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Major article

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.

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 priority[5] 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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Study was conducted at AtlantiCare Regional Medical Center, Bruce A. Eidelson, MD, Dialysis Unit, Atlantic City, NJ.

Conflicts of interest: C. Lindberg consults with health care organizations on Positive Deviance. V. Krebs consults with organizations on social network analysis. All other authors report no conflicts.

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Table 1
Discovery and action dialogue facilitator's guide

Discovery and action dialogue facilitator's guide	
Discovery and action dialogue questions	• How will the next infection be acquired? • What can YOU do to prevent them? • What prevents you from doing this EVERY time? • Is there a group that overcomes barriers frequently and effortlessly? • Do you have any ideas? • What initial steps need to be done to make it happen? • Any volunteers? • Who else needs to be involved?
Tips for discovery and action facilitators: Warning: This can be much harder than it first appears!	Do not: • Answer questions that have not been asked directly to you—seek to elicit insights from participants • Miss opportunities to "catch butterflies" —call attention to emerging ideas and action possibilities as they pop up • Come away with a to-do list for yourself—the idea is to foster ownership and responsibility for action in front-line staff • *Decide about me without me . . .* invite "them" into the next dialogue • Avoid responding positively or negatively to contributions, let the group sift through their own assessments (eg, ask, "How do others think or feel about this suggestion?") Do: • Start with the purpose, "We are here to eliminate Blood Stream Infections in our patients. .. • "Give" questions back to the group, wait at least 20 seconds for a response (looking at your shoes can help!)—this provides opportunities for participants to contribute • Encourage quiet people to talk • Flip cynical assertions by asking, "If I understand you correctly, no one has ever done this successfully or well?" • Work through all the questions without worrying about the order (the dialogue WILL be messy, this is OK) • Maintain humility, you "sit at the feet" of people with solutions

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 underinsured 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.

SHIFT CHANGE: STAFF DESIGNS NEW PLAN TO REDUCE INFECTION RISK AND WAIT TIME

In several discovery and action dialogues (DADs), dialysis unit staff members said they thought the greatest risk for infections happened when patients were coming and going in the treatment area. As is typical in an outpatient hemodialysis unit, about 75 patients a month are treated at the 12 stations. Depending on their needs, patients are on hemodialysis for 3.5 to 4 hours several times per week. The area is open because the staff needs to be able to visually monitor each patient, but the open design meant patients would walk to a machine when they saw it vacated by an earlier patient and stand waiting their turn while staff members cleaned the area; staff felt pressured to turn over stations quickly so that new patients could begin their treatment. Patient shifts overlapped, and patients could begin treatment when their assigned station was vacated. Staff recognized the need for consistent hand hygiene, effective disinfection of the station, and the need to keep patient belongings separate. They also recognized the importance of all the multiple details of preparing a station and knew any small slip-up could undermine the larger infection control effort.

Using the PD process, a staff member decided to hold a DAD to discuss with colleagues how to make the shift change time safer for the patients. The outcome of this DAD was agreement that the whole dialysis unit should be cleaned and disinfected from the prior shift before allowing patients on the next dialysis shift to enter the treatment area. Volunteer staff members signed up to work out the problem, and details were developed over time. A plan evolved for 3 shifts of patients, who would enter at 5 AM, 10 AM, and 3 PM. The entire area and all units would be cleaned and disinfected after each shift, and staff determined that it would be more beneficial to work together on the whole unit rather than cleaning only the stations to which they were assigned. Once the cleaning was complete, patients were invited to enter the unit and begin their treatment. Staff members composed a letter explaining the new system to patients, acknowledging, "We heard what you said about waiting, and our main concern is to keep you safe." Posters reinforced the message. Evidence of a commitment to sustain the improvements came as the staff decided to use the shift change cleaning procedure as one of their yearly customer service goals.

"Now," explains one nurse, "when the second and third shift of patients come in, they see chairs and machines line up, everything clean, orderly and ready, just the way the first shift saw it." "One of the patients said everything seems more professional now," observed a nurse. "It's less rushed, a more friendly and professional atmosphere, and they see us working together as a team." "There's a reduced stress level," she added, "and that makes patients more comfortable." In fact, patient satisfaction scores have improved since the shift change process was implemented. The clinical manager of the unit states, "We have not had to increase shifts or staff, and we have not created any overtime because of the changes. The staff reports that because the focus has changed from 'turn over as fast as you can' to 'make it as clean as possible' they feel less pressure, and they feel better about the work that they're doing because they know it's quality care."

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.[5]

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 questionnaires 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

Table 2
Incidence rates of all AR-BSIs and AR-BSIs in catheter patients across the preintervention and 2 postintervention time periods

Time period	Patient-months	Events	Incidence rate (per 100 patient-months)	Risk ratio (95% CI)	*P* value
All access-related bloodstream infections					
Preintervention	1,518	31	2.04	Referent	Referent
January 2008-August 2009					
Collaborative	799	6	0.75	0.37 (0.15-0.88)	.03
September 2009-July 2010					
Collaborative and positive deviance	1,268	3	0.24	0.12 (0.04-0.38)	<.01
August 2010-December 2011					
Access-related bloodstream infections among catheter patients					
Preintervention	145	3	2.07	Referent	Referent
January 2009-August 2009					
Collaborative	136	4	2.94	1.42 (0.32-6.24)	.46
September 2009-July 2010					
Collaborative and positive deviance	227	3	1.32	0.64 (0.13-3.12)	.43
August 2010-December 2011					

AR-BSIs, access-related bloodstream infections; *CI*, confidence interval.

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 χ^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.[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,[22] Watts,[23] and Baribasi.[24]

Qualitative analysis

To assess the qualitative aspects of the intervention, the authors used exploratory case study methods, with open-ended, reflexive observation and contextual analysis.[25] Semistructured small group interviews were conducted with 16 staff members, representing a cross-section of dialysis center and infection prevention personnel. The authors also toured the dialysis center to secure multiple sources of evidence.[26] The interviews and tours were conducted in May and June 2011. Findings from the qualitative analysis have been interspersed throughout the article to enrich understanding of the intervention.

Ethical review

The Collaborative underwent ethical review at the CDC and was determined to be a nonresearch activity. The social network analysis was reviewed and approved by a CDC Institutional Review Board as well as the AtlantiCare Regional Medical Center Institutional Review Board.

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-BSIs for the final 12 months of the evaluation period. In addition, following

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

Process measure	Prepositive deviance (September 2009-July 2010)	Postpositive deviance (August 2010-December 2011)	*P* value
Equipment procedures	236/245 (96%)	378/380 (99%)	.005
• Storage of patient's equipment/belongings • Handwashing after handling contaminated equipment or supplies and before handling sterile or clean supplies			
General practice	1,166/1,190 (98%)	1,538/1,546 (99%)	<.001
• Correct use of personal protective equipment • Separation of clean and dirty areas and supplies • Appropriate disinfection practices of dialysis station			
Medication administration	333/344 (97%)	267/269 (99%)	.04
• Proper use and storage of syringes and vials • Proper syringe labeling • Sterile practices during medication administration			
Isolation procedures	84/88 (95%)	26/29 (90%)	.24
• PPE worn upon entering and removed upon exiting • Hand hygiene completed • Isolation room door closed during initiation and termination of dialysis • Appropriate linen and trash removal			
Dialysis initiation and termination procedures	458/490 (93%)	328/332 (99%)	<.001
• Observed proper cannulation of graft or fistula • Observed proper discontinuation of dialysis graft of fistula • Observed proper technique for accessing catheter/cleaning catheter • Observed proper technique for discontinuation of dialysis catheter • Confirm dressings are intact on catheter sites • Staff and patient are both masked when access sites are open during initiation/discontinuation of dialysis			

PPE, personal protective equipment.

Table 4
Measures of network parameters: connectivity and inclusion

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

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.

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.[27-29] 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.[30,31] 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 5
Measures of network parameters: centralization and reach

Measure	Prepositive deviance		Postpositive deviance		*P* value
	Number in primary network	Measure	Number in primary network	Measure	
Centralization*					
Collaboration	32	.155	33	.318	<.001
Bloodstream infection prevention	26	.375	30	.516	.82
Innovation	11	.495	29	.559	.25
Reach†					
Collaboration	32	28.06	33	23.39	.004
Bloodstream infection prevention	26	21.08	30	24.07	.04
Innovation	11	7.82	29	19.93	<.001

NOTE. Prepositive deviance is the period prior to instituting positive deviance, and postpositive deviance is the period after initiating positive deviance.
*Measures the mean difference between the connectedness of the most central staff member and all other staff members in the primary network.
†Mean number of other staff that a staff member can reach via 2 steps/links in the network.

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, 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, 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, aid with 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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