRI), and bacteriological variables (presence and type of bacterial growth, *S. aureus* identification, MRSA/MSSA status, and antibiotic susceptibility profile).

Sample Collection
Hand swabs were collected from the dominant hand using sterile cotton swabs moistened with sterile saline. Samples were transported to the microbiology laboratory within two hours in sterile containers and processed according to WHO guidelines [19]. Samples were collected during working hours without strict control of handwashing immediately prior to swabbing.

Bacterial Isolation and Identification
Swabs were inoculated onto Mannitol Salt Agar and incubated at 37 °C for 24–48 h. Colonies with typical *S. aureus* morphology were confirmed by Gram staining, catalase, and coagulase tests.

Antimicrobial Susceptibility Testing
Antimicrobial susceptibility testing was performed using the Kirby–Bauer disk diffusion method and interpreted according to CLSI M100 [20]. The following disks were used: cefoxitin (30 µg) for methicillin-resistant *Staphylococcus aureus* (MRSA)/methicillin-susceptible *Staphylococcus aureus* (MSSA) categorization, and ciprofloxacin (5 µg) as a representative non-β-lactam agent. Methicillin resistance was determined using cefoxitin (30 µg) as a surrogate for the presence of *mecA*; isolates with inhibition zones ≤ 21 mm were considered MRSA and ≥ 22 mm MSSA. Standard quality-control strains (*S. aureus* ATCC 25923 and ATCC 29213) were included in each run. Results for β-lactam agents (e.g., carbapenems and cephalosporins) were not considered for MRSA, given the intrinsic class resistance and to avoid misinterpretation.

Statistical Analysis
Data were analyzed using SPSS v.26 at a significance level of 0.05. Descriptive statistics (frequencies, percentages, means, and standard deviations) were used to summarize demographic and microbiological data. The Chi-square test was applied to examine associations between categorical variables, as it is appropriate for testing independence between nominal data. Fisher's exact test was used instead of Chi-square when expected cell counts were less than five, ensuring valid results in small-sample contingency tables. The distribution of continuous variables was assessed using the Shapiro–Wilk test, which confirmed non-normality for most datasets. Accordingly, non-parametric tests such as the Mann–Whitney U test were applied, whereas parametric tests (Student's t-test) were used only when normality was satisfied. Effect sizes (Cramer's V for categorical variables and Cohen's d for continuous variables) were calculated to complement p-values and provide a better understanding of the data.
Analyses stratified by gender, years of experience, and occupational variables were performed for exploratory purposes only, given the limited sample size, and were not powered to yield definitive subgroup conclusions.

Results
Bacterial Isolation and Species Distribution
Out of the 60 technicians sampled, 40 (66.7 %; 95 % CI: 48.2–81.4) were culture-positive. *S. aureus* accounted for 34/40 isolates (85.0 %; 95 % CI: 62.1–96.8), while coagulase-negative *Staphylococci* were identified in 6/40 samples (15.0 %), as shown in (Table 1).

Table 1. Bacterial species isolated from hand swabs of radiology technicians

Species	N	%	95% CI
S. aureus	34	85.0	62.1–96.8
CoNS	6	15.0	3.2–37.9
Total	40	100.0	—

n = number - % = Percentage

MRSA Prevalence and Distribution
Among the *S. aureus* isolates, 26 (76.5 %; 95 % CI: 50.1–93.2) were MRSA and 8 (23.5 %; 95 % CI: 6.8–49.9) were methicillin-susceptible *S. aureus*, as revealed in (Figure 1).
The overall carriage prevalence of MRSA among radiology technicians was 43.3% (95% CI: 27–61%), indicating a substantial burden. Reporting confidence intervals alongside point estimates provides greater statistical reliability, especially in studies with relatively small sample sizes.

***Received**: 04-08-2025 - **Accepted**: 03-10-2025 - **Published**: 11-10-2025*

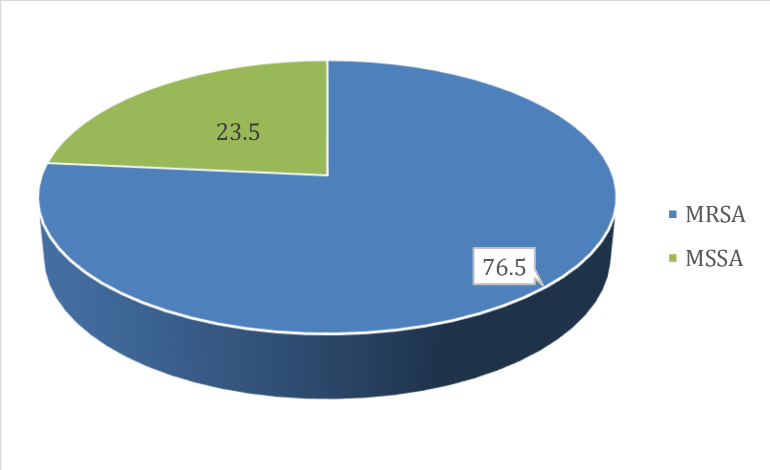

Figure 1. Distribution of MRSA and MSSA among S. aureus isolates

MRSA Prevalence by Hospital

MRSA prevalence was higher at the National Institute of Oncology (60.0 %; 95 % CI: 32.3–83.7) than at Misurata Medical Center (40.0 %; 95 % CI: 12.2–73.8), though the difference was not statistically significant (p = 0.42; Cramer's V = 0.18) as detailed in (Table 2).

Table 2. MRSA distribution by hospital of employment

Hospital	MRSA n (%)	95% CI	MSSA n (%)	95% CI	p-value	Effect Size (V)
MMC	8 (40.0)	12.2–73.8	12 (60.0)	26.2–87.8	0.42	0.18
NIO	18 (60.0)	32.3–83.7	12 (40.0)	16.3–67.7		

n = number - % = Percentage, MMC = Misurata Medical center, NIO = National Institute of Oncology

MRSA Prevalence by Gender

Female technicians had a higher MRSA rate than males (53.8 % vs 33.3 %). However, this difference was not statistically significant (p = 0.28; Cramer's V = 0.21) and should be interpreted as an exploratory finding rather than a definitive association, as shown in (Table 3).

Table 3. MRSA distribution by gender

Gender	MRSA n (%)	95% CI	MSSA n (%)	95% CI	p-value	Effect Size (V)
Male	6 (33.3)	7.5–70.1	12 (66.7)	29.9–92.5	0.28	0.21
Female	14 (53.8)	25.1–80.8	12 (46.2)	19.2–74.9		

n = number - % = Percentage

Occupational Variables

Higher MRSA carriage among technicians with less than five years of experience (62.5 %) compared with those with five or more years (35.7 %), and higher rates among CT technicians (66.7 %) than those working in X-ray (50.0 %) or MRI (25.0 %). None of these differences reached statistical significance (p = 0.062), and the results should be regarded as exploratory trends only as presented in (Figures 2&3).

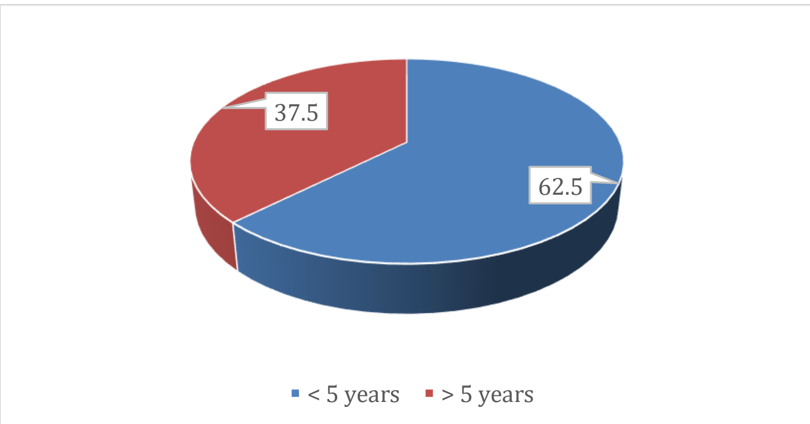

Figure 2. MRSA distribution by technician experience

Received*: 04-08-2025 -* ***Accepted****: 03-10-2025 -* ***Published****: 11-10-2025*

Alqalam Journal of Medical and Applied Sciences. 2025;8(4):2202-2207
https://doi.org/10.54361/ajmas.258417

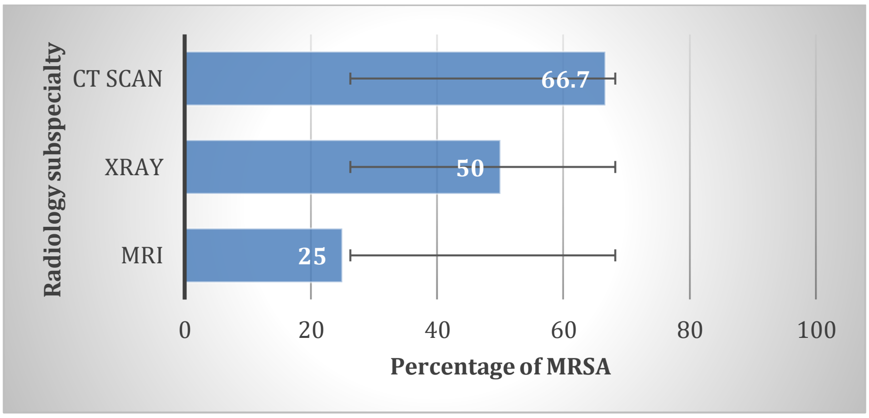

Figure 3. Percentage of MRSA among radiology subspecialties

Antimicrobial Susceptibility

As expected, all MRSA isolates were resistant to β-lactam antibiotics, confirming cefoxitin as a reliable surrogate for methicillin resistance. Beyond this, ciprofloxacin resistance was observed in 23.1% of MRSA isolates (6/26), while the remaining 76.9% (20/26) were susceptible. Due to the intrinsic resistance of MRSA to all β-lactams, results for imipenem and cefotaxime were excluded from the final analysis to avoid misinterpretation.

Discussion

Our findings revealed a high prevalence of MRSA carriage among radiology technicians, exceeding rates reported in several regional studies. This underscores the unique occupational exposure in radiology departments, where frequent patient contact combined with limited infection prevention training may contribute to MRSA colonization.

This study showed a high MRSA carriage rate among radiology technicians in Misurata, with 76.5 % of *S. aureus* isolates being methicillin-resistant, with an overall carriage rate of 43.3 %. These rates exceed the global average estimate of 4–15 % for MRSA carriage among healthcare workers in non-outbreak settings [5,6] and are aligned with local reports from Libya [9] and regional findings from Egypt [11,16], Iran [21], and Somalia [12]. Our findings align with reports from high-income countries, where MRSA colonization among healthcare staff ranges between 2–10%, such as Germany [22]; yet the prevalence in our study (43.3%) underscores a disproportionate burden in resource-limited settings. This disparity highlights the urgent need for targeted infection control interventions. The elevated MRSA prevalence may reflect limited infection-prevention resources, infrequent screening of high-contact staff, and high empirical antibiotic use in the region [7,8,13]. Also, these results were substantially higher than the average African estimate of 13.6% reported in a systematic review [23] and the continental average of 22.5% identified by [24]. Comparable high rates have also been documented in Nigeria [25] and Gabon [26], though these studies focused on broader healthcare worker categories or patient populations.

The observed higher MRSA prevalence in the oncology hospital aligns with the evidence that oncology units may be considered as a harbor, increasing MRSA burdens due to immunocompromised patient populations and intensive use of invasive devices [7,27]. The upward trend in MRSA prevalence globally, as evidenced by Hamwi [28] with an increase from 36% (2015–2019) to 62% in 2020, reinforces the urgency of implementing targeted prevention measures in high-contact healthcare settings.

Although female technicians appeared to have higher MRSA carriage than males, this difference was not statistically significant and should be regarded as exploratory only. Previous meta-analyses have similarly reported no consistent association between gender and MRSA carriage among HCWs [29], suggesting that occupational exposure risk outweighs gender as a predictive factor for colonization.

Years of experience and occupational unit did not show statistically significant associations with MRSA carriage. Nevertheless, exploratory trends suggested that early-career staff may have elevated risk, consistent with findings from Ethiopian medical students and African healthcare workers [13,14]. When stratified by subspecialty, MRSA carriage appeared highest among CT technicians, followed by X-ray and MRI staff. Although these differences were not statistically significant, previous studies have suggested that CT suites may present higher risks of contamination due to prolonged patient contact and the complexity of equipment surfaces [15,16]. These findings highlight that radiology staff may represent an overlooked group in infection prevention programs, underscoring the need for tailored policies.

According to CLSI guidance, MRSA isolates are regarded as resistant to all β-lactam antibiotics due to the presence of *mecA*-encoded PBP2a; therefore, only non-β-lactam agents were reported in the final analysis [20]. In this study, ciprofloxacin was included as an exploratory agent, and moderate resistance was observed among MRSA isolates. This finding is consistent with reports from Iran describing similar resistance profiles [30], and with regional data documenting fluoroquinolone resistance in *S. aureus*, commonly associated with mutations in the *gyrA* and *parC* genes within the quinolone resistance–

***Received**: 04-08-2025 - **Accepted**: 03-10-2025 - **Published**: 11-10-2025*

determining region (QRDR) [31,32], as well as global and regional reviews [33–36]. These results underscore the importance of continued monitoring of fluoroquinolone susceptibility, given their clinical relevance in managing MRSA infections.
The clinical implication of this study is significant: incorporating radiology departments into MRSA surveillance and infection prevention programs could mitigate an underrecognized reservoir of antimicrobial resistance in healthcare facilities. The high MRSA carriage among radiology technicians poses an occupational hazard and potential transmission risk to patients. Radiology departments can act as reservoirs for MRSA through contaminated surfaces such as X-ray tables, CT gantries, and MRI coils [12]. Strict adherence to WHO-recommended hand hygiene protocols [19], regular disinfection of imaging equipment, and targeted MRSA screening programs for high-risk HCWs are essential preventive measures.
This study has several limitations that should be considered when interpreting the results. First, the relatively small sample size and restriction to two hospitals in Misurata limit the generalizability of the findings and reduce the ability to detect subgroup differences. Second, antimicrobial susceptibility testing was restricted: only ciprofloxacin was assessed in addition to cefoxitin, while other clinically relevant first-line agents for S. aureus (e.g., vancomycin, linezolid, clindamycin, trimethoprim–sulfamethoxazole) were not included due to resource constraints. Third, mupirocin, which is an important agent for MRSA decolonization strategies, was not tested. Fourth, sampling focused on hand carriage rather than nasal carriage, which is considered the gold standard for MRSA surveillance, and the timing of sampling relative to handwashing was not standardized; both factors may have influenced detection rates. Finally, molecular characterization of MRSA isolates was not performed because of limited laboratory capacity. The absence of genetic testing (e.g., detection of the *mecA* gene or molecular typing) restricts the ability to confirm resistance mechanisms, explore transmission dynamics, or compare isolates with global MRSA lineages.

Conclusion

In conclusion, this study provides preliminary evidence that radiology technicians may carry MRSA, highlighting a professional group that has not been routinely included in surveillance programs. Although the results are limited in scope, they underline the importance of considering all healthcare units, including radiology, in infection control policies. Larger and more comprehensive studies, ideally incorporating molecular methods, are needed to clarify the epidemiology of MRSA colonization in this group.

Ethics approval and consent to participate

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and approved by the Faculty of Pharmacy Administration, Misurata University, Libya (Approval No. 98/2024). Verbal informed consent was obtained from all participants. Written consent was waived as the samples were collected during routine diagnostic procedures without any patient identifiers.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

Mohanned Alwashaish: Concept – Final writing – Statistical analysis – Practical lab – Revision – Supervisor. Mohamed Almogassbi, Elham Elzwawi: Collection of samples – Paper draft. All authors contributed to manuscript writing and approved the final version.

Acknowledgements

The authors would like to thank all the technicians for their support and assistance during the study.

References

1. Naghavi M, Abate D, Abbasi-Kangevari M, Abdoli A, Abedi P, Abolhassani H, et al. Global burden of bacterial antimicrobial resistance 1990–2024: A systematic analysis. Lancet. 2024;403(10327):123-39.
2. Kumar S, Singh R, Sharma A. Current strategies against multidrug-resistant MRSA infections. Infect Drug Resist. 2025;18:123-37.
3. Hussein N, Ahmed L, Abozait H. Antimicrobial Resistance in Iraq: A Public Health Emergency in the Shadow of Conflict. Razi Med J. 2025 Aug 22:229-38.
4. Alhammad M, Babiker R, Alibrahim Z, Hamed Y. Prevalence of Multidrug-Resistant Staphylococcus aureus among Medical Students in Comparison to Healthcare Workers in Benghazi City. Alq J Med App Sci. 2025 May 3:774-9.
5. Dulon T, Peters C, Schablon A, Nienhaus A. MRSA carriage among healthcare workers in non-outbreak settings in Europe and the United States: A systematic review. BMC Infect Dis. 2014;14:363.
6. Giri S, Singh A, Adhikari N. Prevalence of methicillin-resistant Staphylococcus aureus carriage among nurses and doctors: A systematic review. Am J Infect Control. 2023;51(6):644-50.
7. Ben Ayed H, Ben Jazia E, Khemiri M. Nasal carriage of methicillin-resistant Staphylococcus aureus among healthcare workers in Tunisia. J Infect Public Health. 2021;14(4):493-8.

Received*: 04-08-2025 -* ***Accepted****: 03-10-2025 -* ***Published****: 11-10-2025*

8. El-Kholy A, Baseem H, Hall GS, Procop GW, Longworth DL. Antimicrobial resistance in Cairo, Egypt: Staphylococcus aureus and Gram-negative bacilli. Am J Infect Control. 2020;38(8):639-45.
9. Doro A, Ahmed MO, Elramalli AK. Nasal carriage of methicillin-resistant Staphylococcus aureus among healthcare workers in Tripoli, Libya. Am J Infect Control. 2016;44(9):1054-6.
10. Kwak YG, Seo J, Kim ES, Yoo HM, Kim TH, Kim HY, et al. Risk factors for colonization with methicillin-resistant Staphylococcus aureus among healthcare workers in a tertiary hospital in Korea. Am J Infect Control. 2016;44(12):e277-e81.
11. Azzam R, El-Gendy S, Mostafa H, Hussein A, Sabry S, Hassan M, et al. MRSA colonization among healthcare workers in Egypt: Prevalence, risk factors and resistance patterns. Infect Drug Resist. 2025;18:1121-34.
12. Aweis S, Abukar M, Osman H, Yusuf A. Prevalence and antimicrobial resistance of MRSA among healthcare workers in Mogadishu, Somalia. Front Trop Dis. 2025;2:1425042.
13. Mekuriya W, Tadesse A, Demisse AG, Abebe M, Ayalew M, Kebede T, et al. MRSA nasal carriage and associated risk factors among medical students in Ethiopia. Sci Rep. 2022;12:10245.
14. Bashir A, Olayinka A, Musa J, Ahmed S. MRSA prevalence among healthcare workers in Africa: influence of clinical specialty. Afr J Adv Pract Appl Sci. 2024;6(2):45-53.
15. Kim MS, Lim YS, Jeong H. Contamination of X-ray cassettes with methicillin-resistant Staphylococcus aureus and methicillin-susceptible Staphylococcus aureus in a radiology department. Radiol Technol. 2012;83(3):241-6.
16. Odeh Z, Saleh A, Khaled M, Hassan A, Ibrahim M, Farid M, et al. Radiology department: A potential source of multidrug-resistant contamination. Am J Infect Control. 2023;51(1):89-95.
17. Otter JA, Yezli S, French GL. The role played by contaminated surfaces in the transmission of nosocomial pathogens. Infect Control Hosp Epidemiol. 2013;34(5):449-56.
18. Palmqvist C, Svensson P, Andersson U, Holmberg M, Berglund B, Olsson H, et al. Surface contamination of CT and MRI equipment: A potential source of nosocomial infection. J Hosp Infect. 2019;102(4):456-62.
19. World Health Organization. WHO guidelines on hand hygiene in health care. Geneva: WHO; 2022.
20. Clinical and Laboratory Standards Institute. Performance standards for antimicrobial susceptibility testing; CLSI supplement M100. 30th ed. Wayne, PA: CLSI; 2020.
21. Goudarzi M, Goudarzi H, Azad M. Prevalence and antimicrobial resistance of Staphylococcus aureus isolated from healthcare workers' hands in Iran: A meta-analysis. Iran J Public Health. 2017;46(12):1583-93.
22. Sassmannshausen R, Deurenberg RH, Köck R, Hendrix R, Jurke A, Rossen JW, et al. MRSA prevalence and associated risk factors among healthcare workers in Germany: A cross-sectional study. Front Microbiol. 2016;7:1273.
23. Azzam Y, El-Hassan S, Mensah P, Adeyemi O, Al-Mutairi R, Bello I, et al. Methicillin-resistant Staphylococcus aureus colonization among healthcare workers across Africa: a systematic review and meta-analysis. Antimicrob Resist Infect Control. 2025;14(1):22.
24. Locke M, Tan J, Osei-Tutu E, Fong C, Omari A, McCarthy C, et al. Global variation in MRSA prevalence: a systematic review and meta-analysis. J Infect. 2025;90(2):145-53.
25. Mengistu G, Bello O, Yusuf A, Nwankwo E, Ojo T, Adeyemi T, et al. Nasal carriage of methicillin-resistant Staphylococcus aureus among healthcare workers in Nigeria: prevalence and associated risk factors. Front Public Health. 2024;12:1403012.
26. Gouleu S, Mba E, Obiang P, Nzondo S, Mavoungou E, Kassa A, et al. Methicillin-resistant Staphylococcus aureus among patients with skin and soft tissue infections in Gabon: prevalence and antimicrobial susceptibility. Antimicrob Resist Infect Control. 2024;13(1):105.
27. Abdullahi IN, Uzairue LI, Bello HS. Methicillin-resistant Staphylococcus aureus among healthcare workers: A systematic review and meta-analysis. Antibiotics (Basel). 2023;12(5):812.
28. Hamwi M. Trends in methicillin-resistant Staphylococcus aureus prevalence from 2015 to 2020: a global surveillance report. Int J Antimicrob Agents. 2025;62(1):106112.
29. Hasanpour M, Chen Y, Park S, Al-Dabbagh S, Li J, Lee H, et al. Global prevalence of methicillin-resistant Staphylococcus aureus in elderly care centers: a systematic review and meta-analysis. Antimicrob Resist Infect Control. 2023;12(1):210.
30. Shahkarami MK, Rashki A, Rashki Ghalehnoo M. MRSA epidemiology and susceptibility pattern in healthcare settings in Iran. Asian Pac J Trop Biomed. 2014;4(Suppl 1):S89-S92.
31. Zhao YC, Huang X, Li J, Wang Y, Chen H, Xu Z, et al. Environmental and healthcare factors influencing MRSA antimicrobial resistance in China. Environ Sci Eur. 2025;37(1):64.
32. Li S, Sun S, Yang C, Chen H, Yin Y, Li H, et al. Antimicrobial resistance and molecular characteristics of MRSA from skin and soft tissue infections in China. BMC Infect Dis. 2021;21:260.
33. Shariati A, Dadashi M, Chegini Z, Karami F, Goudarzi M, Darban-Sarokhalil D, et al. Global prevalence and molecular determinants of ciprofloxacin resistance in MRSA: A systematic review and meta-analysis. Front Public Health. 2022;10:1025633.
34. Ayobami O, Willrich N, Suwono B, Eckmanns T, Markwart R. The ongoing challenge of antimicrobial resistance in Staphylococcus aureus: Epidemiology and implications for therapy. J Glob Antimicrob Resist. 2023;32:200-10.
35. Teshome B, Fenta DA, Kibret GD, Belachew SA. Antimicrobial susceptibility patterns of methicillin-resistant Staphylococcus aureus in Africa: A systematic review and meta-analysis. BMC Infect Dis. 2024;24(1):75.
36. Papp-Wallace KM, Endimiani A, Taracila MA, Bonomo RA. Carbapenems: Past, present, and future. Antimicrob Agents Chemother. 2011;55(11):4943-60.

Received: *04-08-2025* - ***Accepted***: *03-10-2025* - ***Published***: *11-10-2025*