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Original Investigation

# Bloodstream Infection Rates in Outpatient Hemodialysis Facilities Participating in a Collaborative Prevention Effort: A Quality Improvement Report

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**Background:** Bloodstream infections (BSIs) cause substantial morbidity in hemodialysis patients. In 2009, the US Centers for Disease Control and Prevention (CDC) sponsored a collaborative project to prevent BSIs in outpatient hemodialysis facilities. We sought to assess the impact of a set of interventions on BSI and access-related BSI rates in participating facilities using data reported to the CDC's National Healthcare Safety Network (NHSN).

**Study Design:** Quality improvement project.

**Setting & Participants:** Patients in 17 outpatient hemodialysis facilities that volunteered to participate.

**Quality Improvement Plan:** Facilities reported monthly event and denominator data to NHSN, received guidance from the CDC, and implemented an evidence-based intervention package that included chlorhexidine use for catheter exit-site care, staff training and competency assessments focused on catheter care and aseptic technique, hand hygiene and vascular access care audits, and feedback of infection and adherence rates to staff.

**Outcomes:** Crude and modeled BSI and access-related BSI rates.

**Measurements:** Up to 12 months of preintervention (January 2009 through December 2009) and 15 months of intervention period (January 2010 through March 2011) data from participating centers were analyzed. Segmented regression analysis was used to assess changes in BSI and access-related BSI rates during the preintervention and intervention periods.

**Results:** Most (65%) participating facilities were hospital based. Pooled mean BSI and access-related BSI rates were 1.09 and 0.73 events per 100 patient-months during the preintervention period and 0.89 and 0.42 events per 100 patient-months during the intervention period, respectively. Modeled rates decreased 32% ($P = 0.01$) for BSIs and 54% ($P < 0.001$) for access-related BSIs at the start of the intervention period.

**Limitations:** Participating facilities were not representative of all outpatient hemodialysis centers nationally. There was no control arm to this quality improvement project.

**Conclusions:** Facilities participating in a collaborative successfully decreased their BSI and access-related BSI rates. The decreased rates appeared to be maintained in the intervention period. These findings suggest that improved implementation of recommended practices can reduce BSIs in hemodialysis centers.

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***INDEX WORDS:*** Dialysis; infection control; bacteremia; quality improvement; catheter-related infections; vascular access devices.

In 2010, more than 370,000 persons received maintenance hemodialysis in the United States for chronic kidney failure.[1] Bloodstream infections (BSIs) are an important cause of morbidity in this population. The rate of hospitalizations for bacteremia or septicemia among maintenance hemodialysis patients was 116 events per 1,000 patient-years in 2010 and has increased 51% since 1993.[1] Hemodialysis patients are particularly susceptible to BSIs because of their need for vascular access, typically through arteriovenous

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(AV) fistulas or grafts or central venous catheters (CVCs). Hemodialysis patients with CVCs have a much higher risk of acquiring a BSI compared with those with AV fistulas or grafts.[2-6] Approximately 37,000 vascular access–related BSIs are estimated to have occurred in US hemodialysis patients with a CVC in 2008,[7] with an average cost per hospitalization of ~$23,000.[8] These represent a large portion of all catheter-related BSIs in the nation, thereby constituting an important target for intervention.[7] Fistula- and graft-related BSIs also contribute to the overall BSI burden in this population, although to a lesser extent.

Preventing CVC- and other vascular access–related BSIs in hemodialysis patients has been identified as a national priority by the US Department of Health and Human Services.[9] Several initiatives have demonstrated the ability to reduce CVC-associated BSIs in intensive care unit patient populations.[10-12] There have been few similar initiatives attempted on a large scale in outpatient hemodialysis centers. In April 2009, the US Centers for Disease Control and Prevention (CDC) announced plans for a collaborative project to prevent BSIs and invited outpatient hemodialysis centers to participate. We assessed changes in BSI rates over time in the group of facilities that joined the CDC Dialysis BSI Prevention Collaborative in 2009, using data reported to the National Healthcare Safety Network (NHSN).

## METHODS

### CDC Dialysis BSI Prevention Collaborative and Interventions

Participation in the CDC Dialysis BSI Prevention Collaborative project (the Collaborative) was voluntary and open to any US outpatient hemodialysis facility. Core activities of the Collaborative included participation in the CDC's NHSN surveillance system, implementation of the Collaborative interventions, and participation in monthly conference calls and yearly in-person meetings. The CDC provided participant training and assistance on NHSN enrollment and reporting procedures. Participants were expected to track and report infections to NHSN in a uniform manner, following the definitions described in the Dialysis Event Surveillance Protocol.[13] The 3 event types that were reported to NHSN were positive blood culture results, intravenous antimicrobial administration starts, and hospitalizations. Participants also were required to complete the NHSN Outpatient Dialysis Center Practices Survey.

At an in-person meeting held in July 2009, CDC subject matter experts shared with the Collaborative participants the evidence supporting various recommended practices for BSI prevention and participants voted on the interventions they believed should be included in the Collaborative. During the next several months, a working group that consisted of CDC staff, experts from outside the CDC, and representatives of 3 Collaborative facilities further defined the proposed interventions; these then were presented to all Collaborative members for discussion and final approval. The resultant "intervention package" (Box 1) included a standard measurement system, evidence-based recommendations from CDC guidelines, staff practice audits with feedback of results, and education of staff. When the intervention package was defined, participants were encouraged to begin implementing the interventions in their respective facilities. Audit tools and other materials also were generated and distributed to support intervention implementation.[14]

**Box 1.** CDC Dialysis BSI Prevention Collaborative Interventions

**Core Interventions**

*Surveillance & feedback using NHSN:* Conduct monthly surveillance for BSIs and other dialysis events and enter events into CDC's NHSN. Calculate facility rates and compare to rates in other facilities using NHSN. Actively share results with front-line clinical staff.

*Chlorhexidine for skin antisepsis:* Use a chlorhexidine (>0.5%) with alcohol solution as first-line agent for skin antisepsis, particularly for central catheter insertion & during dressing changes. Povidone-iodine, preferably with alcohol, or 70% alcohol are alternatives.

*Hand hygiene surveillance:* Perform monthly hand hygiene audits with feedback of results to clinical staff.

*Catheter/vascular access care observations:* Perform quarterly audits of vascular access care & catheter accessing to ensure adherence to recommended procedures. This includes aseptic technique while connecting & disconnecting catheters and during dressing changes. Share results with front-line clinical staff.

*Patient education/engagement:* Provide standardized education to all patients on infection prevention topics including vascular access care, hand hygiene, risks related to catheter use, recognizing signs of infection, and instructions for access management when away from dialysis unit.

*Staff education & competency:* Provide regular training of staff on infection control topics, including access care & aseptic technique. Perform competency evaluation for skills such as catheter care and accessing at least every 6-12 mo and upon hire.

*Catheter reduction:* Incorporate efforts (eg, through patient education, vascular access coordinator) to reduce catheters by identifying barriers to permanent vascular access placement & catheter removal.

**Supplemental Intervention**

*Antimicrobial ointment or chlorhexidine-impregnated sponge dressing:* Apply bacitracin/gramicidin/polymyxin B ointment or povidone-iodine ointment to catheter exit sites during dressing change *or* use a chlorhexidine-impregnated sponge dressing.

Abbreviations: BSI, bloodstream infection; CDC, Centers for Disease Control and Prevention; NHSN, National Healthcare Safety Network.

Collaborative conference calls and in-person meetings presented opportunities for participants to learn about infection prevention topics from subject matter experts and network with other motivated dialysis providers, describe implementation challenges and strategies, and share experiences and success stories. Participants were provided status updates indicating the group's progress toward reporting to NHSN and data feedback reports documenting dialysis event rates for their individual facility, the overall Collaborative, and all dialysis facilities reporting to NHSN.

### Measure Definition

The NHSN Dialysis Event Surveillance Protocol defines a BSI as a positive blood culture collected from a hemodialysis patient as an outpatient or within 1 calendar day after a hospital admission.[13] Among BSIs, the suspected source of the positive blood culture could be reported as the vascular access, a site other than the vascular access, contamination, or uncertain. Guidance to assist users in determining the suspected source is included in the NHSN reporting protocol.[13] An access-related BSI was a subset of BSIs for which the suspected positive blood culture source was reported as the vascular access or uncertain. Positive blood cultures for which the suspected source was contamination or a site other than the vascular access were excluded from the access-related BSI definition, but included as part of the overall BSI measure; we termed these subsets collectively as non–access-related BSIs. Per the surveillance protocol, positive blood cultures are not to be reported if they occurred within 21 days after a previous positive blood culture event in the same patient. Monthly denominators consisted of the number of maintenance hemodialysis outpatients treated in the facility during the first 2 working days of each month, separated by vascular access type. Monthly CVC prevalence was determined as the portion of the patient denominator that was reported as having a CVC. CVC prevalence numerators and denominators were pooled to generate a mean value, expressed as a percentage of patient-months. Pooled mean rates were expressed as the number of events per 100 patient-months and were calculated by pooling numerators and denominators for the period and facilities of interest.

### Participation and Evaluation Period

Our evaluation targeted facilities that joined the Collaborative in 2009. Evaluated facilities regularly participated in the core activities of the Collaborative, described earlier, and reported data to the NHSN. Multiple facilities expressed interest in the Collaborative during 2009, but did not join. These facilities were not included in the evaluation. Facilities that joined the Collaborative since 2009 also were not considered for this evaluation. An evaluation period of January 2009 through March 2011 was selected to ensure that participants reported at least 12 months of intervention period data to the NHSN. The amount of preintervention data available from facilities was more variable.

In March 2011, Collaborative participants were queried about the interventions they had implemented in their facilities and the timing of these interventions. We considered the start of "the intervention" to be the time that best represented the initiation of intervention procedures as a group and the onset of learning and information sharing among facilities in the Collaborative. Based on facilities' responses to our query and the timeframe that had been targeted for intervention implementation, January 2010 was selected as the start of the intervention timeframe for the analysis. Thus, for analysis purposes, the preintervention period was defined as January 2009 through December 2009, and the intervention period, as January 2010 through March 2011. Sixteen of the 17 participating facilities had joined the Collaborative prior to January 2010; one facility joined the Collaborative in March 2010 but had independently initiated most of the Collaborative intervention procedures prior to January 2010. Most participants were engaged in some, but not all, of the Collaborative intervention procedures before January 2010; their efforts expanded and intensified around the time of what was considered the intervention start (January 2010).

### Analysis

Generalized linear mixed models using segmented regression and assuming a Poisson distribution were used to evaluate the effect of the intervention on BSI and access-related BSI rates. Each model estimated the preintervention rate trend ($\beta_1$), the rate change immediately after the intervention start ($\beta_2$), and the difference between preintervention and intervention rate trends ($\beta_3$).[15,16] The intervention period rate trend was estimated by combining $\beta_1$ and $\beta_3$. This was important to assess the true impact of the intervention and ensure that decreases in rate trend that preceded the intervention were not attributed to it. A random intercept for facility was specified to account for variation in baseline rates. Each model was assessed for evidence of first-order positive and negative autocorrelation of the error terms using the Durbin-Watson statistic. The Durbin-Watson statistic did not indicate evidence of overall autocorrelation (BSI model, 1.6; access-related BSI model, 1.7); however, individual facilities had values indicating positive autocorrelation (range: BSI model, 0.6-2.4; access-related BSI model, 0.04-2.4). A first-order autoregressive covariance structure was specified for monthly residual effects by facility. Marginal mean values were used to estimate incidence rate ratios. Robust standard errors were used to estimate variance. All preintervention and intervention rate data were included in the models; 15 facilities contributed at least 1 month of preintervention data. Subanalyses were conducted in facilities with at least 3 (n = 8) and 12 months (n = 6) of preintervention data. Statistical significance was defined as $P < 0.05$. Data were analyzed and plotted using SAS, version 9.3 (SAS Institute Inc).

### Ethical Review

The Collaborative underwent ethical review at the CDC and was determined to be a nonresearch activity.

## RESULTS

Of the 17 facilities included in the analysis, most facilities were not for profit (n = 15), hospital affiliated (n = 11), not part of a corporate chain (n = 16), and located in the Northeast (n = 11; Table 1). Facilities reported a median of 17 months of data to the NHSN during the evaluation period.

During the preintervention period, pooled mean BSI and access-related BSI rates were 1.09 and 0.73 events per 100 patient-months, respectively. During the postintervention period, these rates were 0.89 and 0.42 events per 100 patient-months, respectively. Quarterly crude rates for both access-related BSIs and BSIs were lower for patients with AV fistulas or AV grafts compared with patients with CVCs (Table 2). Crude rates generally were highest in the fourth quarter of 2009, prior to intervention implementation, and appeared to decrease over time to a greater extent in the CVC patient group compared to the AV fistula and graft group. The pooled mean CVC prevalence among Collaborative facilities decreased from 29% to 24% during the first and last intervention months, respectively.

Incidence rate ratios for the segmented regression models are shown in Table 3. Monthly actual and modeled access-related BSI and BSI incidence rates are shown in Fig 1. Statistically significant decreases in modeled BSI (−32%; $P = 0.01$) and access-related BSI (−54%; $P < 0.001$) rates occurred at the start of the intervention (Table 3; Fig 1). During the preintervention period, no change in monthly BSI or access-related BSI rate was detected (Table 3; Fig 1). There also was no change in these rates detected during the intervention period; that is, the initial decrease in rates

**Table 1.** Characteristics of the 17 Participating Facilities Included In Evaluation

| Characteristic | No. or Median |
|---|---|
| Ownership | |
| Not for profit | 15 (88) |
| For profit | 2 (12) |
| Hospital affiliation | |
| Hospital affiliated | 11 (65) |
| Not hospital affiliated | 6 (35) |
| Member of corporate chain of dialysis centers | 1 (6) |
| Large dialysis organization | 0 (0) |
| Dialysis services offered | |
| In-center hemodialysis | 17 (100) |
| Peritoneal dialysis | 6 (35) |
| Home hemodialysis | 2 (12) |
| Region[17] | |
| Midwest | 3 (18) |
| Northeast | 11 (65) |
| South | 3 (18) |
| West | 0 (0) |
| No. of in-center hemodialysis stations | 14 (6-24) |
| Patient census[a] | 50 (10-125) |
| Proportion of patients with CVC[b] | 0.29 (0.12-0.62) |
| No. of months reported | 17 (15-27) |
| Preintervention | 2 (0-12) |
| Postintervention | 15 (13-15) |

*Note:* Seventeen facilities participating in the Centers for Disease Control and Prevention Dialysis BSI Prevention Collaborative. Values are given as number (percentage) or median (range).

Abbreviation: CVC, central venous catheter.

[a]Number of in-center hemodialysis patients assigned to center during first week of previous December.

[b]During first reported month.

that occurred at the start of the intervention was sustained. When restricted to the 8 facilities that reported at least 3 months of preintervention data and the 6 facilities that reported 12 months of preintervention data, significant decreases in BSI and access-related BSI rates (of similar magnitude in comparison to the full models) occurred around the start of the intervention. However, the modeled intervention period BSI rate in these subgroups increased. The intervention BSI rate increased 5.5% per month ($P = 0.001$) in facilities that reported 3 or more months of preintervention data and increased 4.9% per month ($P = 0.005$) in facilities that reported 12 months of preintervention data. There was no trend in preintervention BSI rates. There also was no trend in access-related BSI rates during the preintervention or intervention period. When the BSI and access-related BSI models were adjusted for proportion of patients with a CVC (this was performed including all 17 facilities and the subset of 6 facilities with 12 months of preintervention data), results were unchanged (data not presented). For facilities with 3 or more months of preintervention data, facility-specific preintervention and intervention period rates are shown in Fig S1 (provided as online supplementary material).

## DISCUSSION

The mostly hospital-based hemodialysis facilities participating in this collaborative project were able to demonstrate substantial intervention-associated decreases in their BSI and access-related BSI rates, adding evidence that multicenter initiatives can effectively prevent vascular access infections. BSI reductions of this magnitude have the potential to markedly advance patient safety and produce cost savings.[18] Previous initiatives have reduced central catheter–associated BSIs in inpatient populations.[10,11] These multihospital collaborative projects had used a "bundle" of interventions aimed at improving adherence to recommended CVC insertion practices. As a result of such successes, collaborative-based performance improvement initiatives that bundle strategies to enhance compliance with evidence-based practices are recommended to prevent intravascular catheter–related infections.[19] We followed a similar collaborative model and created a recommended set of interventions focused on catheter maintenance practices because these were considered to be more relevant for BSI prevention in hemodialysis outpatients than insertion practices. Based on early positive results from this initiative, the CDC now recommends the set of interventions used by Collaborative facilities to prevent BSIs in all outpatient hemodialysis settings.[20]

The burden of CVC–associated BSIs in inpatient settings has decreased substantially since 2001. Data from the NHSN and its predecessor system demonstrated a 58% reduction in CVC–associated BSIs in US intensive care units between 2001 and 2009.[7] Much of this decrease has been attributed to widespread implementation of CDC evidence-based central catheter–associated BSI prevention practices that primarily target CVC insertion. Although insertion practices factor into hemodialysis-related BSI prevention, outpatient dialysis providers might have limited control over CVC insertions, which frequently occur outside the dialysis center. This, coupled with the longer term use of hemodialysis catheters, suggests a need to optimize CVC maintenance in dialysis facilities.[21] A bundled approach to standardizing and improving CVC maintenance practices has been assessed to a limited extent in intensive care units and a dialysis unit with promising results.[22,23] In the Collaborative, we incorporated evidence-based interventions recommended in CDC guidelines that were intended to prevent both extraluminal (eg, chlorhexidine skin antisepsis and antimicrobial ointment at the

**Table 2.** Crude BSI and Access-Related BSI Rates for 17 Participating Facilities

| Vascular Access | Quarter | No. Facility-months | Pooled Mean Incidence[a] (95% CI) BSIs | Pooled Mean Incidence[a] (95% CI) Access-Related BSIs |
|---|---|---|---|---|
| All | 2009_4[b] | 37 | 1.31 (0.89-1.88) | 0.92 (0.57-1.41) |
| | 2010_1 | 51 | 0.64 (0.38-0.99) | 0.27 (0.12-0.53) |
| | 2010_2 | 51 | 1.05 (0.72-1.49) | 0.59 (0.35-0.94) |
| | 2010_3 | 50 | 1.10 (0.75-1.55) | 0.52 (0.29-0.85) |
| | 2010_4 | 50 | 0.80 (0.51-1.20) | 0.31 (0.14-0.59) |
| | 2011_1 | 51 | 0.95 (0.63-1.37) | 0.47 (0.26-0.79) |
| AV fistula & AV graft[c] | 2009_4[b] | 37 | 0.56 (0.26-1.07) | 0.25 (0.07-0.64) |
| | 2010_1 | 51 | 0.33 (0.13-0.67) | 0.19 (0.05-0.48) |
| | 2010_2 | 51 | 0.59 (0.31-1.01) | 0.18 (0.05-0.47) |
| | 2010_3 | 50 | 0.46 (0.22-0.84) | 0.14 (0.03-0.40) |
| | 2010_4 | 50 | 0.49 (0.25-0.88) | 0.13 (0.03-0.39) |
| | 2011_1 | 51 | 0.62 (0.34-1.03) | 0.22 (0.07-0.51) |
| Central venous catheter[c] | 2009_4[b] | 37 | 3.04 (1.88-4.65) | 2.46 (1.43-3.94) |
| | 2010_1 | 51 | 1.42 (0.73-2.48) | 0.47 (0.13-1.21) |
| | 2010_2 | 51 | 2.27 (1.37-3.54) | 1.67 (0.91-2.80) |
| | 2010_3 | 50 | 3.06 (1.92-4.64) | 1.67 (0.86-2.92) |
| | 2010_4 | 50 | 1.84 (0.95-3.22) | 0.92 (0.34-2.01) |
| | 2011_1 | 51 | 2.03 (1.11-3.40) | 1.30 (0.60-2.48) |

*Note:* Seventeen facilities participating in the Centers for Disease Control and Prevention Dialysis BSI Prevention Collaborative, October 2009 - March 2011.
Abbreviations: AV, arteriovenous; BSI, bloodstream infection; CI, confidence interval.
[a]Per 100 patient-months.
[b]Preintervention period.
[c]Numerator and denominator are stratified by vascular access type.

exit site) and intraluminal pathways (eg, hand hygiene and hub care) of catheter contamination. Participating facilities worked to standardize and improve staff CVC care practices through education and feedback, competency assessments, and increased attention to hand hygiene prior to catheter manipulation. These approaches were well accepted in the dialysis setting and we believe critical to the observed BSI reduc-

**Table 3.** Incidence Rate Ratios and Percent Change in BSI Rates

| Variable | Coefficient | IRR (95% CI) | Percent Change[a] (95% CI) | *P* |
|---|---|---|---|---|
| **BSIs[b]** | | | | |
| Preintervention trend | $\beta_1$ | 1.01 (0.95 to 1.08) | 1 (−5 to 8) | 0.7 |
| Level change at intervention start | $\beta_2$ | 0.68 (0.50 to 0.92) | −32 (−50 to −8) | 0.01 |
| Change in trend after intervention start | $\beta_3$ | 1.00 (0.92 to 1.08) | 0 (−8 to 8) | 0.9 |
| Intervention trend | $\beta_1+\beta_3$ | 1.01 (0.97 to 1.06) | 1 (−3 to 6) | 0.7 |
| **Access-Related BSIs[c]** | | | | |
| Preintervention trend | $\beta_1$ | 1.02 (0.90 to 1.15) | 2 (−10 to 15) | 0.8 |
| Level change at intervention start | $\beta_2$ | 0.46 (0.33 to 0.62) | −54 (−67 to −38) | $<$0.001 |
| Change in trend after intervention start | $\beta_3$ | 0.99 (0.86 to 1.13) | −1 (−14 to 13) | 0.9 |
| Intervention trend | $\beta_1+\beta_3$ | 1.00 (0.95 to 1.06) | 0 (−5 to 6) | 0.9 |

*Note:* In 17 facilities participating in the Centers for Disease Control and Prevention's Dialysis BSI Prevention Collaborative.
Abbreviations: BSI, bloodstream infection; CI, confidence interval; IRR, incidence rate ratio.
[a]Percent change=(IRR−1) × 100.
[b]Model: $\ln(\lambda) = \beta_0 + \beta_1$ (month) + $\beta_2$ (intervention) + $\beta_3$ (intervention month); n = 27 months, offset: ln(# patient-months), $\lambda$ = # BSIs.
[c]Model: $\ln(\lambda) = \beta_0 + \beta_1$ (month) + $\beta_2$ (intervention) + $\beta_3$ (intervention month); n = 27 months, offset: ln(# patient-months), $\lambda$ = # access-related BSIs.

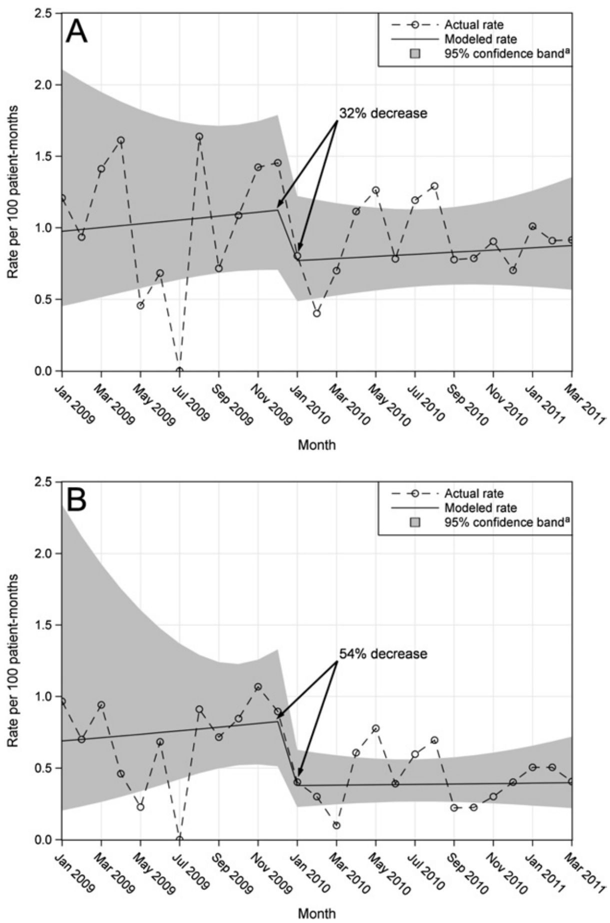


**Figure 1.** (A) Bloodstream infection rates and (B) access-related bloodstream infection rates before and after intervention in 17 facilities participating in the CDC Dialysis Bloodstream Infection Prevention Collaborative. [a]The 95% confidence band for modeled rate.

tions. Participants' examination of catheter connection and disconnection procedures also contributed to the development of a new CVC hub cleansing protocol that subsequently was incorporated into the Collaborative interventions.[14,20] Another important component of the Collaborative interventions was CVC reduction; this also has been promoted through the Fistula First Initiative, a national effort to increase the use of AV fistulas for hemodialysis vascular access.[24] During the evaluation period, Collaborative facilities reduced CVC prevalence in their patients. The successful decrease in CVC use could have contributed to the reduction in overall BSI and access-related BSI rates. However, controlling the BSI and access-related BSI models for the proportion of patients with a CVC had no impact on results. This, together with declining crude BSI and access-related BSI rates in the stratum of patients who had CVCs (Table 2), provides evidence that improved CVC maintenance practices also played a role.

Most facilities in this initiative experienced a decrease in their individual access-related BSI and BSI rates (Fig S1). When all 17 facilities were analyzed, the observed 32% BSI rate decrease and 54% access-related BSI rate decrease were sustained through the end of the evaluation period (Fig 1). The increasing postintervention BSI rate identified in the subset analyses might be a result of diminished adherence over time in some facilities and emphasizes the importance of continued reinforcement of desired practices in all facilities.

NHSN was used as the measurement tool across participating facilities. Compared to the inpatient Central Line-Associated BSI module,[25] the NHSN Dialysis Event Surveillance involves simplified measures for ease of reporting in outpatient settings that typically lack the regular on-site presence of infection control professionals. By definition, the NHSN Dialysis Event BSI measure includes positive blood culture events that do not represent a clinical diagnosis of BSI. It also includes secondary BSIs that are not vascular access related and might not be health care–associated infections. The access-related BSI measure reflects the subset of BSIs that potentially are preventable through improved care of the vascular access. However, this measure is subjective. To assess changes in access-related BSI rates while ensuring that the observed impact was not purely due to increasing misclassification of access-related BSIs as non– access-related BSIs over time, we analyzed access-related BSI and BSI rates and found reductions in both. An analysis of non–access-related BSIs identified no change in these rates over time (data not presented).

The NHSN Dialysis Event BSI measure has been endorsed by the National Quality Forum,[26] and hemodialysis facility participation in the NHSN has rapidly increased in response to Medicare's Quality Incentive Program rule for end-stage renal disease.[27] Both these developments have solidified the role of the NHSN as the measurement tool for vascular access infection–related quality improvement. Although we could have instituted more rigorous clinical definitions for BSI and access-related BSI, we believe that demonstrating impact using NHSN metrics that have emerged as the measurement standard for vascular access infection prevention in this setting is important.

Most of the Collaborative interventions are ones we believe differ from usual practice in US dialysis facilities. For example, when this initiative started, a minority of outpatient dialysis facilities used chlorhexidine for skin antisepsis, performed surveillance using NHSN, or had updated catheter care protocols with dedicated implementation efforts and regular audits to assess adherence; anecdotal information and limited available data on current practices suggest that routine use of antimicrobial ointment or chlorhexidine-impregnated sponge dressings at CVC exit sites remains relatively uncommon (Rosenblum et al[28] and CDC, unpublished NHSN Outpatient Dialysis Center Practices Survey data, 2012). We surveyed several dialysis provider organizations to determine their current practices and how these compare to the Collaborative interventions. All reported performing infection surveillance and regular staff education and having strong catheter reduction programs. While not necessarily a part of organization-wide policies, the interventions involving staff practice audits (eg, hand hygiene and vascular access care) were expected to be taking place in all their facilities. For some dialysis provider organizations, patient education procedures were not completely standardized and staff competency assessments were not universally performed. Finally, use of chlorhexidine and CVC hub cleansing were not standard practice and use of antimicrobial ointment at the CVC exit site was recommended by some organizations but left to the discretion of the treating physicians.

There were several limitations to this analysis. The Collaborative was a prevention initiative, not a research study. As such, it did not include a control arm. Many facilities had a limited number of preintervention data points for the statistical analysis. Because BSI prevention was the priority, facilities were encouraged to not delay implementation of interventions in order to report baseline data. Because fewer than 3 months of preintervention data might be inadequate, we analyzed the subset of 6 facilities with 12 months of preintervention data and found similar reductions in BSIs and access-related BSIs. Identifying a uniform start date for interventions in each facility was not possible. We chose a timeframe that represented the initiation of new interventions and intensification of prior efforts in the context of the Collaborative. Although separate regression models to analyze BSIs and access-related BSIs stratified by vascular access type would have aided our understanding of the Collaborative impact, we lacked sufficient sample size to perform these additional analyses. There was marked variation in monthly rates (Fig 1), likely related to the rarity of BSI outcomes. We lacked sufficient data points to analyze by quarter, which would have been preferable given the rate variability.

Our quasi-experimental design precludes us from being able to establish with certainty that the Collaborative interventions were responsible for the reduction in infection rates. However, several findings support this possibility. First, the decrease in BSI and access-related BSI rates coincides with the timing of introducing the intervention package in Collaborative facilities. Second, access-related BSI rates decreased to a greater extent than BSI rates (Fig 1). Third, the access-related BSI and BSI reductions were most marked in CVC patients compared with those with AV fistulas or grafts (Table 2). This pattern is in line with the interventions, which targeted vascular access-related BSIs and more specifically, CVC-associated BSIs, for prevention.

The facilities in the Collaborative were nonrepresentative of all hemodialysis centers. They tended to be not for profit, hospital affiliated, and by virtue of volunteering to participate in this effort, highly motivated to address infection prevention in their patients. Collaborative facilities may have had unique organizational cultures conducive to necessary changes in staff behavior and/or facility policy. None of the participating facilities belonged to a large dialysis organization, further exemplifying the lack of representativeness of Collaborative members. However, the purpose of this initiative was to demonstrate what is possible among interested providers as a first step toward broader prevention efforts. Data are emerging to suggest that implementing CDC-recommended catheter care practices can have an impact on BSI rates even in more typical large dialysis organization facilities.[28] Finally, the Collaborative facilities' crude preintervention rates (Table 2) were lower than pooled mean rates reported among all dialysis facilities in NHSN (CDC, unpublished NHSN dialysis event data, January 2007-April 2011). Their ability to achieve and maintain significant reductions in these infection rates suggests that facilities throughout the nation with higher baseline rates also should be able to demonstrate meaningful improvements.

Collaboration among facilities to prevent health care–associated infections has been highlighted as an essential part of successful prevention initiatives.[10] This also was true for this Collaborative project. The interventions relied on in this initiative were not novel; instead, facilities aimed to ensure consistent adherence to well-described means of prevention found in existing CDC recommendations. Participation in the creation of the intervention package may have led to a greater understanding of the components and heightened commitment to implementation. The networking that occurred among facilities allowed participants to discuss and develop solutions to common implementation barriers and share effective practices. Specific processes used at each facility were neither measured nor prescribed. Some participants have described their involvement and experiences in the Collaborative.[29,30] Although there was flexibility in how facilities implemented the interventions and used the tools, all participating facilities used a standard data collection system, incorporated evidence-based CDC recommendations, performed practice audits with feedback of results to staff, and educated clinical staff.

With increased attention to health care–associated infection measurement and prevention in hemodialysis settings,[9,27] identifying a set of preventive measures that are feasible and effective is essential. We believe this initiative has helped define what is achievable through focused efforts among dialysis facility staff to improve adherence to CDC-recommended practices for BSI prevention. An important next step is to reproduce the results in other dialysis facilities to expand the impact and further prevent these devastating patient infections.

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## SUPPLEMENTARY MATERIAL

Figure S1: Facility-specific preintervention and intervention period infection rates.

Note: The supplementary material accompanying this article (http://dx.doi.org/10.1053/j.ajkd.2013.03.011) is available at www.ajkd.org.

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