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EFFECTIVENESS OF VARIOUS CHLORHEXIDINE-BASED INSERTION SITE PROTOCOLS IN PREVENTING CRBSI AMONG HEMODIALYSIS PATIENTS: A SYSTEMATIC REVIEW AND SYNTHESIS WITHOUT META-ANALYSIS (SWIM)

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ABSTRACT
Chronic Kidney Disease (CKD) is a global health issue affecting 10–15% of the world's population, often progressing to End-Stage Renal Disease (ESRD). Hemodialysis (HD) is the primary renal replacement therapy; however, the use of a Central Venous Catheter (CVC) for vascular access increases the risk of Catheter-Related Bloodstream Infections (CRBSI). Skin pathogens such as Staphylococcus aureus account for 40–80% of CRBSI cases, contributing to increased morbidity and mortality. The use of chlorhexidine (Chlorhexidine Gluconate/CHG) at the insertion site aims to inhibit extraluminal bacterial colonization. However, the effectiveness of various CHG protocols remains a subject of debate due to the risk of contact dermatitis and cost-effectiveness. This systematic review aims to evaluate the effectiveness of various chlorhexidine-based insertion site care protocols in preventing CRBSI events in hemodialysis patient. This systematic review was conducted in accordance with the PRISMA 2020 guidelines, using the "Synthesis Without Meta-analysis" approach, and is registered with PROSPERO 2026 under CRD420261368887. A search was conducted in the EBSCO, PubMed, Sage Journals, ScienceDirect, Scopus, and Wiley databases using the keyword "chlorhexidine-based catheter insertion care for the prevention of CRBSI." Articles published between 2010 and 2025 were searched, resulting in a total of 1,412 articles identified from the initial database search.. A total of 7 articles meeting the inclusion criteria, consisting of RCTs and quasi-experimental studies. The outcomes analyzed included catheter-related infections such as CRBSI, CLABSI, and CRI. The direction of effects was analyzed narratively, and study quality was assessed using RoB 2 and JBI. Four studies showed a reduction in the incidence of infection, while three studies showed no significant difference. No increased risk of infection was found in any of the studies. Most studies used chlorhexidine sponges or patches (4 studies, 57%); 28% used chlorhexidine-impregnated dressings; and the remainder used chlorhexidine solution. Most studies were of moderate to good quality, with some potential for bias. Three studies showed p-values < 0.05. Chlorhexidine-based care protocol interventions show a tendency to reduce catheter-related infections in hemodialysis, but results remain inconsistent. The implementation of evidence-based nursing practices, particularly tailored to tunneled and non-tunneled catheters, is necessary to optimize infection prevention.

Keywords: catheter-related bloodstream infection; central venous catheter; chlorhexidine; hemodialysis; insertion site care; synthesis without meta-analysis

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INTRODUCTION

Chronic Kidney Disease (CKD) is often asymptomatic in its early stages, leading to delayed diagnosis and progression to End-Stage Renal Disease (ESRD) (Roşu et al., 2025). ESRD is a condition in which the kidneys are no longer able to maintain fluid, electrolyte, and metabolic balance in the body. This condition is irreversible and requires renal replacement therapy, such as dialysis or kidney transplantation (Miao et al., 2025). CKD has become a major global health problem, affecting approximately 10–15% of the world's population, many of whom eventually require dialysis or kidney transplantation (Roşu et al., 2025).

In the United States, more than 700,000 individuals undergo renal replacement therapy or dialysis, and this number is projected to increase by 29–68% by 2030. Globally, the population receiving kidney failure therapy is expected to rise from 2.6 million in 2010 to 5.4 million by 2030. In the United States alone, more than 60% of patients with kidney failure undergo long-term hemodialysis, accounting for approximately 500,000 individuals (Miao et al., 2025). The 2023 Indonesian Health Survey also reported a continuous increase in the number of patients undergoing hemodialysis since the implementation of the national health insurance program (BPJS Health) in 2014 (Hustrini et al., 2025).

Vascular access is a critical determinant of outcomes in patients undergoing hemodialysis (Miao et al., 2025). However, the use of vascular access frequently contributes to bacteremia, which is a major complication among patients receiving long-term hemodialysis (Kasradze et al., 2025; Miller et al., 2016). The vascular access most commonly associated with infection is the central venous catheter (CVC). Infections associated with central venous catheters are commonly referred to as Catheter-Related Bloodstream Infections (CRBSIs). The incidence of CRBSIs has been reported at 1.1–5.5 episodes per 1,000 catheter-days and is associated with increased morbidity, hospitalization, and mortality (Miller et al., 2016).

The most common pathogens causing CRBSIs are gram-positive bacteria, particularly Staphylococcus aureus and coagulase-negative staphylococci, which account for 40–80% of CRBSI cases (Miller et al., 2016). Skin colonization by pathogens is closely associated with catheter colonization, thereby increasing the risk of CRBSIs. Therefore, hygienic interventions at the catheter insertion site may reduce the risk of infection (Heimann et al., 2018). A recent study analyzed the use of chlorhexidine gluconate (CHG)-containing CVC dressings (3M Tegaderm CHG IV) compared with non-CHG dressings (3M Tegaderm Advanced IV) in neutropenic patients. The German Society of Hematology and Medical Oncology recommends the use of CHG dressings in cancer patients to prevent CVC-related infections (Heimann et al., 2018).

Within 7–10 days after central venous catheter insertion, bacteria from the skin surface may migrate from the catheter exit site into the intravascular space along the external surface of the catheter (Xu et al., 2024). CHG is used as part of extraluminal care at the catheter insertion site because it releases antimicrobial agents that inhibit bacterial colonization on the skin and the external catheter surface. This mechanism is expected to reduce bacterial migration through the extraluminal pathway and reduce the risk of CRBSIs (Azzopardi & Trapani, 2024). Several studies have demonstrated that the use of CHG dressings significantly reduces the incidence of CRBSIs. However, other studies suggest that CHG dressings may not be effective in preventing CRBSIs and may even increase the risk of contact dermatitis and hospitalization costs (Xu et al., 2024). Based on this background, this study aims to evaluate the effectiveness of various chlorhexidine-based insertion site care protocols in preventing catheter-related bloodstream infections (CRBSIs) among patients undergoing hemodialysis.

METHOD

Research Design

This systematic review was conducted based on the PRISMA 2020 guidelines. Due to heterogeneity in study designs, populations, and outcome reporting, a meta-analysis could not be performed. Therefore, data synthesis was conducted using the Synthesis Without Meta-analysis (SWiM) guideline to ensure transparent and systematic reporting of the findings (Campbell et al., 2020). This review was also registered in PROSPERO under registration number CRD420261368887.

Sample and Eligibility Criteria

The studies included in this review met the following inclusion criteria: (1) adult patients (>18 years old) undergoing hemodialysis; (2) patients using tunneled or non-tunneled vascular access; (3) studies published within the last 15 years; and (4) articles published in English.

The exclusion criteria were: (1) interventions not involving chlorhexidine; (2) intraluminal interventions such as catheter caps or antiseptic caps; (3) pediatric or neonatal populations; (4) narrative reviews or opinion articles; and (5) studies without full-text availability.

A total of 1,412 articles were initially identified through database searching. After removing duplicates, 1,260 articles remained. Articles were excluded if they were unrelated to the research topic, were systematic reviews or meta-analyses, case reports, or study protocols. Finally, articles seven met the eligibility criteria for analysis, with an additional two articles identified through Google Scholar searching (Figure 1).

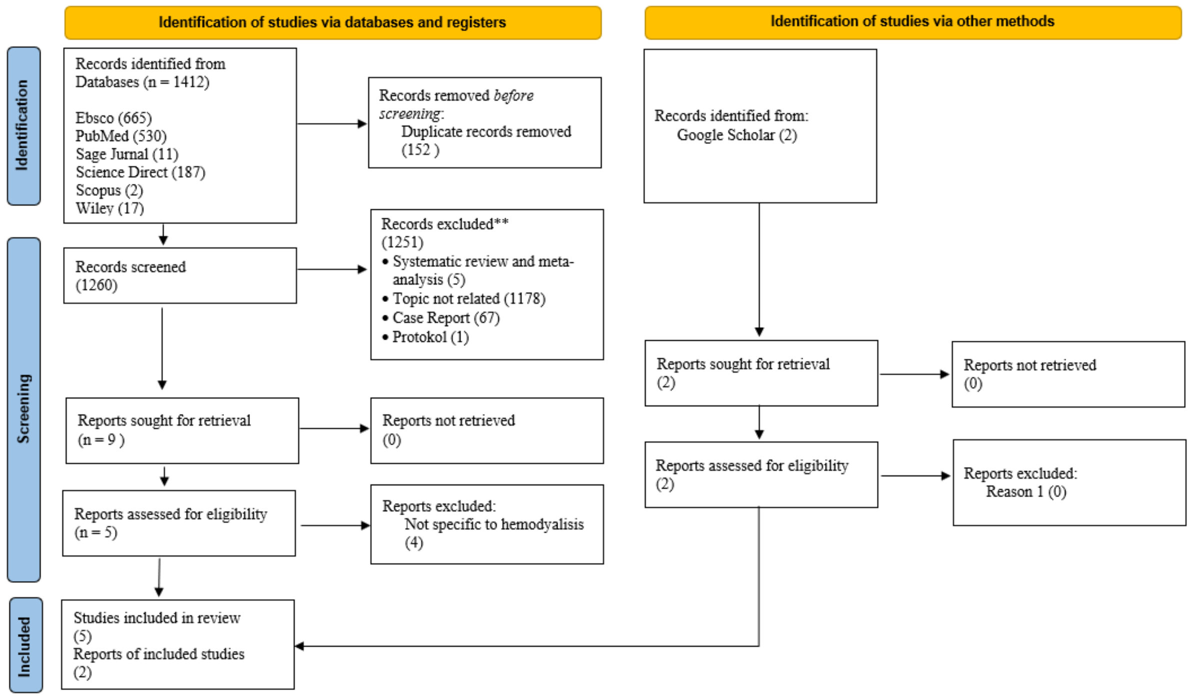


Figure 1. PRISMA flow diagram 2020

Search Strategy

The literature search was conducted to identify evidence regarding the effectiveness of chlorhexidine-based interventions applied at vascular access insertion sites in reducing the incidence of catheter-related bloodstream infections (CRBSIs) among patients undergoing hemodialysis. The Population (P) consisted of patients undergoing hemodialysis, the Intervention (I) was the use of chlorhexidine-based care at the insertion site, there was no specific Comparison (C), and the Outcome (O) was the incidence of CRBSIs.

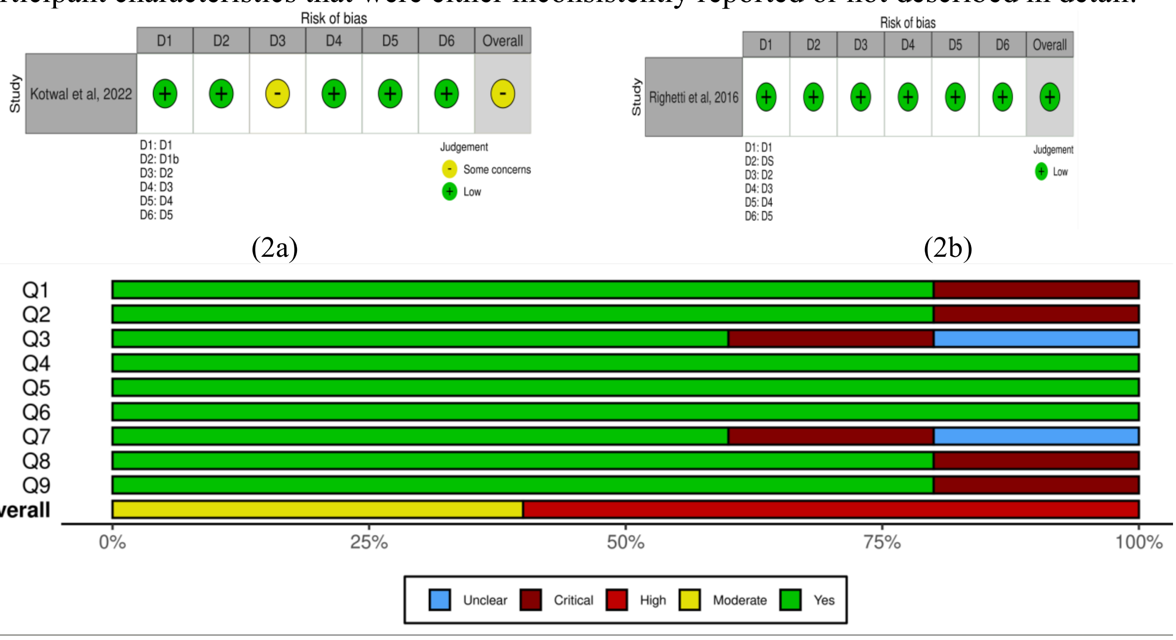
Articles were searched from six databases: EBSCO, PubMed, Sage Journals, ScienceDirect, Scopus, and Wiley. The search was conducted up to February 31, 2025, focusing on chlorhexidine-based catheter insertion site care interventions for preventing CRBSIs. The search strategy used combinations of the following keywords: “hemodialysis,” “haemodialysis patient,” “dialysis patient,” “renal dialysis,” “central venous catheter,” “hemodialysis catheter,” “vascular access,” “tunneled catheter,” “temporary dialysis catheter,” “chlorhexidine dressing,” “chlorhexidine-impregnated dressing,” “antiseptic dressing,” “antimicrobial dressing,” “CHG dressing,” “chlorhexidine gel dressing,” “transparent dressing,” “exit-site,” “exit-site insertion,” “catheter-related bloodstream infection,” “CRBSI,” “CLABSI,” “exit-site infection,” and “catheter colonization." These terms were combined using the Boolean operators AND and OR. Searches in PubMed were conducted using Medical Subject Headings (MeSH) terms. Additional searches were performed through Google Scholar to identify potentially missed studies. All identified articles were managed and duplicate records were removed using Zotero Reference Manager. Only peer-reviewed articles were included to ensure the quality and reliability of the scientific evidence.

Study Quality Assessment

The methodological quality of the included studies was assessed using the Risk of Bias (RoB) 2 tool for randomized controlled trials (RCTs), while quasi-experimental studies were evaluated using the Joanna Briggs Institute (JBI) critical appraisal checklist. For crossover RCTs, six domains were assessed: D1 (randomization sequence), DS (carryover effects and washout period), D2 (adherence to intervention), D3 (missing outcome data), D4 (outcome measurement), and D5 (selection of reported results). For cluster RCTs, six domains were evaluated: D1a (cluster randomization), D1b (timing of participant recruitment), D2 (adherence to intervention), D3 (missing outcome data), D4 (outcome measurement), and D5 (selection of reported results).

The JBI tool for quasi-experimental studies consisted of nine assessment criteria: Q1 (clarity of cause-and-effect relationship between intervention and outcome), Q2 (presence of a control group), Q3 (similarity of participant characteristics), Q4 (consistency of treatment aside from the intervention), Q5 (outcomes measured before and after intervention), Q6 (consistent outcome measurement methods), Q7 (reliability of outcome measurement), Q8 (completeness and explanation of follow-up), and Q9 (appropriateness of statistical analysis).

Among the crossover RCTs, one study was classified as low risk of bias, while one cluster RCT study showed some concerns (Kotwal et al., 2022; Righetti et al., 2016). Of the five quasi-experimental studies assessed using the JBI tool, three were rated as high quality (Apata et al., 2017; Camins, 2013; Shiri et al., 2015), while two studies were categorized as moderate quality (Zimbudzi, 2012; Roderman et al., 2024) (Figure 2). In the RCT studies, limitations included the lack of blinding among researchers regarding the intervention and differences in adherence to interventions that were not measured. In the quasi-experimental studies, major limitations included the absence of randomization, unreported confounding factors, and heterogeneous or imbalanced participant characteristics that were either inconsistently reported or not described in detail.



(2c)

Figure 2. Study quality and *risk of bias* . (2a) RoB 2 *Cluster* RCT (*n=1*). (2b) *Crossover* RCT (*n=1*). (2c) Study quality with JBI (*n=5*)

Data Analysis

Due to substantial heterogeneity in study designs, outcome definitions, and variations in incidence reporting across the included studies, a quantitative meta-analysis was not performed. Therefore, the findings were synthesized narratively following the PRISMA-SWiM (Synthesis Without Meta-analysis) guidelines. Studies were grouped according to study design, including randomized controlled trials (RCTs) and quasi-experimental studies, to account for methodological variations. Risk of bias assessments were also considered in the interpretation of findings, and results from RCTs were analyzed separately from non-randomized studies to minimize potential overestimation of intervention effects. The primary outcome analyzed was the incidence of catheter-related bloodstream infections (CRBSIs). Secondary outcomes included exit-site infections, catheter colonization, and other catheter-related complications reported in the included studies. Because of variations in CRBSI definitions and incidence reporting methods (eg, percentages, cases per 1,000 catheter-days, or cases per 1,000 hemodialysis sessions), pooled effect size estimation was not conducted. Instead, the direction of effect was determined by comparing infection incidence between intervention and control groups within each study. Studies were then categorized as showing: (1) a reduction in CRBSI incidence, (2) no significant difference, or (3) an increase in CRBSI incidence in the intervention group.

Data Extraction

Data extraction was conducted by the primary researcher and independently reviewed by a second reviewer. Any discrepancies between reviewers were resolved through re-evaluation by the second reviewer. Extracted data included study characteristics (authors, publication year, and country), study methodology (study design, sample size, and study population), participant characteristics (age, sex, type of hemodialysis catheter), intervention characteristics (type of chlorhexidine-based intervention and comparison intervention), and primary and secondary outcomes (CRBSI incidence, exit-site infection, catheter colonization, and other catheter-related complications such as bleeding).

RESULT

Study Characteristics

Table 1 presents seven studies conducted across four countries: the United States (n=3), Australia (n=2), Iran (n=1), and Italy (n=1). The study designs included two randomized controlled trials (RCTs), two quasi-experimental studies, two quality improvement pre–post studies, and one non-randomized controlled trial conducted using either retrospective or prospective approaches. Sample sizes ranged from 14 to 4,112 participants, indicating substantial heterogeneity across studies. Three studies reported that participants aged over 60 years predominated, whereas one study reported that most participants were younger than 60 years. One study did not report age characteristics. Male participants predominated in four studies, while one study reported a majority of female participants and two studies did not specify gender characteristics.

Regarding vascular access characteristics, 57% of studies (n=4) involved tunneled central venous catheters, 14% (n=1) involved non-tunneled central venous catheters, 14% (n=1) included both types, and the remaining studies did not specify catheter type. The interventions varied across studies and included several forms of chlorhexidine-based interventions, such as chlorhexidine-impregnated dressings, chlorhexidine solutions, and chlorhexidine sponge or patch dressings. Four studies (57%) used chlorhexidine sponge or patch dressings, 28% used chlorhexidine-impregnated dressings, and the remaining studies used chlorhexidine solutions. Chlorhexidine-impregnated dressings and chlorhexidine sponge or patch dressings were generally replaced every seven days or earlier if they became soiled, bloody, or detached. In studies using chlorhexidine solutions, dressings were changed three times weekly. Comparison groups used polyurethane dressings, adhesive dry gauze dressings, standard care, or povidone-iodine solutions covered with transparent dressings. Some studies also reported the use of 0.114% sodium hypochlorite antiseptic solutions, which were replaced every seven days.

The primary outcome in all seven studies was catheter-related infection, including central line-associated bloodstream infection (CLABSI). Two studies (28.5%) also evaluated exit-site infections, while one study (14.2%) assessed bacterial catheter colonization.

Outcomes

All seven studies reported primary outcomes related to catheter infections, including catheter-related bloodstream infection (CRBSI), central line-associated bloodstream infection (CLABSI), and catheter-related infection (CRI). Although there were variations in the outcome definitions used across studies, all outcomes represented catheter-related infections among hemodialysis patients. Among the included studies, four demonstrated a reduction in infection incidence in the intervention groups compared with the control groups. The remaining three studies found no significant differences between groups. None of the studies reported an increased infection incidence associated with the intervention. Overall, the findings suggest a general trend toward reduced catheter-related infections following chlorhexidine-based interventions, although consistency across studies remained limited. Several studies also reported secondary outcomes such as bacterial colonization and local infections at catheter insertion sites. However, these outcomes were reported inconsistently and were therefore not included in the primary direction-of-effect analysis (Table 2).

Heterogeneity

Table 3 demonstrates that variations in outcome definitions across studies represented a major source of heterogeneity in this review. Although most studies used the term catheter-related bloodstream infection (CRBSI) or related terms such as central line-associated bloodstream infection (CLABSI) and catheter-related infection (CRI), differences existed in the diagnostic criteria applied. Some studies defined CRBSI based on positive blood cultures combined with clinical signs of sepsis, whereas others required stricter microbiological confirmation, such as matching organisms identified in peripheral blood cultures and catheter-tip cultures. In addition, not all studies reported the use of peripheral blood cultures as part of the diagnostic process, and some studies did not clearly describe their operational definitions. Variations were also observed regarding whether local infections and catheter colonization were included as part of the outcome definitions, further contributing to heterogeneity. These differences may have influenced comparisons across studies and affected the interpretation of intervention effects on catheter-related infections in hemodialysis patients.

Direction of Effect

Table 4.
Analysis of Effect Direction

No.	Author (Year)	Direction of Study Effect
1.	Camins et al, 2010	No difference
2.	Zimbabwe, 2012	No difference
3.	Shiri et al, 2015	Reducing CRBSI
4.	Righetti et al, 2016	Reducing CRBSI
5.	Apata et al, 2017	Reducing CRBSI
6.	Kotwal et al, 2022	No difference
7.	Roderman et al, 2024	Reducing CRBSI

Among the seven studies included in the analysis, four studies demonstrated that the intervention was associated with a reduction in catheter-related bloodstream infection (CRBSI) incidence, while the remaining three studies found no significant differences between the intervention and control groups. None of the studies reported an increase in CRBSI incidence. Overall, these findings suggest a general trend toward reduced CRBSI incidence following the interventions, although consistency across studies remains limited. While most studies reported beneficial effects, the absence of significant differences in several studies indicates variability in intervention effectiveness, which may be influenced by differences in study design, intervention type, and outcome definitions used across studies.

Table 1.
Data Extraction of Study Characteristics

No	Author (Year)	Country	Study Design	Study Duration	Gender	Age	Population (N), Hemodialysis Catheter Type	Dressing Type		Intervention Details		Outcome
								Intervention Group	Control Group	Intervention Group	Control Group	
1.	Camins et al, 2010	United States of America	*Prospective non-blinded cross-over intervention trial*	First 6 months of dialysis center A: intervention Dialysis center B: control second 6 months Dialysis center A: control Dialysis B: intervention	Man I : 17 C : 35 Woman I : 14 C : 55 p value: 0.12	< 60 years : I : 24 C : 49 >60 years: I : 7 C : 41 P value: 0.02	N : 121 I: 31 C:90 Dialysis Session I: 5847 dialysis sessions C: 5764 dialysis sessions *Tunneled Central Venous Catheter*	*chlorhexidine-impregnated foam dressing (Biopatch)*	Standard protocol (use of sodium hypochloride)	*Dressing* was added.	-Skin antisepsis using sodium hypochlorite 0.114% before each dialysis session -Transparent dressings are changed every 7 days or if blood is visible, the dressing is dirty or the dressing has come loose.	CRBSI incident
2.	Zimbabwe, 2012	Australia	Observational longitudinal study (before-after study)	The intervention phase involved 14 patients using Biopatch *dressings* (43 dressings) and the follow-up (control) phase involved using conventional dressings for 3 months.	N/A	N/A	N : 14 *Tunneled Central Venous Catheter*	*CHG-impregnated dressing (Biopatch)*	*Chlorhexidine 2% cleansing + mupirocin ointment + standard dressing (IV3000)*	-The permacath catheter entry site is cleaned with 2% chlorhexidine, then a biopatch is installed and attached to *the exit site* , then covered with two layers of IV3000 dressing. - *Dressings* are changed every 7 days	-Follow up phase after stopping the use of Biopatch™, conventional *dressing is used* , namely by cleaning with 2% chlorhexidine + applying Mupirocin ointment (Bactroban) + installing a transparent IV3000 dressing. - *Dressings* are changed 3 times a week	CRBSI event, *exit site event*

No	Author (Year)	Country	Study Design	Study Duration	Gender	Age	Population (N), Hemodialysis Catheter Type	Dressing Type		Intervention Details		Outcome
								Intervention Group	Control Group	Intervention Group	Control Group	
3.	Shiri et al, 2015	Iran	Quasi-experiment	Only mentioned in 2013	Betadine Male: 18 (54.5%) Female: 10 (43.5%) Chlorhexidine Male: 15 (45.5%) Female: 13 (56.5%)	Betadine > 60 years : 9 (32%) <60 years: 19 (68%) Chlorhexidine >60 years: 5 (17.8%) <60 years: 23 (82.2%)	N = 56 I = 28 C= 28 *Non Tunneled Central Venous Catheter*	Chlorhexidine 4% + transparent dressing	Cleaning the catheter insertion with betadine (povidone iodine) 10% + transparent dressing	-The catheter insertion is cleaned with 4% chlorhexidine for 30 seconds then covered with *a transparent dressing.* - *Dressings* are changed every 3 times a week	-Insert the catheter with 10% betadine (povidone iodine) for 2 minutes then cover with *a transparent dressing* . - *Dressings* are changed every 3 times a week	CRBSI incidence, bacterial colonization
4.	Righetti et al, 2016	Italy	Prospective *randomized controlled trial*	The study was conducted over 2 periods, namely 6 months, where the two types of dressing were exchanged after 6 months (*Crossover*) (total duration 1 year).	Man : C: 16 I : 18 Woman : C : 14 I : 11	C : 71.1 ± 2.1 I : 70.9 ± 2.1	N : 59 C : 30 I: 29 *Tunneled cuffed central venous catheter*	Tegaderm CHG dressing	Polyurethane dressing	-The skin is cleansed with chlorhexidine in alcohol, and a tegaderm CHG dressing is applied during the first session and left on for the second and third sessions. *The dressing* will be removed if signs of infection appear. - *The dressing* is maintained for 1 week (not replaced during the second and third HD sessions)	-The skin is cleaned with chlorhexidine in alcohol, after drying it is covered with dry gauze and a standard polyurethane dressing, the dressing is changed every HD session. -Change of *dressings* is carried out 3 times per week at each HD session (3 sessions)	*Bloodstream Infection*) events , *exit site* events, and both events
5.	Apata et al, 2017	United States of America	*Quality Improvement Project (Pre-*	This study was conducted in two phases.	Baseline EDC Male: 127 (55%) Female:	Baseline EDC : 60.0±3.8 EDG:	EDC: Time A (Sept 2011-August 2012) = 232 Time B (Sept	*Chlorhexidine-impregnated transparent (CHG-transparent)*	*adhesive dry gauze dressing*	-When using *CHG-transparent dressing,* do not use antibiotic	- The skin at the insertion site is given antibiotic ointment at the catheter site,	The incidence of CRI (*Catheter related*

No	Author (Year)	Country	Study Design	Study Duration	Gender	Age	Population (N), Hemodialysis Catheter Type	Dressing Type		Intervention Details		Outcome
								Intervention Group	Control Group	Intervention Group	Control Group	
			Post Test)	Phase 1 (HD EDC units used chlorhexidine and HD EDG and EDN units used gauze) and Phase 2 (HD EDC, EDG, and EDN units used chlorhexidine). Each phase was conducted for 1 year.	105 (45%) EDG Male: 89 (52%) Female: 83 (48%) EDN Male: 117 (58%) Female: 85 (42%) Pre-Intervention EDC Male: 128 (56%) Female: 102 (44%) EDG Male: 90 (52%) Female: 83 (48%) EDN Male: 141 (59%) Female: 97 (41%) Post Intervention EDC Male: 126 (54%)	59.5±3.2 EDN : 58.5±6.5 Pre-Intervention EDC : 60.3±4.2 EDG : 60.4±3.4 EDN : 57.9±6 Post Intervention EDC: 61.2±4.1 EDG : 61.3±3.6 EDN: 59.1±14.9	2012-August 2013) = 230 Time C (Nov 2013-Aug 2014) = 235 EDG Time A = 172 Time B = 173 Time C = 177 EDN Time A = 202 Time B = 238 Time C = 247 Baseline (Sept 2011-August 2012) all units still using *adhesive dry gauze dressing* = 606 Pre-Intervention (Sept 2012-August 2013) = 641 Intervention (Sept 2013-August 2014) = 659 *Tunneled central venous catheter*	*dressings*		ointment. -*Dressing* changes are done once a week	covered with gauze and a plaster. -Change *dressings* 3 times a week	*infection*)

No	Author (Year)	Country	Study Design	Study Duration	Gender	Age	Population (N), Hemodialysis Catheter Type	Dressing Type		Intervention Details		Outcome
								Intervention Group	Control Group	Intervention Group	Control Group	
					Female: 109 (46%) EDG Male: 101 (57%) Female: 76 (43%) EDN Male: 143 (58%) Female: 104 (42%)							
6.	Cotwal et al, 2022	Australia	*Stepped wedge, cluster random design*	This study began with an observational phase, with no interventions yet, and served as baseline data. The intervention was applied to all services in a multifaceted bundle (catheter care during insertion, catheter maintenance, and catheter removal). The	Man : C :2121 (60.3) I : 1735 (61) Woman: C : 1398 (39.3) I : 1110 (39)	C: mean: 60.7 (SD: 15.8) I : mean : 60.9 (SD : 15.9)	N : 6364 I : 3519 C : 2845 *Tunneled and Non Tunneled Central Venous Catheter*	Intervention bundle (one of which *is impregnated dressings* with *chlorhexidine impregnated patch* or *sponge*)	Baseline of the protocol that existed at that time	Interventions include catheter care from start to finish (at insertion, during care, at removal). There are two intervention components in the treatment, namely antibacterial dressing and catheter *locking solution.* where each service may choose one or both. Other components in the bundle are	Usual care in each dialysis unit before the intervention bundle is implemented	CRBSI incident

No	Author (Year)	Country	Study Design	Study Duration	Gender	Age	Population (N), Hemodialysis Catheter Type	Dressing Type		Intervention Details		Outcome
								Intervention Group	Control Group	Intervention Group	Control Group	
				interventions were not implemented simultaneously but at one of three points. The starting point was randomly determined from December 20, 2016, to March 31, 2020.						highly recommended to be implemented.		
7.	Roderman et al, 2024	United States of America	*Quality Improvement Project (Pre-Post Test)*	Pre-intervention period January 2020-December 2022 (23 months) and post-intervention period October 2022-December 2023 (14 months)	N/A	N/A	N= 4112 Pre-intervention 21,141 HD procedures Post intervention 9017 HD action sessions The type of dialysis catheter is not mentioned.	Intervention: implementation of standard catheter care procedures (dressing changes) using *chlorhexidine gluconate (CHG)* on *impregnated dressings* (CHG pads)	Routine practice before the implementation of standard catheter care procedures (dressing changes)	Post Intervention -Q4 2022, 1 hospital uses CHG caps. All hospitals use CHG pads	Pre-intervention -In the 3rd quarter of 2020, 1 hospital was appointed as a pilot project, where external dialysis (vendors from outside the hospital) became internal dialysis (in-house dialysis) which focused on standardization of protocols, interventions and policies. By the third quarter of 2021, all hospitals will	The incidence of *central line associated bloodstream infection* (CLABSI)

No	Author (Year)	Country	Study Design	Study Duration	Gender	Age	Population (N), Hemodialysis Catheter Type	Dressing Type		Intervention Details		Outcome
								Intervention Group	Control Group	Intervention Group	Control Group	
											have in-house dialysis facilities. -Quarter 1 2022, all policies and procedures are uniform (standard intervention packages referring to the CDC (*Centers for Disease Control*), AAMI (*Association for Advancement of Medical Instrumentation*), TJC (*The Joint Commission*) -Q3 2022, 8 hospitals started using CHG Caps	

Table 2.
Clinical *Outcomes* Extraction and Significance

No.	Author (Year)	Outcome Incidence (CLABSI)		Key Results	Other outcome results	p value
		Intervention	Control			
1.	Camins et al, 2010	6.3 BSIs/ 1000 dialysis sessions	5.2 BSIs/1000 dialysis sessions	There is no significant difference	The results of the multivariate analysis showed that those aged ≥60 years had a 72% lower risk of developing BSI (aOR 0.28 (0.09–0.82); P = 0.02)	0.46 (RR 1.22, CI 0.76, 1.97)
2.	Zimbabwe, 2012	There were no cases of CLABSI	1 case of CLABSI occurred	There is no significant difference	37% *of suspected exit cite* infections occurred 19% of cases of bleeding occurred in the catheter insertion area.	-

No.	Author (Year)	Outcome Incidence (CLABSI)		Key Results	Other outcome results	p value
		Intervention	Control			
3.	Shiri et al, 2014	3.6% local colonization and infection occurred	21.5% of colonization and local infection occurred	There is a significant difference	- The 10% betadine group experienced bacterial colonization of 10.7% and the chlorhexidine group 1.8% (p value < 0.05)	-
4.	Righetti et al, 2016	0.09 per 1000 catheter days	0.65 per 1000 catheter days	There is a significant difference	-CRI (Catheter Related Infection) in the intervention group was 0.28 per 1000 catheter days while in the control group it was 1.21 per 1000 catheter days (p value 0.02) -The incidence of *exit site* and *bloodstream infections* in the control group was 4 and in the intervention group there were none (p value 0.04) -Multivariate analysis showed that the type of dres associated with the incidence of CRI where CHG had an OR of 0.23, which means that the use dressing could reduce the incidence of infection by	0.05
5.	Apata et al, 2017	Phase 1 EDC Unit (*dry gauze*) 0.82 per 1000 catheter days Phase 1 EDG Unit (*dry gauze*) 2.02 per 1000 catheter days Phase 1 EDN Unit (*dry gauze*) 1.23 per 1000 catheter days Phase 2 EDG Unit (*transparent CHG)* 0.26 per 1000 catheter days Phase 2 EDN Unit (*transparent CHG*) 0.88 per 1000 catheter days Phase 2 EDC Unit (*CHG Transprant*) 0.58 per 1000 catheter days	Phase 1 EDC Unit (*transparent CHG*) 1.69 per 1000 catheter days Phase 1 EDG Unit (*dry gauze*) 1.8 per 1000 catheter days Phase 1 EDN Unit (*dry gauze*) 0.91 per 1000 catheter days Phase 2 EDG Unit (*dry gauze*) 1.86 per 1000 catheter days Phase 2 EDN	There is a significant difference	There isn't any	Phase 1 EDC Unit →<0.05 Phase 1 Unit EDG →0.75 Phase 1 EDN Unit →0.4 Phase 2 Unit EDG →< 0.05 Phase 2 EDN Unit →<0.05 Phase 2 EDC Unit →0.65

No.	Author (Year)	Outcome Incidence (CLABSI)		Key Results	Other outcome results	p value
		Intervention	Control			
			Unit (*dry gauze*) 1.89 per 1000 catheter days Phase 2 EDC Unit (*CHG transparent*) 0.73 per 1000 catheter days			
6.	Kotwal et al, 2022	0.29 per 1000 catheter days	0.21 per 1000 catheter days	There is no significant difference	-Suspected CRBSI for the control group was 0.12 per 1000 catheter days while for the intervention group it was 0.06 per 1000 catheter days (p value 0.06, RR 0.52, 95% CI 0.26;1.03) -Total CRBSI (*confirmed* and *suspected*) for the control group was 0.37 per 1000 catheter days and for the intervention group 0.45 per 1000 catheter days (p value 0.97, RR 0.99, 95% CI 0.67;1.47) -All CVC-related infections in hemodialysis patients (*tunneled and non-tunneled* CVC) in the control group were 0.55 per 1000 catheter days and in the intervention group 0.4 per 1000 catheter days (p value 0.06, RR 0.72 95% CI 0.52;1.01)	0.2 (RR 1.37, 95% CI 0.85;2.21)
7.	Roderman et al, 2024	1 case of CABSI	8 cases of CABSI	There is a significant difference	There isn't any	0.048

Table 3.
Extraction of Outcome Definitions

No.	Author (Year)	Outcome Terms Used	Operational Definitions Used	Peripheral Culture
1.	Camins et al, 2010	CRBSI (*catheter-related bloodstream infection*)	It is said to be CRBSI if it meets the following criteria: a. Positive Culture - There is a positive blood culture result - While the catheter is still in place or ≤ 48 hours when the catheter is removed b. There are clinical signs of sepsis At least one of fever (temperature > 38 degrees) or hypotension (systolic	Not mentioned

			blood pressure < 90 mmHg) c. No other focus of infection was found	
2.	Zimbabwe, 2012	CABSIs (*Catheter Associated Blood Stream Infections*)	Not explained *clearly* in *the study*	Not mentioned
3.	Shiri et al, 2014	Local colonization and infection	- Bacterial colonization is the finding of bacteria from microbiological culture results on the skin around the catheter. - Local infection of the catheter is the presence of signs and symptoms of infection at the insertion site, namely tenderness at the catheter site, pain, redness, fever, chills, and discharge of serous fluid or pus from the wound.	There isn't any
4.	Righetti et al, 2016	CRBSI (*catheter-related bloodstream infection)*	CRBSI is a clinical symptom of infection accompanied by positive blood culture results from a catheter or from peripheral blood vessels without any other source of infection.	Yes
5.	Apata et al, 2017	CRI (*catheter-related infection*)	CRI is bacteremia in hemodialysis patients who have a tunneled central venous catheter or have an infection in the tunnel catheter.	Yes
6.	Kotwal et al, 2022	CRBSI (*catheter-related bloodstream infection)*	CRBSI is an infectious condition if one of the following conditions is met: Condition 1 The same bacteria were found in catheter *tip culture* and peripheral blood culture (the catheter is the source of infection) Condition 2 The same bacteria were found in one blood sample from the catheter and one blood sample from a peripheral vein (there were two positive blood cultures with the same organism) Condition 3 The patient had bacteremia and no other source of infection was found apart from the hemodialysis catheter.	Yes
7.	Roderman et al, 2024	CLABSI (*central line-associated bloodstream infections*)	Not explained *clearly* in *the study*	Not mentioned

DISCUSSION

The findings of this review indicate that several studies reported a trend toward reduced catheter-related bloodstream infection (CRBSI) incidence among hemodialysis patients following chlorhexidine-based interventions at vascular access insertion sites. However, not all studies demonstrate statistically significant differences between intervention and control groups, suggesting that the effectiveness of these interventions remains inconsistent. This inconsistency may be related to variations in participant characteristics, including age and sex, as well as differences in study design, intervention formulations, and outcome definitions across studies. These methodological differences also prevent the performance of a quantitative meta-analysis (Campbell et al., 2020).

The terminology and definitions used across studies also varied considerably. CRBSI is primarily used as a clinical diagnosis to guide treatment decisions and generally requires quantitative blood culture testing demonstrating that the catheter is the source of infection. In contrast, central line-associated bloodstream infection (CLABSI), as defined by the Centers for Disease Control and Prevention National Healthcare Safety Network (NHSN), refers to bloodstream infections occurring in patients who had a central line within the previous 48 hours without necessarily requiring microbiological confirmation that the catheter was the direct source of infection. Because the CLABSI definition is broader, reported CLABSI rates are often higher than CRBSI rates, potentially leading to overestimation (O'Grady et al., 2024; Lok et al., 2020).

The Kidney Disease Outcomes Quality Initiative recommends standardized definitions for catheter-related infections to ensure valid, comparable, and evaluable data. According to KDOQI, the Centers for Disease Control and Prevention, and the Infectious Diseases Society of America, the diagnosis of CRBSI should include three essential criteria: clinical signs of infection, positive blood culture results, and the absence of other infection sources besides the catheter, ideally supported by microbiological confirmation from the catheter itself (Lok et al., 2020).

The chlorhexidine-based interventions used across the reviewed studies varied in formulation, although all were based on chlorhexidine compounds. Chlorhexidine gluconate is a broad-spectrum cationic biguanide antiseptic effective against various bacteria associated with catheter infections. Sponge-based formulations provide active antimicrobial protection at the catheter insertion site (Buetti et al., 2020). The Kidney Disease Outcomes Quality Initiative recommends selecting chlorhexidine formulations for infection prophylaxis based on clinical considerations (Lok et al., 2020).

Evidence from intensive care unit multicenter randomized controlled trials has shown that chlorhexidine-impregnated dressings significantly reduced infection rates from 1.1% to 0.5%. A study involving 601 oncology patients undergoing chemotherapy also demonstrated a significant reduction in CRBSI incidence compared with standard dressings ($p = 0.016$). Furthermore, a meta-analysis of eight randomized controlled trials found that chlorhexidine-impregnated sponge dressings effectively reduced bacterial colonization at catheter exit sites. However, the same meta-analysis concluded that there was no statistically significant reduction in overall CRBSI incidence ($p = 0.11$), despite a numerical decrease from 3.8% to 2.2% (O'Grady et al., 2017).

One important source of heterogeneity influencing CRBSI outcomes in hemodialysis patients is the variation in catheter types. The reviewed studies included both tunneled and non-tunneled catheters. Patients undergoing hemodialysis are generally recommended to use tunneled cuffed catheters because the subcutaneous tunnel acts as a barrier that limits bacterial migration into the bloodstream. The Kidney Disease Outcomes Quality Initiative guidelines refer to findings by Weijmer et al., which demonstrated marked differences in infection rates between tunneled and non-tunneled catheters. The infection risk becomes particularly pronounced after 14 days of catheter use, with non-tunneled catheters showing substantially higher infection risks compared with tunneled catheters (Zrimšek & Gubenšek, 2026).

Nurses play a critical role in the care and monitoring of hemodialysis catheters. Recommendations from the Kidney Disease Outcomes Quality Initiative for preventing CRBSIs include minimizing catheter manipulation, avoiding unnecessary dressing changes, ensuring that trained staff perform vascular access care, conducting regular retraining to improve adherence to aseptic procedures, and limiting catheter use exclusively for dialysis purposes except during emergencies. Nurses should also be able to recognize signs of exit-site infection, including redness, pain, and purulent drainage. For tunneled central venous catheters, symptoms such as pain along the catheter tract, redness, swelling, and drainage should also be carefully monitored (Lok et al., 2020).

This review has several limitations. Significant heterogeneity among studies prevented quantitative meta-analysis. Variations in bloodstream infection definitions and the limited number of available studies also affected the interpretation of findings. Future studies should focus on conducting more randomized controlled trials among hemodialysis patients using standardized catheter types and consistent CRBSI definitions specific to hemodialysis populations.

CONCLUSION

Overall, chlorhexidine-based catheter care protocols appear to reduce the incidence of catheter-related bloodstream infections (CRBSIs) among hemodialysis patients, although findings remained variable across studies. Differences in catheter characteristics and outcome definitions influence the interpretation of results. The implementation of evidence-based nursing practices may support the reduction of CRBSI incidence in hemodialysis patients according to the type of catheter used.

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