RESEARCH PAPER

Methicillin-resistant *Staphylococcus aureus* in a hemodialysis patient: Systematic review

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Abstract

Methicillin-resistant *Staphylococcus aureus* (MRSA) is a high-priority pathogen in public health, whose association with hemodialysis patients proposes a clinical challenge due to the combination of intrinsic and extrinsic risk factors that increase the likelihood of invasive infections and mortality. Objective: To synthesize the available evidence on epidemiology, risk factors, clinical impact, and prevention and control strategies for methicillin-resistant *Staphylococcus aureus* in hemodialysis patients. Methodology: A systematic review was conducted in four databases: PubMed, Scopus, Cochrane, and Google Scholar, following the PRISMA statement, which resulted in the inclusion of 22 studies. Results: The review shows a highly variable prevalence of nasal colonization (1.4% - 53%) and confirms that central venous catheters are the main risk factor for bacteremia, associated with severe metastatic complications and increased mortality. In addition, social determinants such as poverty and ethnicity were identified as relevant risk factors. Screening and decolonization strategies using mupirocin and chlorhexidine have been shown to be effective in reducing the burden of infection. Conclusion: Managing MRSA in hemodialysis requires a multifactorial approach that prioritizes optimizing vascular access, implements evidence-based decolonization programs, and addresses underlying social inequalities to mitigate its clinical and public health impact.

Key words: *Staphylococcus aureus*, Methicillin Resistance, MRSA, Renal Dialysis

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Introduction

Methicillin-resistant *Staphylococcus aureus* (MRSA) is a pathogen of critical importance in both hospital and community settings, characterized by its resistance to all beta-lactam antibiotics (penicillin, cephalosporins, and carbapenems) due to the presence of mecA gene or its variant mecC, which encodes the altered penicillin- binding 2a (PBP2a) [1]. This resistance drastically reduces treatment options, giving MRSA a global public health threat profile [2]. MRSA infections range from asymptomatic colonization, especially in areas such as the nasal passages and skin, to invasive and potentially fatal infections such as bacteremia, endocarditis, pneumonia, and skin and soft tissue infections [3,4]. Its ability to form biofilms and acquire additional resistance to other classes of antibiotics, including fluoroquinolones, macrolides, and aminoglycosides, further complicates clinical management and contributes to increased morbidity, mortality, and hospital costs [5]. The connection between MRSA and hemodialysis (HD) patients has evolved historically, influenced by the interaction of both intrinsic and extrinsic risk factors. HD patients present a multifactorial immunological vulnerability (uremic immune dysfunction, poor nutritional status, comorbidities such as diabetes) that makes them more prone to infections [6]. Added to this are factors of repeated exposure: permanent vascular access (central venous catheters, arteriovenous fistulas) acts as a common entry route for pathogens, and frequent visits to dialysis units involve repeated contact with healthcare settings, where MRSA is endemic [7].

*Author for Correspondence: chna.env@mdurohtak.ac.inThroughout history, rates of colonization and infection caused by MRSA in this population have been consistently higher than in the general population. Early research indicated that catheter-associated bacteremia was the main manifestation, linked to high morbidity and mortality rates, prolonged hospitalization, and high costs [8,9]. Advances in understanding the problem have led to the implementation of active colonization surveillance strategies and vascular access infections preventions protocols, which have shown variable effectiveness in reducing incidence. Studies have indicated that nasal carriers of MRSA have a significantly higher risk of developing subsequent bacteremia, and that decolonization can reduce this risk, although its long-term and population with high reinfection rates effectiveness, remains a subject of ongoing debate [10].

Investigating MRSA in hemodialysis patients is crucial for several reasons: This population represents a high-risk group with a higher burden of infections, where MRSA is considered one of the main causes of healthcare-associated bacteremia [11,12]. The clinical implications are severe: MRSA infections in HD are associated with significantly higher 30- and 90-day mortality rates compared with infections caused by methicillin-sensitive strains, as well as an increased risk of metastatic complications, recurrent hospitalizations, and loss of vascular access, which is essential for patient survival [13,14].

From a public health and healthcare management perspective, these infections generate exorbitant costs due to the need for last-resort antibiotics (such as vancomycin, daptomycin, or linezolid), prolonged hospital stays, and complex management [15,16]. Therefore, it is essential to conduct an updated systematic review that synthesizes the latest evidence on epidemiology, risk factors, and prevention strategies. This will directly benefit clinical practice by informing evidence-based prevention guidelines, optimizing surveillance and decolonization protocols, and guiding the rational use of antimicrobials, thereby mitigating the individual and collective impact of MRSA and contributing to improved clinical outcomes and equality of life for a medically vulnerable population.

Recent systematic reviews have revealed key findings for understanding MRSA in the context of hemodialysis. Globally, a systematic review study conducted in the US that covered relevant studies observed important aspects for the prevention of infections due to antimicrobial management, including active surveillance and targeted decolonization of high-risk populations, especially in patients undergoing hemodialysis. They showed that decolonization in adults is more effective than active surveillance with contact precautions, and emphasized the importance of measures such as hand hygiene, environmental cleaning, and alert systems [17].

Another systematic review was conducted in Africa in accordance with PRISMA guidelines. Studies reporting rates of colonization by methicillin-resistant *Staphylococcus aureus* and risk factors for resistance in African populations were included. Two studies were identified in hemodialysis patients: one conducted in Egypt with a colonization rate of 16.4% and another in Morocco with a rate of 1.4% [18]. This confirmed that MRSA colonization increases the risk of subsequent infections in HD patients, with the central venous catheter being the access site with the highest risk.

In the Americas, the most relevant epidemiological findings from a review study in Brazil reveal that, in patients undergoing hemodialysis using central venous catheters, catheter-related bloodstream infections are common and that between 12% and 38% of these infections are caused by methicillin-resistant *Staphylococcus aureus*, which is associated with a mortality rate three to five times higher than that of methicillin-sensitive strains, emphasizing the relevance of this pathogen as a critical risk factor for morbidity and mortality in this population [19].

Given this problem, the research question arises: “What is the current state of knowledge on epidemiology, risk factors, and prevention and control strategies against methicillin-resistant *Staphylococcus aureus* in hemodialysis patients?” Reviewing this topic is necessary to synthesize the existing evidence on aserious clinical problem and offer conclusions that can guide clinical practice and future research in microbiology.

1. Materials and Methods

This study was based on a systematic review of the literature in four databases: Scopus, PubMed, Google Scholar, and Science Direct. The initial research was conducted in each database according to the inclusion and exclusion criteria established for the review of studies, using Boolean descriptors and specific filters for each database.

The selection process for the articles to be analyzed was carried out by four co-authors of this review, each using a different database, and any contradictions were resolved by consensus among the six authors. Primary articles, full texts, clinal cases, and randomized trial published in English and Spanish between 2021 and 2025 were included Review studies in animals and duplicate studies were excluded. Article selection was conducted in accordance with the PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses); this flow diagram allows for the identification, screening and inclusion of eligible studies [20]. Subsequently, the selected records were imported into Rayyan, a web-based application for managing systematic literature reviews and meta-analyses, which enabled efficient screening and filtering of studies [21].

1.1 Procedure.

Record screening was conducted through the review of titles and abstracts. Subsequently, full texts were assessed to exclude studies that did not meet the inclusion criteria, resulting in the final set of articles included in this review.

The literature search yielded a total of 228 records, distributed as follows: 125 from PubMed, using the search strategy *“Staphylococcus aureus”* AND “Methicillin” AND “Renal Dialysis”; 32 in Google Scholar with the strategy "*Staphylococcus aureus*" +"Methicillin" +"hemodialysis patient" +"risk fac-tors" OR"clinical impact" OR"prevention" OR"control strategies", filetype:pdf; In Science Direct, 36 articles were identified, with the strategy "*Staphylococcus aureus*" AND "Methicillin" AND "hemodialysis patient" and in ESCOPUS 35 studies, with the strategy "*Staphylococcus aureus"* AND "Methicillin" AND "hemodialysis patient"

After title screening, 7 duplicate records were removed, reducing the total to 221 documents. Subsequently, 198 studies were excluded following title review, 24 after abstract screening, and 8 after full-text assessment, resulting in 22 articles included in the final analysis.

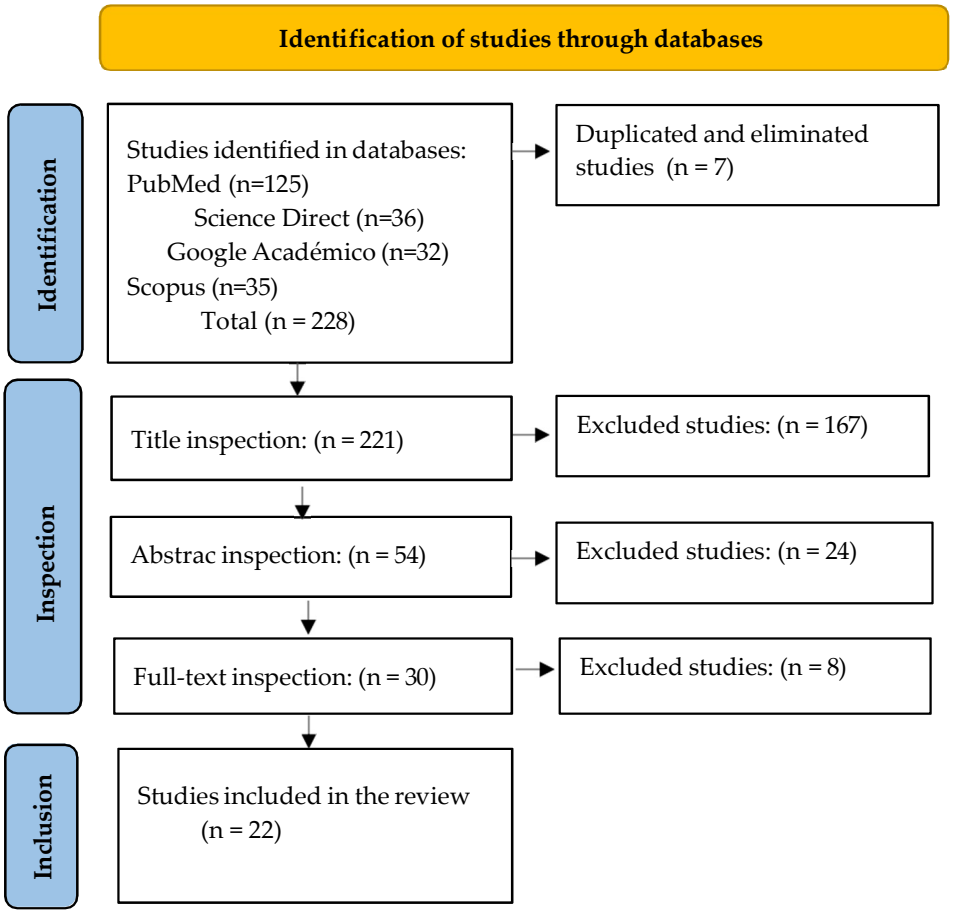

Figure 1. *Identification, selection, and inclusión of studies.*

2. Results

Table 1. *Features of epidemiological studies*

Author (Year) and Country	Title	Metodology	Key Findings
Aboumaurad et al., 2024, Brazil [22]	Nasal colonization by *Staphylococcus aureus* and antimicrobial susceptibility profile in hemodialysis patients using a seven-collection protocol.	Prospective descriptive study. Forty-seven patients on hemodialysis with weekly nasal sampling for 7 weeks.	Fifty-three percent (n=25) of patients were nasal carriers of S. aureus. A minority (16%) were resistant to oxacillin and methicillin,
Al-Dmour et al., 2023, Jordan [23]	Genetic identification of methicillin-resistant *Staphylococcus aureus* nasal carriage and its antibiogram among renal dialysis patients in a tertiary care hospital in Al-Karak, Jordania.	Cross-sectional study of 83 hemodialysis patients. Nasal swabs were collected and incubated at 37 °C for 24–48 h.	The prevalence of MRSA was 9.6% (8/83 patients). All MRSA isolates harbored the *mecA* and *SCCmec* genes and showed complete resistance to methicillin.
Chhakchhuak et al., 2023, India [24]	Retrospective Analysis of Spectrum of Infections and Antibiotic Resistance Pattern in Chronic Kidney Disease Patients on Maintenance Hemodialysis	Retrospective study including 586 hemodialysis patients over a 2-year period, analyzing microbiologically confirmed infections.	In the case of confirmed catheter-associated bloodstream infections, S. aureus was found to be resistant to methicillin (12.5%).

Jiang et al., 2021, Pakistan [25]	Prevalence of drug-resistant microbes in sepsis cases of catheter and fistula based haemodialysis	Cross-sectional study of blood samples from 100 patients. Bacterial isolation was performed using culture media, and antibiotic resistance was assessed by the Kirby–Bauer disk diffusion method.	Bacteria were identified in 22% of samples, with *S. aureus* being the most frequent pathogen (17%). Only one *S. aureus* isolate was identified as methicillin-resistant (*mecA*-positive).
Montoya Urrego et al., 2022, Colombia [26]	The remarkable genetic relationship between *Staphylococcus aureus* isolates from hemodialysis patients and their household contacts: Homes as an important source of colonization and dissemination	Cross-sectional study including molecular typing (PFGE and *spa* typing) of isolates from hemodialysis patients and their household contacts.	In 52.4% of households with multiple colonized individuals, a genetic relationship between isolates was observed, indicating intrahousehold transmission as a significant source of colonization.
Ngo Bell et al., 2024, France [27]	Central venous catheter-related bloodstream infections: Epidemiology and risk factors for hematogenous complications	Single-center retrospective study conducted over 2 years in a tertiary hospital, including hemodialysis patients with catheter-related bloodstream infections.	*S. aureus* accounted for 34% of infections. Hematogenous complications (14%) occurred in infections caused by MRSA. Three-month mortality was higher among diabetic patients.
Jun et al., 2021, China [28]	Analysis of pathogenic distribution and drug resistance of catheter-related blood stream infection in hemodialysis patients with vein tunneled cuffed catheter	Retrospective study of 75 patients with tunneled catheters and bloodstream infections. Blood cultures and antimicrobial susceptibility testing were performed.	Forty-four percent of cultures were positive, with *S. aureus* being the most prevalent pathogen (45.5%). MRSA accounted for 20% of *S. aureus* isolates.
Sheikhzadeh et al., 2023, Iran [29]	The high cross-transmission in methicillin resistant *Staphylococcus aureus* between healthy and patient communities	Cross-sectional study including nasal swabs from 231 hemodialysis patients and 400 healthy individuals. PCR was used to detect virulence factors and ERIC-PCR for genotyping.	*S. aureus* prevalence was 35.5% in patients versus 15% in healthy individuals. MRSA prevalence was higher in patients (47.6% vs. 36.7%), with greater multidrug resistance (70.7% vs. 31.7%).

Table 2 summarizes case studies and cohort analyses focusing on risk factors associated with severe methicillin-resistant Staphylococcus aureus (MRSA) infections in patients undergoing hemodialysis.

Table *2*. Risk factors

Author, Year, Country	Title	Metodology	Key Findings
Batista et al., 2023, Brazil [30]	Endogenous Panophthalmitis and Eye Enucleation Secondary to Methicillin-Resistant *Staphylococcus aureus* Bacteremia: A Rare Complication of Tunneled Dialysis Catheter Use	Case report.	Prolonged use of a tunneled hemodialysis catheter (12 months), history of previous MRSA bacteremia, uncontrolled diabetes mellitus, immunosuppression associated with chronic kidney disease, and lack of native vascular access (arteriovenous fistula).
Lai et al., 2024, Taiwan [31]	Exploration of agr types, virulence-associated genes, and biofilm formation ability in Staphylococcus aureus isolates from hemodialysis patients with vascular access infections	Molecular analysis of clinical isolates from hemodialysis patients with vascular access infections.	Tunneled catheter access (TCC) was associated with a higher frequency of MRSA and carriage of virulence-associated genes, as well as enhanced biofilm-forming capacity.
Kuo et al., 2024, Taiwán [32]	Multiple Cold Abscesses of a Chest Wall with Ribs Destruction in a Hemodialysis Patient	Case report of a hemodialysis patient with an MRSA-infected tunneled catheter.	An MRSA-infected tunneled catheter led to persistent bacteremia, septic thrombophlebitis, and metastatic abscess formation. Immunosuppression related to advanced age, diabetes, and

			renal failure contributed to severe complications.
Kumar et al., 2024, USA [33]	A Rapidly Deteriorating Case of Bivalvular Endocarditis in a Hemodialysis Patient: A Case Report	Clinical case report.	Risk factors included vascular access (fistula or catheter), poorly controlled diabetes, immunosuppression due to end-stage renal disease, and frequent manipulation of skin flora during dialysis sessions.
Newman et al., 2022, USA [34]	Calcified Catheter-Related Fibrin Sheath Forms Large Intravenous Cast in Hemodialysis Patient Causing Embolic Sequelae	Case report.	Identified risk factors included abnormal calcium–phosphate metabolism and prolonged duration of central venous catheter (CVC) use.
Rha et al., 2023, USA [35]	*Vital Signs: Health Disparities in Hemodialysis-Associated *Staphylococcus aureus* Bloodstream Infections — United States, 2017–2020*	Negative binomial regression model using data from the National Healthcare Safety Network (NHSN) and the Emerging Infections Program (EIP).	Central venous catheter (CVC) use was identified as the most significant risk factor. Higher infection rates were observed among Hispanic patients, individuals aged 18–49 years, and populations living in regions with higher poverty, overcrowding, and lower educational attainment.
Seong-Ho, 2021, USA [36]	Risk Factors for Recurrent *Staphylococcus aureus* Bacteremia	Prospective study examining a cohort of 759 patients with *Staphylococcus aureus* bacteremia (SAB).	MRSA was more common among patients with recurrent bacteremia (56.5%) compared with those experiencing a single episode (43.7%). Black hemodialysis patients exhibited the highest risk of recurrence, followed by White patients.

Table 3 presents prevention strategies against methicillin-resistant *Staphylococcus aureus* (MRSA) infections in patients undergoing hemodialysis, based on studies conducted in Spain, Italy, Switzerland, India, the US, and Colombia.

Table 2. Prevention

Author (Year) and Country	Title	Metodology	Key Findings
Almenara et al., 2023, Spain [37]	Tunneled catheter-related bacteremia in hemodialysis patients: incidence, risk factors and outcomes. A 14-year observational study	Estudio observacional retrospectivo que describe y evalúa un protocolo para la prevención de infecciones.	Nasal screening and decolonization of *Staphylococcus aureus* using mupirocin, pre-insertion chlorhexidine body bathing, ultrasound-guided sterile technique, and citrate catheter locking were associated with improved infection prevention.
Alfano et al., 2021, Italy [38]	Methicilli Resistant *Staphylococcus aureus* Peritonitis due to Hematogenous Dissemination from Central Venous Catheter in a Maintenance Dialysis Patient	Case report.	Immediate removal of the infected catheter and the peritoneal catheter, combined with prolonged susceptibility-guided antibiotic therapy (daptomycin for 15 days), led to clinical resolution.
Hassoun-Kheir, 2025, Switzerland [39]	Secular trends of bloodstream infections in hemodialysis patients: insights from a longitudinal Swiss study	Longitudinal cohort study conducted at a Swiss university hospital including adult maintenance hemodialysis patients.	Twenty-eight cases of MRSA bloodstream infection were identified. MRSA BSI rates showed a decreasing trend following implementation of a screening and decolonization program for *S. aureus* carriers.
Dhillon et al., 2021, India [40]	A study of nasal carriage of methicillin resistant S*taphylococcus aureus* in patients undergoing hemodialysis in a tertiary care hospital of Punjab	Cross-sectional study assessing nasal carriage and antimicrobial resistance profiles.	Routine screening for nasal *S. aureus*/MRSA carriage in hemodialysis patients and reinforcement of infection-control practices were emphasized to prevent transmission.

Miller et al., 2022, USA [41]	Chlorhexidine and Mupirocin for Clearance of Methicillin-Resistant *Staphylococcus aureus* Colonization After Hospital Discharge: A Secondary Analysis of the CLEAR Trial	Multicenter randomized clinical trial.	A post-discharge decolonization regimen using chlorhexidine (body wash and oral rinse) and intranasal mupirocin reduced *S. aureus* colonization by more than 50% across multiple body sites.
Torres et al., 2021, Colombia [42]	High mupirocin susceptibility in isolates of *Staphylococcus aureus* colonizing hemodialysis patients in a dialysis unit at Medellín	A post-discharge decolonization regimen using chlorhexidine (body wash and oral rinse) and intranasal mupirocin reduced *S. aureus* colonization by more than 50% across multiple body sites.	High susceptibility to mupirocin was observed, supporting its use as prophylaxis in high-risk patients.
Vanegas et al., 2021, Colombia [43]	A longitudinal study shows intermittent colonization by *Staphylococcus aureus* with a high genetic diversity in hemodialysis patients	Longitudinal study assessing colonization dynamics and molecular typing.	Findings highlight the need for continuous surveillance and consideration of selective decolonization in colonized patients at high risk of infection.

3. Discussion

The results confirm that this population remains a critical high-risk group and reveal dynamic epidemiological patterns, a variety of multifactorial risk factors, and the variable effectiveness of preventive interventions. Epidemiology and colonization. The studies presented in Table 1 support the high burden of MRSA in HD patients reported in previous reviews. However, the prevalence of nasal colonization shows extreme heterogeneity, ranging from 1.4% in Morocco [18] to 53 % in Brazil [22] and 47,6 % in Iran [29]. This variability may be attributed to multiple factors, including differences in methodological designs and sample characteristics across studies, as evidenced by the seven-collection protocol that resulted in a high prevalence rate [22].

In addition, local infection-control contexts, historical antibiotic use, and screening policies as discussed in international guidelines [10,17] are key determinants. From a biological perspective, the high level of intrahousehold transmission documented in Colombia [26] and between patient and healthy communities in Iran [29] emphasizes that the MRSA reservoir extends beyond the healthcare setting, thereby complicating control strategies based solely on hospital-centered interventions. This finding broadens the understanding of risk beyond the intrinsic patient-related factors initially considered.

Regarding risk factors, Table 2 clearly identifies vascular access—particularly tunneled central venous catheters (CVCs)—as the most relevant extrinsic risk factor for invasive MRSA infections. This fully supports the evidence from case studies (30,32,33,38), which conclude that CVCs not only serve as portals of entry but also act as reservoirs for persistent bacteremia, potentially leading to devastating metastatic complications (e.g., endocarditis, abscesses, pan ophthalmitis). These complications are directly associated with the increased 30–90-day mortality that has been reported [13]. The interaction with intrinsic factors such as uremic immunosuppression [6,7], diabetes, and advanced age creates a "risk cocktail" that explains the severity of these clinical presentations. An important and timely finding is the identification of structural health disparities. The study by Rha et al. [35] in the United States links MRSA infections to Hispanic ethnicity, poverty, and lower educational attainment—factors that extend beyond biological determinants and point to social determinants of health that limit access to preventive care (e.g., arteriovenous fistulas) and favor the use of CVCs. This represents a critical dimension that must be incorporated into public health policies. Regarding prevention strategies, these align with the recommendations of international guidelines [10,17]. Active screening and targeted decolonization—particularly using intranasal mupirocin and topical chlorhexidine [37,39,41]—emerge as effective interventions to reduce colonization and bloodstream infections. The Swiss study [39] demonstrates that a sustained program can achieve declining trends in MRSA incidence, which is consistent with the findings of the previously cited U.S. review [17].

However, significant challenges remain that help explain the discrepancies observed across studies. First, long-term effectiveness and reinfection—previously identified as ongoing concerns [10]—are reflected in the Colombian longitudinal study [43], which demonstrates intermittent colonization and high genetic diversity, suggesting multiple sources of reinfection. Second, variability in mupirocin susceptibility [42] and the emergence of resistance may limit the future utility of this crucial intervention. Finally, and critically, many successful interventions [41] depend on both patient adherence and healthcare system capacity, which may not be feasible in resource-limited settings or among populations with the socioeconomic characteristics previously identified [35].

This highlights that there is no one-size-fits-all solution; strategies must be tailored to the local epidemiological context, resistance profiles, and healthcare system capacity. The available evidence supports the idea that MRSA in hemodialysis represents a multifaceted

problem that requires an equally multidimensional approach. The main clinical implication is the urgent need to optimize vascular access by promoting the use of arteriovenous fistulas and minimizing the duration of central venous catheter use whenever possible [8,9]. Simultaneously, the implementation of screening and decolonization programs, grounded in local susceptibility data, should be considered a standard practice in dialysis units [17,37]. From a public health perspective, it is also essential to address the social inequalities [35] that predispose patients to CVC use and increased exposure, as well as strengthen epidemiological surveillance to monitor resistance trends [5] and the effectiveness of interventions. The evidence of community and intrahousehold transmission [26, 29] further suggests that prevention strategies should be expanded, when feasible, to include close contacts.

This systematic review has several limitations. Language bias [restricted to English and Spanish publications] and temporal bias (2021–2025) may have led to the exclusion of relevant studies. In addition, the substantial methodological and geographical heterogeneity among the included studies limits the generalizability of the findings. Potential publication bias may have resulted in an overestimation of MRSA prevalence or of the effectiveness of preventive interventions. Furthermore, the predominance of observational study designs weakens causal inference and affects the overall quality of the evidence. Consequently, important gaps in literature were identified. These include the lack of robust longitudinal studies and randomized controlled trials evaluating decolonization strategies; the scarcity of research addressing transmission dynamics and preventive interventions in community and household settings; and the absence of evidence regarding the sustainable implementation of prevention programs in resource-limited environments. Moreover, there is limited research assessing the impact of interventions targeting social determinants of health on MRSA risk among hemodialysis patients.

4. Conclusions

The prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) among patients undergoing hemodialysis is high and exhibits marked geographic heterogeneity, with reported nasal colonization rates ranging from 1.4% to 53%. This variability is largely influenced by differences in local infection control policies and antibiotic selective pressure. Vascular access through catheters has been consistently identified as the main factor associated with bloodstream infections, with MRSA accounting for a substantial proportion of cases and being associated with increased mortality.

Regarding risk factors, the use of central venous catheters—particularly tunneled and long-term devices—represents the most significant modifiable risk factor and is directly associated with recurrent bacteremia, endocarditis, and metastatic complications. These risks are further exacerbated by comorbidities such as diabetes mellitus and immunosuppression related to chronic kidney disease. Crucially, social determinants of health, including ethnicity, poverty, and low educational level, also play a key role by limiting access to safer vascular access alternatives, thereby perpetuating dependence on central venous catheters.

Structured protocols for active screening and targeted decolonization, particularly using intranasal mupirocin and topical chlorhexidine, constitute an effective strategy for reducing MRSA colonization burden and infection rates. However, their long-term effectiveness is challenged by intermittent colonization and reinfection from extra-hospital reservoirs, the potential emergence of mupirocin resistance, and their reliance on patient adherence and adequately resourced healthcare systems. Therefore, these interventions must be mandatorily integrated with the prioritized promotion of native vascular access, specifically arteriovenous fistulas, and tailored to local epidemiological and socioeconomic contexts to ensure sustainability and maximize their impact on reducing MRSA-related morbidity and mortality.

Conflict of interest. The authors declare no conflicts of interest

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