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Original Article

Interventions to reduce unnecessary central venous catheter use to prevent central-line–associated bloodstream infections in adults: A systematic review

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Abstract

Objective: To identify, describe, and evaluate interventions to reduce unnecessary central venous catheter (CVC) use to prevent central-line–associated bloodstream infections (CLABSIs) in adults.

Design: Systematic review.

Methods: The review has been registered in PROSPERO, an international prospective register of systematic reviews. We searched PubMed, EMBASE, the Cochrane Central Register of Controlled Trials (CENTRAL), and the Cumulative Index to Nursing and Allied Health (CINAHL) from inception until August 28, 2018, to collect experimental and observational studies. We included all studies that implemented interventions to reduce unnecessary CVC use, defined as interventions aimed at improving appropriateness, awareness of device presence, or prompt removal of devices.

Results: In total, 1,892 unique citations were identified. Among them, 1 study (7.1%) was a randomized controlled trial, 9 studies (64.3%) were quasi-experimental studies, and 4 studies (28.6%) were cohort studies. Furthermore, 13 studies (92.9%) demonstrated a decrease in CVC use after intervention despite different reporting methods, and the reduction rate varied from 6.8% to 85%. Also, 7 studies (50.0%) that reported the incidence of CLABSI described a reduction in CLABSIs ranging from 24.4% to 100.0%. Data on secondary outcomes were limited, and results of the descriptive analysis showed 70%–84% compliance with these interventions, less catheter occlusion, shorter duration of hospitalization, and cost savings.

Conclusions: Interventions to reduce unnecessary CVC use significantly decrease the rate of CLABSI. Healthcare providers should strongly consider implementing these interventions for prevention of CLABSI in adults.

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Central-line–associated bloodstream infections (CLABSIs) have long been among the most common forms of healthcare-associated infections (HAIs). They are associated with increased morbidity, mortality, length of stay (LOS), and healthcare costs.[1–4] The estimated increased LOS for 10–19 days is US$32,000–$45,814 per CLABSI episode.[3–6] The development of CLABSIs is directly related to the use of central venous catheters (CVCs), and the CLABSI rate increases with the prolonged catheter dwell time.[7] However, in recent studies, CVCs were frequently retained unnecessarily because of inappropriate placement, or they were not removed promptly.[8,9] Thus, interventions that reduce unnecessary CVC use may enhance the comfort and safety of patients.

Notable efforts have been devoted to reducing the national incidence of CLABSI, and recent data from Centers for Disease Control and Prevention (CDC) indicated a 50% decrease in the CLABSI rate occurred between 2008 and 2014 among national acute-care hospitals,[10] usually by implementing a bundle of measures. However, little attention has been given to strategies that reduce unnecessary CVC use, and no evidence-based articles have explored the effectiveness of these strategies. Thus, we performed a systematic review to identify, describe and evaluate interventions to reduce unnecessary CVCs use for preventing CLABSIs in adults.

Methods

This review was conducted following the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement[11] and the recommendations in the *Cochrane Handbook for Systematic Reviews of Interventions version 5.1.0*.[12] This review has been registered with PROSPERO (registration no. CRD42018086680).

Criteria for study selection

We considered experimental and observational studies with or without a control group that evaluated any intervention to reduce unnecessary CVC use. We defined CVC interventions as interventions aimed at improving appropriateness, awareness of device presence, or prompt removal of devices in adult patients (age ≥ 18 years).

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The primary outcomes were CVC use and CLABSI rate. Measurements of CVC use vary, including the percentage of patients with (unnecessary) CVCs before and after the intervention versus the total (or mean) number of days of CVC use before and after the intervention. CLABSI rates are mainly reported as the proportion of patients who developed CLABSIs or as CLABSI episodes per 1,000 CVC days before and after the intervention. The secondary outcomes of interest include compliance with the intervention, catheter-related noninfectious complications, hospital-related outcomes (LOS and mortality of patients), and cost.

Data sources and searches

Four electronic databases were searched from inception until August 28, 2018: PubMed, EMBASE, The Cochrane Central Register of Controlled Trials (CENTRAL), and the Cumulative Index to Nursing and Allied Health (CINAHL). We also scanned the reference lists of all included articles and relevant reviews identified through the search. We did not apply a language restriction. The search strategy included terms relating to or describing the population, intervention, and outcomes. Further details of the search strategies are available in the Supplementary Materials online.

Data extraction and analysis

Titles, abstracts, and full-text screening, as well as data extraction, were performed independently by the 2 review authors (Xiong, Chen). Any disagreement was settled by discussion. A standardized, pilot-tested form was utilized to extract data from the included studies for assessment of study quality and key characteristics of the identified studies. Extracted information included author, publication year, country, study design, characteristics of participants, follow time, details of the intervention, and information for assessment of the risk of bias. The methodological quality of the studies was evaluated using various methods depending on the study design.

The quality of randomized controlled trials (RCTs) was assessed using the Cochrane Review Manager (Revman) version 5.3 'Risk of bias' table software.[12] The following 7 standard criteria were used to assess the methodological quality of RCTs: (1) sequence generation, (2) allocation concealment, (3) blinding of participants and researchers/healthcare providers, (4) blinding of outcome assessors, (5) methods of addressing incomplete outcome data, (6) selective reporting of outcomes, and (7) other possible sources of bias. For each quality criterion, we assessed and graded the study as low risk, high risk, or unclear risk according to recommendations for judging the risk of bias provided in chapter 8 of the *Cochrane Handbook for Systematic Reviews of Interventions*.[12]

The quality of quasi-experimental studies (QESs) was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Quasi-Experimental Studies (nonrandomized experimental studies).[13] The checklist included 9 items: (1) clear cause and effect, (2) similar participants, (3) similar treatment, (4) whether there is a control group, (5) multiple measurements of the outcome both before and after the intervention, (6) complete follow-up, (7) outcomes measured in the same way, (8) outcomes measured in a reliable way, and (9) appropriate statistical analysis. Each criterion was graded as yes, no, unclear, or not applicable according to the explanation for the critical appraisal tool for QESs.[13]

The quality of observational studies was assessed using the Newcastle-Ottawa Scale (NOS),[14] which has been used by review groups at the Cochrane Collaboration to evaluate the quality of observational analytical studies. This 8-item tool uses a star system to assess methodological quality across 3 categories: the methods for selecting the study groups; their comparability at baseline; and the ascertainment of the outcome of interest. Scores range from 0 to 9 stars.

Data verification and analysis were conducted by one author (Xiong), and a descriptive analysis was performed.

Results

Search results

In total, 1,892 unique citations were retrieved through the literature search; of these, 14 studies were included in this review (Fig. 1). The study selection procedure is described below.

Characteristics of included studies

A comprehensive description of the studies is summarized in Table 1. The 14 included studies were published between 2010 and 2018 and were performed in the United States,[15–24] Canada,[25,26] France,[27] and Thailand.[28] Of the eligible studies, 1 (7.1%) was a cluster RCT,[28] 4 (28.6%) were cohort studies,[22–24,26] and 9 (64.3%) were QESs, including 5 before-and-after QESs,[15,16,18,25,27] 3 interrupted time-series studies,[19–21] and 1 pilot study.[17] These studies were all conducted in adult departments; all patients were ≥18 years old. Only 2 studies included all inpatients and observation patients.[16,18] Most studies included only a specific department: 5 studies implemented the intervention in the medical and/or surgical wards,[19,20,23,25,28] 2 studies were performed in the emergency departments,[22,24] and 5 studies focused on patients in intensive care units only.[15,17,21,26,27]

Only 4 studies (28.6%) specified the type of CVC used.[18–20,25] Morata,[18] Swaminathan,[20] and Reeves[19] included only peripherally inserted central venous catheters (PICCs). Grady[27] defined the CVCs as nontunneled; nondialysis catheters in jugular, subclavian, or femoral veins; or PICCs. Only 5 studies (35.7%) mentioned the definition of CLABSI,[15,16,20,21,25] and they all used the Centers for Disease Control and Prevention/National Healthcare Safety Network (CDC/NHSN) criteria.

The sample size of included studies varied. Most studies reported sample size in terms of number of patients, ranging from

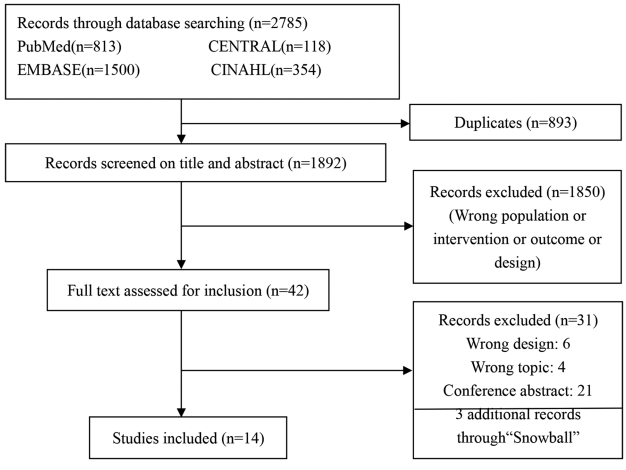

Fig. 1. Flow chart of study selection procedure. Note. CENTRAL: The Cochrane Central Register of Controlled Trials; CINAHL: Cumulative Index to Nursing and Allied Health.

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Table 1. Characteristics of Included Studies

Source (Country)	Design	Participants, No.	Data COLLECTION	Interventions	Outcome measures
Rattanaumpawan, 2016[28] (Thailand)	RCT	General medicine ward patients (N = 874)	2013.2–7	CARE program: Daily reminders from nurses to physicians to document an appropriate indication for CVC use	Compliance, mean duration of CVC days, LOS, mortality, CLABSI rate
Arora, 2014[15] (USA)	QES (Pre–Post)	Adult ICU patients (N = 3,302)	2008.10–2012.1	IDT Rounds: Daily discussion for the presence or absence of CVCs	Total CVC days, CLABSI rate
Chandramohan, 2018[16] (USA)	QES (Pre–Post)	All patients in a LTACH (N = 32,099 patient days)	2015.1–2017.3	A MIPT made weekly recommendations to remove unnecessary CVCs	CVC utilization rate, CLABSI rate
Deutsch, 2013[17] (USA)	QES	SICU patients (N = 31)	2011.6–12	USGPIVs program: use of USGPIVs in patients with DIVA to prevent unnecessary CVCs	CVC days avoided, Cost analysis
Grady, 2015[27] (Canada)	QES (Pre–Post)	Medical inpatients (N = 2,782 patient days)	2013.1–2014.12	Reminders: Online tool used for physician audits of CVCs	Compliance, CVC use
Morata, 2017[18] (USA)	QES (Pre–Post)	All inpatient and observation patients	2014.10–2016.6	USGPIVs; CVC approval: requiring manager approval for placement of CVCs	PICC reduction rate, cost analysis
Reeves, 2017[19] (USA)	QES (ITS)	Patients in the medical–surgical and step-down units	2012–2015	USGPIV program	PICC reduction rate, inappropriate PICC reduction rate
Seguin, 2010[27] (France)	QES (Pre–Post)	SICU patients (N = 1,271)	2005.8–2007.4	Reminders: Daily use of red square added to the patient's daily care sheet, questioned the physician about the utility of the CVCs.	Mean duration of CVC days, CLABSI rate
Swaminathan, 2018[20] (USA)	QES (ITS)	General medicine ward or ICU patients who receive a PICC (N = 7,576)	2014.8–2016.7	MAGIC-based appropriateness tool of PICC placement; dedicated training on peripheral venous access alternatives; EMR incorporated MAGIC; provider education	LOS, PICC use, inappropriate PICC reduction rate, PICC-related complications, CLABSI rate
Weeks, 2014[21] (USA)	QES (ITS)	Adult ICUs (N = 792 hospitals)	2008.5–2012.9	Use of a daily goals instrument to set daily goals of care for each patient. One question on the daily goals form is, "Can catheters/tubes be removed?"	Total CVC days, CLABSI rate
AU, 2012[22] (USA)	Cohort study	EM patients with DIVA (N = 100)	2010.11–2011.6	USGPIV program	CVC use, cost analysis
Galen, 2018[23] (USA)	Cohort study	Adult medical patients	2011.6–12	USGPIV program	Newly placed central venous catheters per day
Ilan, 2012[26] (Canada)	Cohort study	Adult ICU patients (N = 191)	2010.4–5 (28d)	Reminders: Daily use of a checklist by the IDT to remove any CVC if it is no longer necessary.	Inappropriate CVC reduction rate, CLABSI rate
Mccarthy, 2013[24] (USA)	Cohort study	ED patients (N = 401,532)	2006–2011	USGPIV program	CVC use

NOTE. RCT, randomized controlled trial; QES, quasi-experimental study; ITS, interrupted time series; ICU, intensive care units; LTACH, long-term acute-care hospital; SICU, surgical intensive care units; PICC, peripherally inserted central venous catheters; EM, emergency department; DIVA, difficult intravenous access; CVC, central venous catheter; CARE, the catheter reminder and evaluation; MIPT, multidisciplinary infection prevention team; IDT, interdisciplinary team; USGPIV, ultrasound-guided peripheral intravenous catheter; MAGIC: Michigan Appropriateness Guide for Intravenous Catheters; EMR, electronic medical record; LOS, length of stay; CLABSI, central-line–associated bloodstream infection.

31 to 401,532 patients.[15,17,20,22,24,26–28] Other studies reported only the patient days[16,25] or number of studied hospitals.[21] Another 3 studies did not specify the sample size.[18,19,23] The duration of data collection was variable from 1 month to 60 months, and some studies collected >1 set of preintervention or/and postintervention data. For our analysis, we used only the first preintervention and the final postintervention data.

Description of interventions

The types of interventions reported varied across studies. We classified all interventions into 2 categories. First, we considered interventions that sought to avoid unnecessary CVC placement (ie, patients without CVCs do not develop CLABSIs). Accordingly, 7 studies (50.0%) examined the effect of interventions to avoid unnecessary CVC placement. Among them, 1 study (7.1%) implemented institutional restrictions on CVCs, which used the Michigan Appropriateness Guide for Intravenous Catheters (MAGIC) to improve PICC use.[20] Another 6 studies (42.9%) used ultrasound-guided peripheral intravenous catheters (USGPIVs) as an alternative to CVCs.[17–19,22–24] Especially for patients with difficult vascular access, USGPIVs may reduce the need for CVCs.

Second, we considered interventions to prompt the removal of unnecessary CVCs. Although guidelines strongly recommend prompt removal of CVCs, many CVCs are left in place when they are no longer needed. Chopra et al[29] reported that 21.2% of clinicians were unaware of the presence of a CVC, and only a few hospitals had a written policy to evaluate CVC necessity or appropriateness.[30] The most common strategy is to maintain physician or nurse awareness of the CVC's existence, which occurs with reminder-system interventions. The remaining 7 studies (50.0%) all implemented reminder interventions.[15,16,21,25–28] Reminder formats included verbal reminders, written or printed reminders, and online reminders.

Quality of included studies

The quality analysis of the included studies is presented in the Supplementary Materials online. The only RCT included had a medium risk of bias due to random sequence generation and blinding of outcome assessment, but it did not include allocation concealment or blinding of participants.[28] Among the 9 QESs, 8 reported clear cause and effect,[15–17,19–21,25,27] 5 included similar participants in comparisons,[15,17,19–21] and all 9 reported participants that received similar treatments. However, only 1 study had a control group,[20] and 4 studies had multiple measurements of outcomes both before and after the intervention.[18–21] The remaining 4 cohort studies all reported a low risk of bias in the selection of participants, comparability of cohorts, and outcome measures.[22–24,26] Overall, the quality of studies included was moderate to high.

Primary outcomes

CVC use. All included studies reported the outcomes of CVC use despite diverse measurements and reporting methods (Table 2). Overall, 7 studies reported the number of CVCs used,[18–20,22–25] with different reporting methods. Moreover, 2 studies reported the number of CVCs used per 1,000 patient days. Compared with nonintervention groups, CVC use in the intervention groups significantly decreased by 46.6% and 33.6%, respectively ($P < .01$).[20,25]

Table 2. Details of Central Venous Catheter (CVC) Use Outcomes Reported in Studies

		Results		
Outcome: CVC Use	First Author, Year	Pre (Con)	Post (Exp)	Reduction Rate (%)
No. of CVCs /1,000 patient days	Swaminathan 2017[20]	9.51	6.31	33.6[a]
	Grady 2015[25]	130.8	69.8	46.6[a]
No. of newly placed CVCs/day	Galen 2018[23]	0.67	0.47	29.9
Patients with CVCs, %	Morata 2017[18]	Not reported	Not reported	46.7
	Reeves 2017[19]	Not reported	Not reported	24.0
	AU 2012[22]	Not reported	Not reported	85.0
	Mccarthy 2013[24]	0.81	0.16	80.2
Patients with inappropriate CVCs, no. (%)	Reeves 2017[19]	26/60 (43.3)	17/64 (26.6)	38.7[a]
	Swaminathan 2017[20]	472/517 (91.3)	291/446 (65.3)	28.5[a]
	Ilan 2012[26]	41/81 (50.6)	29/110 (26.4)	47.8[a]
Total CVC days, mean (SD)	Arora 2014[15]	3,986 (199.3)	4,305 (215.2)	−8.0[a]
	Weeks 2014[21]	516(403)	481(420)	6.8[a]
CVC days avoided	Deutsc 2013[17]	283 central-line days avoided		
Mean duration of CVC days, median (IQR)	Seguin 2010[27]	5 (3–9)	4 (3–7)	20.0[a]
Mean duration of CVC days, mean (SD)	Rattanaumpawan 2016[28]	2.7 ± 14.6	1.9 ± 8.8	29.6[a]
Total catheter days/total patient days, %	Chandramohan 2018[16]	46	39	15.2

Note. CVC, central venous catheter; SD, standard deviation; IQR, interquartile range; Pre (Con), preintervention or control group; Post (Exp), postintervention or experimental group; Reduction rate, (pre–post)/pre × 100%.
[a]$P < .05$, statistically significant.

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Galen et al[23] described the number of newly placed CVCs per day and found a 29.9% decrease, but the difference was not significant ($P = .08$). The other 4 studies simply reported the reduction in the rate of patients with CVCs, ranging from 24.0% to 85.0%.[18,19,22,24]

The rate of inappropriate CVC placement was reported in 3 studies, including 2 QESs[19,20] and 1 cohort study,[26] but the definitions of inappropriate CVCs were quite different among the 3 studies. Reeves et al[19] referred to PICCs inserted only because of an inability to obtain PIV access; Swaminathan et al[20] defined it in accordance with MAGIC; and Ilan et al[26] referred to no apparent indication for CVC placement. In all 3 studies, however, a significant decrease in the percentage of patients with inappropriate CVCs after an intervention was reported ($P < .05$).

Moreover, 6 studies reported the CVC use in terms of CVC days,[15–17,21,26,27] and they all described a decrease of CVC days at the intervention site compared to the nonintervention site, except one. Aora et al[15] found a statistically significant increase in the number of CVC days, which may have been related to more CVCs being captured through the implementation of a reminder intervention. Deutsch et al[17] reported a total of 283 central-line days avoided during the study period by using USGPIVs. Weeks et al[21] showed significant decreases in total line days and 4% fewer central-line catheter days. The other 2 studies reported that a reminder intervention significantly reduced the mean duration of CVC days per patient ($P < .01$).[27,28] Chandramohan et al[16] mentioned that the CVC utilization ratio, calculated by dividing the number of total catheter days by the number of patient days, nonsignificantly decreased from 46% to 39%.

CLABSI rate

Overall, 7 studies reported the incidence of CLABSIs; they all described a trend toward a reduction in CLABSI ranging from 24.4% to 100.0% (Table 3). Another 4 studies reported the CLABSI rate as a percentage of patients who developed CLABSIs.[15,20,27,28] Only Rattanaumpawan et al[28] and Seguin et al[27] found a statistically significant reduction ($P < .05$). Moreover, 5 studies reported CLABSI episodes per 1,000 CVC days,[15,16,21,26,27] the preferred reporting method requested by the CDC/NHSN, and 3 studies reached a statistically significant reduction in the CLABSI rate ($P < .05$).[21,26,27]

Secondary outcomes

Only 2 studies mentioned compliance with the intervention. Rattanaumpawan et al[28] reported that nurse compliance was 83%, whereas responsible physician compliance was only 74%. Grady et al[25] reported an overall auditing adherence rate of 70%.

Only 1 study provided data on catheter-related noninfectious complications.[20] They observed a significant decrease of 6.4% in the proportion of patients with catheter occlusion after intervention and no significant change in the proportion of patients with venous thrombus embolism.

The single cluster RCT reported hospital-related outcomes.[28] In this study, the reminder group had a significantly shorter LOS, but hospital mortality was comparable between the 2 groups.

Two studies analyzed the cost-effectiveness of implementing USGPIV to replace CVCs. Deutsch et al[17] reported an estimated cost savings of $13,614 were avoided during the study period. Morata et al[18] observed a cost savings of ~$1,545,600.

Discussion

In this review, we identified a decrease in CVC use after interventions, despite nonuniform reporting methods. The reduction in CVC use varied from 6.8% to 85%. Such a wide range in the reduction rate is likely related to several factors: diverse study designs, different settings, variable analysis units, and differing definitions. Half of the included studies indicated that the CLABSI rate decreased by 24.4%–100.0% after the intervention. Also, CVCs were inserted in ~30% of hospitalized patients,[31] and CVC use has inherent risks, most notably CLABSI. However, many CVCs are now inserted inappropriately or are not promptly removed, resulting in CVCs being unnecessarily retained in patients.[32] Our literature review revealed that the prevalence of unnecessary CVC use ranges between 4.6% to 32.7%.[33,34] Previous studies have described a strong link between unnecessary CVC use and adverse device-related local and systemic complications.[32] These reports are consistent with our findings that interventions for the prevention of unnecessary CVC use are effective in decreasing CLABSIs.

Table 3. Details of Central-Line–Associated Bloodstream Infection (CLABSI) Rate Outcomes Reported in Studies

		Results		
Outcome: CLABSI Rate	First Author, Year	Pre (Con)	Post (Exp)	Reduction Rate (%)
Patients who developed CLABSIs, no. (%)	Rattanaumpawan, 2016[28]	13/441 (29.5)	9/433 (20.3)	31.2[a]
	Seguin, 2010[27]	12/676 (1.8)	2/595 (0.3)	83.3[a]
	Swaminathan, 2017[20]	126/3,083 (4.1)	14/446 (3.1)	24.4
	Arora, 2014[15]	14/1,776 (0.8)	7/1,526 (0.5)	37.5
CLABSI episodes/1,000 CVC days	Arora, 2014[15]	3.5	1.6	54.3
	Weeks, 2014[21]	1.96	1.15	41.3[a]
	Seguin, 2010[27]	2.8	0.7	75.0[a]
	Ilan, 2012[26]	0.5	0	100.0[a]
	Chandramohan, 2018[16]	1.45	0.39	73.1

Note. CLABSIs, central-line–associated bloodstream infections; pre (Con), preintervention or control group; post (Exp), postintervention or experimental group; reduction rate = (pre–post)/pre × 100%.
[a]$P < .05$, statistically significant.

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Data regarding our secondary outcomes were limited. Only 2 studies reported compliance with interventions, and these rates varied from 70% to 84%, which were comparably high, based on previously reported rates of compliance to CLABSI bundles of 53.7%–80%.[35–38] Similarly, few studies have focused on noninfectious complications and hospital-related outcomes; more studies are needed to assess these outcomes. Regarding cost, 2 studies employing the USGPIVs program both reported a lower cost compared with CVC use: 2 other kinds of intervention (ie, restriction of CVCs insertion and reminders) are essentially simple and low-cost approaches.

In 2014, Meddings et al[39] published a narrative review to summarize interventions to reduce catheter-associated urinary tract infection (CAUTI) by reducing unnecessary urinary catheter use. Urinary catheter reminders and stop orders significantly reduced CAUTI rates in this study. To our knowledge, no evidence-based studies have assessed the efficacy of reducing CLABSI using interventions that avoid unnecessary CVC use. Our review provides the first evidence that interventions to reduce unnecessary CVC use are effective in preventing CLABSI in adults. Furthermore, these interventions appear to be convenient, low risk, low cost, effective, and sustainable.

Our study has several limitations. First and most importantly, the included studies varied significantly in methodology. The studies varied in terms of study design; details of the interventions; definitions of CLABSI, CVC, and unnecessary CVC; and outcome reporting methods. Because of the substantial methodological differences, we did not perform a meta-analysis of the results of the studies. Second, only 1 of the included studies was a cluster RCT; the remaining 13 studies were either QESs or cohort studies. Because RCTs are more methodologically rigorous than other study designs, factors inherent in the studies included may limit the generalizability of our review. Third, only 2 studies mentioned compliance with these interventions. Osorio et al[38] suggested that compliance with a CLABSI bundle was a protective factor against the development of CLABSI, so compliance may impact CLABSI rate. Fourth, we did not assess the efficacy of these interventions on noninfectious complications and health-related outcomes because the information provided was insufficient to do so. Finally, data on the insertion conditions of interventions implementing USGPIVs were insufficient. However, previous studies have demonstrated a significantly higher success rate, shorter time to successful cannulation, and fewer attempts for USGPIVs compared with the traditional method.[40]

In summary, interventions to reduce unnecessary CVC use significantly decreases the rate of CLABSIs. Healthcare providers should strongly consider implementing interventions to avoid CVC use (eg, alternatives to CVCs or restriction of CVC insertion) and/or to ensure prompt removal of unnecessary CVCs (eg, reminders). More RCTs with uniform definitions and outcome measures regarding CVC use and CLABSI rates are needed to comprehensively assess the effectiveness and safety of these interventions.

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References

1. Iordanou S, Middleton N, Papathanassoglou E, Raftopoulos V. Surveillance of device associated infections and mortality in a major intensive care unit in the Republic of Cyprus. *BMC Infect Dis* 2017;17:607.
2. Mishra SB, Misra R, Azim A, *et al*. Incidence, risk factors and associated mortality of central line-associated bloodstream infections at an intensive care unit in northern India. *Int J Qual Health Care* 2017;29:63–67.
3. Kaye KS, Marchaim D, Chen TY, *et al*. Effect of nosocomial bloodstream infections on mortality, length of stay, and hospital costs in older adults. *J Am Geriatr Soc* 2014;62:306–311.
4. Goudie A, Dynan L, Brady PW, Rettiganti M. Attributable cost and length of stay for central line-associated bloodstream infections. *Pediatrics* 2014;133:e1525–e1532.
5. Stevens V, Geiger K, Concannon C, Nelson RE, Brown J, Dumyati G. Inpatient costs, mortality and 30-day re-admission in patients with central-line–associated bloodstream infections. *Clin Microbiol Infect* 2014;20:O318–O324.
6. Zimlichman E, Henderson D, Tamir O, *et al*. Health care-associated infections: a meta-analysis of costs and financial impact on the US health care system. *JAMA Intern Med* 2013;173:2039–2046.
7. Callister D, Limchaiyawat P, Eells SJ, Miller LG. Risk factors for central-line–associated bloodstream infections in the era of prevention bundles. *Infect Control Hosp Epidemiol* 2015;36:214–216.
8. Burdeu G, Currey J, Pilcher D. Idle central venous catheter days pose infection risk for patients after discharge from intensive care. *Am J Infect Control* 2014;42:453–455.
9. Tejedor SC, Tong D, Stein J, *et al*. Temporary central venous catheter utilization patterns in a large tertiary care center: tracking the "idle central venous catheter." *Infect Control Hosp Epidemiol* 2012;33:50–57.
10. Healthcare-associated infections (HAI) progress report. Centers for Disease Control and Prevention website. https://www.cdc.gov/hai/surveillance/progress-report/index.html. Published 2016. Accessed April 10, 2018.
11. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Ann Intern Med* 2009;151:264–269, w264.
12. Higgins J, Green S. *Cochrane Handbook for Systematic Reviews of Interventions version 5.1.0*. The Cochrane Library website. http://handbook-5-1.cochrane.org/. Published 2011. Accessed Janurary 5, 2018.
13. Tufanaru C, Munn Z, Aromataris E, Campbell J, Hopp L. Chapter 3: Systematic reviews of effectiveness. The Joanna Briggs Institute website. https://reviewersmanual.joannabriggs.org/. Published 2017. Accessed February 6, 2018.
14. Wells G, Shea B, O'Connell D, *et al*. The Newcastle-Ottawa Scale (NOS) for assessing the quality if nonrandomized studies in meta-analyses. Ottawa Hospital Research Institute website. http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp. Published 1999. Accessed February 7, 2018.
15. Arora N, Patel K, Engell CA, LaRosa JA. The effect of interdisciplinary team rounds on urinary catheter and central venous catheter days and rates of infection. *Am J Med Qual* 2014;29:329–334.
16. Chandramohan S, Navalkele B, Mushtaq A, Krishna A, Kacir J, Chopra T. Impact of a multidisciplinary infection prevention initiative on central line and urinary catheter utilization in a long-term acute care hospital. *Open Forum Infect Dis* 2018;5:ofy156.
17. Deutsch GB, Anantha Sathyanarayana S, Singh N, Nicastro JM. Ultrasound-guided placement of midline catheters in the surgical intensive care unit: a cost-effective proposal for timely central line removal. *J Surg Res* 2013;191:1–5.
18. Morata L, Ogilvie C, Yon J, Johnson A. Decreasing peripherally inserted central catheter use with ultrasound-guided peripheral intravenous lines: a quality improvement project in the acute care setting. *J Nurs Adm* 2017;47:338–344.
19. Reeves T, Altmiller G, Morrison D. A nurse-led ultrasound-enhanced vascular access preservation program: a quality improvement initiative combines advanced technology and patient-centered care. *Am J Nurs* 2017;117:56–64.

20. Swaminathan L, Flanders S, Rogers M, *et al*. Improving PICC use and outcomes in hospitalised patients: an interrupted time series study using MAGIC criteria. *BMJ Qual Saf* 2018;27:271–278.
21. Weeks KR, Hsu YJ, Yang T, Sawyer M, Marsteller JA. Influence of a multifaceted intervention on central line days in intensive care units: results of a national multisite study. *Am J Infect Control* 2014;42:S197–S202.
22. Au AK, Rotte MJ, Grzybowski RJ, Ku BS, Fields JM. Decrease in central venous catheter placement due to use of ultrasound guidance for peripheral intravenous catheters. *Am J Emerg Med* 2012;30:1950–1954.
23. Galen BT, Southern WN. Ultrasound-guided peripheral intravenous catheters to reduce central venous catheter use on the inpatient medical ward. *Qual Manag Health Care* 2018;27:30–32.
24. Mccarthy M, Al TK. Ultrasound-guided peripheral intravenous access program is associated with a marked reduction in central venous catheter use in noncritically ill emergency department patients. *Ann Emerg Med* 2013;61:198–203.
25. Grady D. A Simple Approach to reducing inappropriate use of central venous catheters. *JAMA Intern Med* 2015;175:1234.
26. Ilan R, Doan J, Cload B, Squires M, Day A. Removing nonessential central venous catheters: evaluation of a quality improvement intervention. *Can J Anaesth* 2012;59:1102–1110.
27. Seguin P, Laviolle B, Isslame S, Coue A, Malledant Y. Effectiveness of simple daily sensitization of physicians to the duration of central venous and urinary tract catheterization. *Intensive Care Med* 2010;36:1202–1206.
28. Rattanaumpawan P, Teeratorn N, Thamlikitkul V. A Cluster-randomized controlled trial of the catheter reminder and evaluation program. *Infect Control Hosp Epidemiol* 2016;37:231–233.
29. Chopra V, Govindan S, Kuhn L, *et al*. Do clinicians know which of their patients have central venous catheters? A multicenter observational study. *Ann Intern Med* 2014;161:562–567.
30. Chopra V, Kuhn L, Ratz D, Flanders SA, Krein SL. Vascular nursing experience, practice knowledge, and beliefs: results from the Michigan PICC1 survey. *J Hosp Med* 2016;11:269–275.
31. Climo M, Diekema D, Warren DK, *et al*. Prevalence of the use of central venous access devices within and outside of the intensive care unit: results of a survey among hospitals in the prevention epicenter program of the Centers for Disease Control and Prevention. *Infect Control Hosp Epidemiol* 2003;24:942–945.
32. Becerra MB, Shirley D, Safdar N. Prevalence, risk factors, and outcomes of idle intravenous catheters: an integrative review. *Am J Infect Control* 2016;44:e167–e172.
33. Trick WE, Vernon MO, Welbel SF, Wisniewski MF, Jernigan JA, Weinstein RA. Unnecessary use of central venous catheters: the need to look outside the intensive care unit. *Infect Control Hosp Epidemiol* 2004;25:266–268.
34. Kara A, Johnson CS, Murray M, Dillon J, Hui SL. Can the identification of an idle line facilitate its removal? A comparison between a proposed guideline and clinical practice. *J Hosp Med* 2016;11:489–493.
35. Lee KH, Cho NH, Jeong SJ, Kim MN, Han SH, Song YG. Effect of central-line bundle compliance on central line-associated bloodstream infections. *Yonsei Med J* 2018;59:376.
36. Liang HW, Lin HL. Compliance with central-line insertion bundles in an intensive care unit. *Am J Infect Control* 2014;42:581–582.
37. Leung PO, Lin HL, Lai CC. Different compliance with central-line insertion bundle between intensivist and nonintensivist staff in intensive care units. *Infect Control Hosp Epidemiol* 2014;35:601–603.
38. Osorio J, Álvarez D, Pacheco R, Gómez CA, Lozano A. Implementation of an insertion bundle for preventing central-line–associated bloodstream infections in an intensive care unit in Colombia. *Rev Chilena Infect* 2013;30:465–473.
39. Meddings J, Rogers MA, Krein SL, Fakih MG, Olmsted RN, Saint S. Reducing unnecessary urinary catheter use and other strategies to prevent catheter-associated urinary tract infection: an integrative review. *BMJ Qual Saf* 2014;23:277–289.
40. Liu YT, Alsaawi A, Bjornsson HM. Ultrasound-guided peripheral venous access: a systematic review of randomized-controlled trials. *Eur J Emerg Med* 2014;21:18–23.

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