Embracing collaboration: A novel strategy for reducing bloodstream infections in outpatient hemodialysis centers

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Background: The incidence of access-related bloodstream infections (AR-BSIs) in US outpatient hemodialysis centers is unacceptably high. This paper presents the implementation and results achieved from a multi-pronged strategy to reduce AR-BSIs in 1 outpatient hemodialysis center.

Methods: The intervention, which took place between 2009 and 2011, involved membership in the Centers for Disease Control and Prevention Hemodialysis Bloodstream Infection Prevention Collaborative, implementation of a panel of infection prevention interventions, and use of positive deviance (PD) to engage staff. Changes in the incidence of AR-BSIs and infection prevention process measures between the pre- and postintervention time periods, as well as alterations in the center’s social networks, were examined to assess impact.

Results: The incidence of all AR-BSIs dropped from 2.04 per 100 patient-months preintervention to 0.75 (P = .03) after employing the Collaborative interventions and to 0.24 (P < .01) after augmenting the Collaborative interventions with PD. Adherence rates increased significantly in 4 of 5 infection prevention process measure categories. The dialysis center’s social networks became more inclusive and connected after implementation of PD.

Conclusion: Participating in a Collaborative, employing a panel of infection prevention strategies, and engaging employees through PD resulted in a significant decline in AR-BSIs in this facility. Other hemodialysis facilities should consider a similar approach.

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There is nothing so well learned as that which is discovered.
–Socrates

Among patients on hemodialysis, infection is the most common cause of morbidity and the second most common cause of death.1 Infections are numerous and costly. In 2008, there were an estimated 37,000 BSIs among hemodialysis patients with central lines.2 The cost to treat 1 bloodstream infection (BSI) caused by

Staphylococcus aureus was estimated several years ago to be $24,034.3 To place the risk in perspective, researchers have estimated that the incidence of sepsis in end-stage renal disease patients is up to 100 times higher than in the general population.4 These risks may grow because the number of patients with end-stage renal disease is estimated to increase 150% by 2020.1 A troubling picture emerges from these facts, one that led the Centers for Disease Control and Prevention (CDC) to label this challenge a national priority5 and leading authorities in the field to conclude, “The burden of disease in this population should stimulate all of us to demand aggressive BSI prevention efforts as an expected part of routine patient care.”6(p. 574)

At the local level, addressing this challenge will require dialysis centers to consistently follow interventions shown to decrease BSIs. Accomplishing this will require behavioral change by staff members and culture change in centers. Positive deviance (PD) is a social and behavioral change process developed to address such issues. The process rests on the premise that in organizations there

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are individuals and groups whose different (deviant) practices produce better (positive) results than colleagues who have access to the same resources.7–9 It has been used to tackle a range of health-related problems in the developing world such as childhood malnutrition, HIV/AIDS prevention, and female genital cutting.10,11 Success on these issues led to recent and successful PD efforts in hospitals in North and South America to reduce infection rates from multidrug-resistant organisms, improve hand hygiene adherence, and tackle surgical site infections.12–18

To decrease the incidence of access-related BSIs (AR-BSIs) in an outpatient hemodialysis center, a multipronged intervention strategy was employed: involvement in a BSI prevention collaborative; implementation of a panel of evidence-based infection prevention practices; and use of PD to engage staff in carrying out the collaborative interventions. This is the first known use of PD in a dialysis setting.

To gauge the impact of this combination strategy, we examined the incidence of AR-BSIs and related process measures pre- and postintervention. To assess the effect of PD on staff interactions and engagement, we evaluated changes in the facility’s social networks before the initiation of the PD process and 4 months later. We also conducted qualitative interviews.

METHODS

Facility

The AtlantiCare Regional Medical Center Bruce A. Eidelson, MD, Dialysis Unit is a 12-station hospital-based outpatient hemodialysis center serving patients in the Atlantic City, NJ, region. The dialysis center provides care mostly to the community’s underserved end-stage renal disease population. Prior to the interventions described in this paper, the center deployed several strategies to reduce BSIs: dialysis infection-related events surveillance through the CDC’s National Healthcare Safety Network (NHSN); use of chlorhexidine for skin antisepsis; hand hygiene surveillance with results reported to staff; and process measures compliance monitoring. Despite these interventions, BSI incidence remained above the facility goal of less than 1 infection per 100 patient-months.

Interventions

**CDC BSI Prevention Collaborative**

Established in 2009, the CDC Hemodialysis BSI Prevention Collaborative (the Collaborative) comprised 21 outpatient hemodialysis facilities that joined together to demonstrate that significant reductions in BSI rates were possible. Members of the Collaborative and CDC experts created this panel of interventions:

- Surveillance for dialysis events using NHSN;
- use of chlorhexidine for skin antisepsis;
- audits of hand hygiene;
- observation of catheter and vascular access care;
- patient education and engagement;
- staff education and competency testing;
- catheter use reduction programs; and
- use of antimicrobial ointment at catheter exit sites (an optional recommendation).

AtlantiCare leaders believed that PD could advance engagement of front-line staff in prevention efforts and implementation of these interventions.

**Positive Deviance**

The initial orientation to PD for professionals from the dialysis center took place in early 2010. Six staff members were trained to serve as internal PD resources and to facilitate discovery and action dialogues (DADs)14 with members of the dialysis staff. On July 31, 2010, kick-off sessions were held to expose dialysis staff and other hospital personnel to the PD process, information on national BSI trends in hemodialysis, and stories from patients about how serious infections had impacted their lives. A staff member admitted to AtlantiCare Regional Medical Center after being infected with methicillin-resistant S
 aureus at another facility described her illness, pain, and fears about infection risk to her family and her own future health. “She asked ‘what have I done to deserve this?’ This really brought it home to us,” one nurse participant recalled. “Her experience made us realize what she suffered can be prevented if we all do our part.”

Next, multiple DAD sessions were held to draw out the wisdom of front-line dialysis staff and actively engage them in the drive to eliminate infections. “How will the next infection be caused in our dialysis unit?” was a typical opening question. If someone responded by saying it was likely an infections would result from unwashed hands, the facilitator would encourage exploration of this observation. Next, participants would be asked to identify colleagues who practiced optimal hand hygiene and to identify barriers that inhibited high rates of hand hygiene. Staff members would then generate ideas on how to deal with them. The facilitator would then invite colleagues to take responsibility for next steps. Follow-up discussions and regular DADs were incorporated into staff meetings to promote learning and progress on implementation plans. “Now there is a vehicle for people to voice their differences, and there are changes in morale,” a participant observed. “It’s working.” One major change stemming from DAD was creation of 3 separate shifts for dialysis patients with thorough disinfection of the entire unit and equipment between shifts (see box). Table 1 contains the DAD facilitator’s guide used at AtlantiCare.

**Outcome measures**

AR-BSIs were measured using the dialysis event module in NHSN. An AR-BSI was defined as a positive blood culture that was either attributed to the vascular access or an unknown source collected from a hemodialysis patient as an outpatient or within 1 day after a hospital admission. Repeat positive blood cultures were not counted as another AR-BSI unless the subsequent positive blood culture was taken 21 or more days after the first positive blood culture. An AR-BSI in a catheter patient was defined as an AR-BSI in a patient who had a catheter at the time of the infection. Infection rates were reported as events per 100 patient-months and were stratified by 3 time periods: before the intervention (January 2008-August 2009 for AR-BSI and January 2009-August 2009 for AR-BSI in catheter patients); participation in the Collaborative only (September 2009-July 2010); and participation in the Collaborative augmented with PD (August 2010-December 2011). Data for AR-BSIs were not collected by vascular access type before January 2009. Risk ratios were calculated using Fisher exact test. Additional analysis of this data, using interrupted time series models and Poisson regression, was recently published by the CDC.²

**Process measures**

Five categories of prevention process measures—dialysis session initiation and termination procedures, equipment storage and segregation of clean and dirty equipment, medication administration, general practice consisting of the use of personal protective equipment and disinfection of the treatment station, and isolation procedures—were evaluated. Compliance with these standards was monitored a minimum of 8 times per month by the dialysis clinical manager or infection preventionist. Adherence rates were calculated for each category and reported monthly at quality assurance/performance improvement meetings. A z-test comparing proportions was performed to determine whether there was a difference in adherence with each process measure category before and after implementation of PD. Comparable process measure data were not collected for periods prior to the intervention.

**Social network analysis**

To determine changes in the dialysis center’s social networks that accompanied the implementation of PD, staff members were surveyed using an 11-item questionnaire on 2 occasions: at the time of the kick-off in July 2010 and again in November 2010. The questionnaire collected information on whom staff members interacted with and how often they interacted, around 3 areas: general collaboration during daily work, BSI prevention, and innovation (ie, people with whom respondents shared new ideas). Changes in connectivity, inclusion, reach, and centralization were calculated for each of the 3 areas. Connectivity was defined as the proportion of existing connections between center staff in the largest network divided by the total number of possible connections in the largest
network and is proportional to how densely connected a network is. Inclusion was defined as the number of staff in the largest network divided by the total number of staff and is proportional to how inclusive a network is. Reach was defined as the mean number of other staff that a staff member can reach via 2 connections and measures how much awareness a staff member has about what is being discussed in the network. In addition, we measured a centralization score that calculated the mean difference between the connectedness of the most central staff member and all other staff members in the primary network. It measures how dependent a network is on a single staff member. Proportions were compared using Pearson $\chi^2$ test or Fisher exact test. Means were compared using a $t$ test.

Social network analysis was employed to gain insights into the impact of PD on staff connections and engagement. A growing body of evidence, from spurred by complexity science and relational coordination informed research, suggests that quality is highly dependent on the nature of interactions on health care teams, the extent of connections among staff members, the degree to which diversity is welcomed, and the flow of information through informal staff networks.\textsuperscript{19-21} This evidence and the methods used in the social network analysis dimension of this research were informed by network science described in the work of Newman et al.,\textsuperscript{22} Watts,\textsuperscript{23} and Baribasi.\textsuperscript{24}

### RESULTS

#### Outcome measures

AR-BSIs incidence rates for the preintervention, Collaborative, and Collaborative with PD time periods ranged from 2.04 per 100 patient-months to 0.24 per 100 patient-months and varied for AR-BSIs in catheter patients from 2.94 per 100 patient-months to 1.32 per 100 patient-months. The incidence rate for AR-BSIs was significantly lower in both postintervention periods than in the preintervention period. Incidence rates for AR-BSIs in catheter patients dropped from postintervention period 1 (2.94) to postintervention period 2 (1.32), but the change did not reach statistical significance (Table 2).

#### Process measures

Changes in adherence rates for the 5 process measure categories for the pre- and post-PD periods are shown in Table 3. Adherence rates in 4 of the 5 process categories were high, 99%, and increased significantly from the pre- to postperiods.

#### Social network analysis

Fifty-one health care personnel were identified for inclusion in the social network analysis; 46 (90%) completed the first survey, and 46 (90%) completed the second survey. Changes in the connectivity, inclusion, centralization, and reach network measures across the collaboration, BSI prevention, and innovation areas are shown in Tables 4 and 5. There were changes in all 3 measured areas. For collaboration, there were increases in centralization and reach and a decrease in connectivity, and inclusion did not change significantly. For BSI prevention, there was an increase in reach, but inclusion, connectivity, and centralization did not change. For innovation, there were increases in inclusion and reach but a decrease in connectivity; centralization did not change significantly.

### DISCUSSION

At AtlantiCare’s outpatient hemodialysis center, implementation of a package of interventions and membership in a collaborative supported by a defined behavioral change process resulted in a lower incidence of overall AR-BSIs and AR-BSIs in patients with catheters. Notably, this included only 1 AR-BSI for the final 12 months of the evaluation period. In addition, following
implementation of PD, there were significant improvements in important infection prevention process measures. Social network analysis suggested that, following initiation of PD, the networks generally became larger and the number of connections increased but also became more centralized. Together, these results suggest the utility of prevention collaboratives to decrease BSIs in dialysis settings and the potential for a behavioral change methodologies, such as PD, to provide added benefit by increasing adherence to recommended prevention strategies and furthering engagement of staff in prevention efforts.

A number of intervention strategies, with a concentration on those for dialysis patients with central lines, have been recommended for prevention. Achieving uniformly high adherence rates and thus preventing BSIs in outpatient hemodialysis settings is complex and difficult. Members of the Collaborative worked together with CDC experts to identify a panel of evidence-based and feasible interventions that could be implemented in dialysis centers to prevent BSIs and to develop solutions to challenges that arose during implementation. This type of approach has been successfully used in intensive care units to decrease the incidence of central line-associated BSIs. Of note, even though the Collaborative interventions were targeted at catheter-related AR-BSIs, the set of interventions was associated with reductions in the rate of all AR-BSIs at the AtlantiCare center.

### Table 3
Process measure adherence rates over the 2 postintervention time periods

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Equipment procedures</td>
<td>236/245 (96%)</td>
<td>378/380 (99%)</td>
<td>.005</td>
</tr>
<tr>
<td>General practice</td>
<td>1,166/1,190 (98%)</td>
<td>1,538/1,546 (99%)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Medication administration</td>
<td>333/344 (97%)</td>
<td>267/269 (99%)</td>
<td>.04</td>
</tr>
<tr>
<td>Isolation procedures</td>
<td>84/88 (95%)</td>
<td>26/29 (90%)</td>
<td>.24</td>
</tr>
<tr>
<td>Dialysis initiation and termination procedures</td>
<td>458/490 (93%)</td>
<td>328/332 (99%)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

PPE, personal protective equipment.

### Table 4
Measures of network parameters: connectivity and inclusion

<table>
<thead>
<tr>
<th>Measure</th>
<th>Prepositive deviance, n (%)</th>
<th>Postpositive deviance, n (%)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connectivity*</td>
<td>428/992 (43)</td>
<td>376/1,056 (36)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Bloodstream infection prevention</td>
<td>136/650 (21)</td>
<td>212/870 (24)</td>
<td>.11</td>
</tr>
<tr>
<td>Innovation</td>
<td>30/110 (27)</td>
<td>96/812 (12)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Inclusion*</td>
<td>32/46 (70)</td>
<td>33/46 (72)</td>
<td>.83</td>
</tr>
<tr>
<td>Bloodstream infection prevention</td>
<td>26/46 (57)</td>
<td>30/46 (65)</td>
<td>.39</td>
</tr>
<tr>
<td>Innovation</td>
<td>11/46 (24)</td>
<td>29/46 (63)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

NOTE. Prepositive deviance is the period prior to instituting positive deviance, and postpositive deviance is the period after initiating positive deviance.

* Measures the proportion of existing connections between unit staff in the primary (ie, largest) network divided by the total number of possible connections in the primary network.

* Measures the number of staff included in the primary network divided by the total number of staff.
Contributing to the dialysis center’s success was the use of a behavioral change intervention, PD. Use of similar interventions has resulted in reductions in health care-associated infections in other settings.\(^{13,31,32}\) As evidenced by the increases in process measure compliance, PD helped engage staff around infection prevention practices and helped sustain the gains in process measure improvement. Prior to the employment of PD, adherence to implemented practices would wane within a few months of an in-service or skills fair; after the behavioral change intervention process measure compliance remained consistently in the upper 90% compliance range. The significant increases in compliance to infection prevention process measures suggest that PD helped the staff assume responsibility for improving infection prevention practice, helping insure that changes instituted prior to PD implementation were sustained and generating additional improvements after implementation, such as the new shift change protocol.

Through the use of social network analysis, we were able to evaluate changes in this facility’s networks following the implementation of PD. The inclusion of staff in the largest network (inclusion) increased in all 3 areas (not all were statistically significant), suggesting that staff members were more involved in all 3 of the tested areas. However, although the number of connections between staff in the largest network increased for BSI prevention and innovation networks following the implementation of PD, the connectivity measure did not increase significantly in part because of the increased number of possible connections in the post-PD time period. Furthermore, the increase in reach for BSI prevention and innovation suggests more rapid information flow and greater connectedness. Of note, both BSI prevention and innovation networks were more centralized than the collaboration network, suggesting that staff members were more dependent on facilitators for innovation and BSI prevention than they were for their daily work. This increase in centralization for all 3 measures may appear counter to the intended impact of PD but is often evident when a new approach is introduced into a facility often by a small number of facilitators. As the effort matures and more staff members are recruited into the effort, the centralization score might be expected to stabilize or decrease (email communication, V. Krebs, December 2010).

PD had a dramatic effect on the culture of the dialysis center (oral communications, Gemma Downham, Erin Jones, Pamela Peterson, October 2011). Prior to the implementation of PD, leaders and infection prevention personnel were seen by staff as adversaries rather than collaborators. Staff members would warn one another when infection prevention staff entered the unit. With PD, staff members became accustomed to looking among themselves for novel infection prevention practices and then working with their colleagues to implement their ideas. Staff members became comfortable talking about infection prevention, created a cohesive team to prevent infections, and began to hold each other accountable. These changes likely contributed to the significant increases in adherence to process measures and are reflected in the social network maps.

Observations from staff members highlighted growing commitment to their work and newly emphasized teamwork. “Our driving focus is infection control,” said one nurse. Another nurse explained that staff members are alert to help each other with suggestions, reminders, and tasks if necessary, and encouragement. “We can’t do what we do without each other,” he said. Attendees at a staff meeting broke into applause when a quarterly report disclosed zero BSIs. Another staff member commented, “We were determined to be a model for the rest of the organization. The dialysis unit became the poster child for hand hygiene.”

A sign on the door of an isolation room at one end of the dialysis unit is another indication of change. When 4 doctors tried to enter the isolation room without proper garb, a nurse blocked the door and refused to budge until they donned gowns and gloves. As they re-entered the unit, she reminded them to dispose of their gowns and gloves in the bin in the isolation room. Then she gave them hand sanitizer. The sign, suggested by staff, reads: “STOP. Do Not Enter. Please See Staff.” Staff prepared an infection control protocol to give to anyone entering the room.

There are several limitations to this evaluation. First, results are based on the experience of one dialysis center and may not be generalizable to other centers. Second, the social network analysis was based on a retrospective survey, which might have been subject to recall bias among respondents. Third, the results of the time series analyses were limited by the fact that AR-BSIs are a relatively rare outcome and that there were a small number of time points between interventions. Finally, we were unable to stratify AR-BSIs by access type before 2009.

According to the CDC, prevention of health care-associated infections, such as AR-BSIs among hemodialysis patients, is a high public health priority. Prevention efforts at this facility were enhanced by including strategies for engaging staff in the process and by collaborating with other facilities to learn and help overcome barriers. Other outpatient hemodialysis facilities should consider similar combined strategies for BSI prevention that increase collaboration among their staff and with other centers.

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