Aligning pharmacy and health-system objectives to eliminate central-line-associated bacteremias

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The Centers for Disease Control and Prevention (CDC), the Centers for Medicare and Medicaid Services (CMS), and the Joint Commission have made the elimination of bloodstream infections (BSIs) a priority for hospitals.1-4 Hospital-acquired BSIs were the eighth leading cause of death in the United States in 2002.5 A high mortality rate and limited treatment options emphasize prevention strategies utilizing “new infection-control technology and techniques.” In 2002, 1.7 million health-care-acquired infections (HAIs) occurred in the United States.6 Despite CDC-issued guidelines to prevent i.v. catheter-related infections, 30,665 deaths were due to BSIs, the most severe type of HAI.1,6 BSIs have been reported to occur in as many as 1.7% of patients with a central venous catheter (CVC).7

Healthy People 2000 reported a device-associated nosocomial infection rate of 6.9 per 1000 use-days in the medical–coronary intensive care unit (ICU), 5.3 per 1000 use-days in the surgical or medical–surgical ICU, and 11.4 per 1000 use-days in the pediatric ICU.8 The composite 1998 baseline rate of central-line-associated bloodstream infections (CLABSIs) in ICU patients was 5.5 cases per 1000 catheter-use-days.9,10 HAIs increase hospitalization costs by $15,000 per patient, resulting in an estimated $30 billion in annual avoidable costs.11 In 2007 the Pennsylvania Health Care Cost Containment Council reported a mean inpatient charge of $37,943 versus $266,506 for patients with BSIs.12 From 2005 to 2007, the BSI rate ranged from 1.6 to 1.9 per 1000 cases, with mortality increasing from 20.8% to 21.6%, further suggesting that current infection-control practices remain inadequate.

The U.S. Surgeon General reported national targets for reducing CVC-associated bacteremias.9 Despite the publication of consensus statements, there remains a gap between recommendations and usual care. The Government Accountability Office identified 1200 practices, 13 guidelines, and numerous infection-control standards regarding CVC-associated bacteremias.13 Evidence-based recommendations have not been prioritized to guide hospital actions and fail to weigh the costs and organizational obstacles to implementation.

The Joint Commission confronted this challenge, releasing National Patient Safety Goal (NPSG) 07.04.01, requiring the implementation of “best practices or evidence based guidelines to prevent central line-associated bloodstream infections” by January 1, 2010.2,3 CMS considers vascular catheter-associated infection a serious preventable event, and it is included under the hospital-acquired conditions payment restrictions.4 CMS will no longer pay for additional costs associated with this condition, except when documented to be present on hospital admission.

Regulatory agencies and payers are now using financial consequences to force practice change. The NPSG performance elements will test a health system’s leadership through patient outcomes. An understanding of BSI terminology, risk factors, pathogenesis, prevention strategies, and decision options will allow clinicians to have shared roles and
BSI basics. A BSI refers to bloodstream bacteremia. A secondary BSI is caused by an undocumented source (e.g., postoperative surgical sites, hospital-acquired urinary tract infections). A BSI is further defined by the presence of a CVC. A CVC is a vascular access device that terminates at or close to the heart or one of the great vessels. A CVC may be inserted for physiological assessment (e.g., monitoring central venous pressure, pulmonary capillary wedge pressure, or cardiac output), medication or fluid administration, or infusion of blood products. Multilumen catheters, consisting of two to five ports meeting at one site, facilitate simultaneous uses (Figure 1). Nontunneled catheters are placed percutaneously directly into a vessel and sutured to the skin at the insertion site. They are temporary catheters, intended for two weeks’ use or less. These catheters are equipped with “wings” that are used for sutures. Like other catheters, nontunneled catheters can be used to deliver medications, nutrition, or blood products or to collect blood samples.

There are two types of permanent catheters: tunneled and implanted (Figure 1). Tunneled catheters are surgically tunneled through the tissue and then into a vein. The procedure is performed in an operating room or in an interventional radiology suite. These catheters are often equipped with cuffs. Tissue will adhere to the cuff, securing the catheter and preventing it from dislodging. These cuffs can also be designed to protect against infections. The outer, tissue-interfacing surface is impregnated with a biocompatible antimicrobial agent that is incorporated into its construction. The antimicrobial cuff is not intended as a treatment for catheter-related infections. Implanted catheters or infusion ports are infusion systems that contain a self-sealing injection port. They are connected to catheter tubing implanted under the skin in the chest wall. Tunneled catheters for short-term use are associated with lower rates of infection and can last for months to years in the body.

A BSI is considered to be associated with a central line if the line was in place during the 48 hours before the BSI developed. This definition of a CLABSI includes CVGs that are placed from a peripheral location (i.e., peripherally inserted central catheter), that use femoral access, and that are placed centrally via subclavian and internal jugular veins.

Clinically, a subset of CLABSI cases satisfy a stricter definition and are categorized as catheter-related BSIs. To meet the definition of a catheter-related BSI, all other causes of the infection must be excluded and a culture from the catheter tip must demonstrate substantial colonies of an organism that is identical to those found in the bloodstream. Finally, an infusate-related BSI refers to concordant growth of the same organism from the infusate and blood cultures with no other identifiable source. For CDC surveillance purposes, an infusion refers to any solution that is introduced into the bloodstream through a catheter lumen. This includes continuous infusions, intermittent infusions, and flushes.

Organisms linked to BSIs. Microorganisms causing hospital-acquired BSIs have changed over time. Data from 1992 to 1999 revealed that coagulase-negative staphylococci and Staphylococcus aureus accounted for 37% and 12.6% of reported hospital-acquired BSIs, respectively. Over 50% of all S. aureus ICU isolates were resistant to oxacillin, and 25.9% of enterococcal ICU isolates were resistant to vancomycin. Gram-negative bacilli accounted for 14% of catheter-associated BSIs. Candida species caused 8% of hospital-acquired BSIs; of these, 48% were caused by non-albicans species, which were more likely to demonstrate fluconazole resistance.

Hospitals report surveillance data on laboratory-confirmed CLABSiS to the CDC’s National Healthcare Safety Network (NHSN). BSI rates vary depending on the reporting...
agency’s criteria and surveillance population.\textsuperscript{18,19} NHSN reports on ICU patients. The Joint Commission’s ICU measure uses NHSN’s criteria for laboratory-confirmed CLABSIs. The Institute for Healthcare Improvement (IHI) project uses NHSN’s definition for laboratory-confirmed CLABSIs but requires that the patient be in the ICU at the time of catheter insertion. This excludes all patients with a CVC inserted in the emergency department, by interventional radiology, or in the operating room, further underestimating the magnitude of the problem.

**Risk factors for CLABSIs.** There are multiple risk factors for CLABSIs, including hospital type and size and the ICU population. Patient risk factors include severity and type of illness (e.g., third-degree burns, postoperative cardiac surgery).\textsuperscript{16,20} The major controllable risk factors include an inexperienced or marginally skilled person inserting the CVC, an insertion site in the internal jugular or femoral vein, placement in an old site over a guide wire, limited use of sterile barriers, heavy bacterial colonization of the insertion site, contamination of the catheter hub, and catheter placement exceeding seven days.\textsuperscript{20}

Most serious CLABSIs occur in ICU patients, although more CLABSIs occur in patients outside ICUs.\textsuperscript{1} In 2,459 patients at six tertiary care medical centers, 29% of the patients had a CVC but only 60% of them were in the ICU.\textsuperscript{21} The CVC utilization ratio (CVC days:number of inpatient days) was 0.55 for patients in the ICU and 0.24 for all other units but the actual numbers of CVCs used were 238 and 525, respectively. NHSN’s data for 2006 revealed similar CVC utilization ratios: medical and surgical ward rates were 0.23 and 0.24, respectively; on ICU, the rates ranged from 0.44 to 0.73.\textsuperscript{22} More BSIs were identified in non-ICU patients (\( n = 133,368 \)) than in ICU patients (\( n = 81,942 \)).\textsuperscript{5}

**Causes of CLABSIs.** In 1996, CDC guidelines identified three sources for intravascular-device-related infections; extraluminal, intraluminal, and indeterminate.\textsuperscript{23} Extraluminal sources are primarily migration of skin organisms from insertion. Intraluminal sources are primarily hub contamination, hematogenous spread (i.e., spread by the blood system), and infusate contamination. Safdar and Maki\textsuperscript{24} divided contamination into two categories: catheter-related infection due to colonization of the device and (2) infusate-related infection due to contamination of the fluid administered. In a catheter-related infection due to colonization, the microorganisms gain access by one of three mechanisms: percutaneous, facilitated by capillary action at the time of the line’s insertion or in the days after (Figure 2A); contamination of the catheter hub (Figure 2B) and lumen when the catheter is inserted over a percutaneous wire or later when the hub is manipulated; and hematogenous spread from remote sources (e.g., an infected wound or pneumonia) that infects the catheter tip.

Microorganisms on catheter surfaces take two forms: embedded in a biofilm or free-floating and disseminated over the catheter surface. The insertion of a foreign body, such...
as a catheter, causes the development of a biofilm on that foreign body. Colonization and biofilm formation can occur as soon as 24 hours after catheter insertion.\textsuperscript{25} Catheters are not uniformly smooth; therefore, surface irregularities at the microscopic level provide opportunities for adhesion and coating by plasma and connective proteins. The organisms are usually embedded in a biofilm layer, where they are metabolically active and viable. Host defenses are unable to defeat infections arising on polymer products, suggesting that the biofilm offers protection to the embedded microbiological colony.\textsuperscript{26}

The dominant cause of CLABSI with short-term CVC use (i.e., no longer than 10 days) is extraluminal contamination.\textsuperscript{27} Infusate-related infections (Figure 2C) result from either intrinsic or extrinsic contamination. Intrinsic contamination, contamination that occurs during manufacturing, occurs less frequently in the United States compared with other countries but has been the cause of most device-related BSIs.\textsuperscript{28} Extrinsic contamination of fluids or medications refers to contamination in the pharmacy or to in-use contamination on the unit or at the bedside, occurring during the preparation of syringes or infusions, intermittent infusions, flushes, or continuous infusions.\textsuperscript{1,24,29}

Intraluminal contamination sources of BSIs include the i.v. tubing, catheter hubs and injection ports, piggyback systems (used as an alternative to stopcocks for medication administration), in-use contamination of i.v. fluids, and contamination during manufacturing. Catheter hub contamination and lumen contamination are the major modes of BSIs with long-term catheter use (>10 days).\textsuperscript{30} The organisms usually gain access onto the hub from the hands of medical personnel and then migrate along the internal surface of the catheter, resulting in luminal colonization and, finally, a BSI.\textsuperscript{25} Stopcock contamination has been reported to range from 45% to 50%, with the high frequency attributed to the number of manipulations that occur with longer use.\textsuperscript{23-25} The hub rather than the infusate solution is the most common source of contamination. Leon et al.\textsuperscript{31} compared a standard hub with a new hub with an antisectic chamber that contained 3% iodinated alcohol. The rates of hub-related sepsis were 1.7% in the study group and 7.0% in the control group. The rates of infusate-related sepsis were 0.8% in the study group and 0.9% in the control group.

There are a number of ways the infusate can be contaminated: contamination of the medication vials or ampuls, multiple manipulations performed to prepare a syringe, the need to add infusion fluid, and the possible exposure of the contents of the ampul to environmental factors (e.g., air, hands).\textsuperscript{32} Multiple-use solutions used in admixing, flush syringes, or i.v. fluids can also become contaminated.\textsuperscript{33} Contamination may occur when the practitioner reinserts the original needle into a multidose vial or i.v. solution. Contamination may also occur when the needle is left in the diaphragm of the vial.\textsuperscript{33} The same syringe may be used repeatedly to withdraw medication. These contaminated vials may be put back into the unit stock or sit on the counter.\textsuperscript{34} There is a growing body of evidence that nurse staffing affects the rate of hospital-associated infections.\textsuperscript{35,36} Overcrowding, understaffing, and a lack of balance between workload and resources have been identified as factors contributing to microorganism cross-transmission. This may be due to inadequate training, a lack of time to comply with infection-control methods, job-related burnout, high rates of staff turnover, use of float staff, and job dissatisfaction.\textsuperscript{35,36}

In a simulation of medium-risk level, sterile complex compounding, 5.2% of 539 samples tested positive for microbial growth.\textsuperscript{37} This rate was slightly higher when compounding was performed by technicians (6.2%) and slightly lower for pharmacist-compounded products (4.4%). While the absolute risk of microbial contamination is low, the consequences may range from serious to life threatening. Earlier studies reported contamination rates of 0–27%.\textsuperscript{21,38} Melnyk et al.\textsuperscript{39} reported a contamination rate of 1.4% in multidose vials.

I.V. admixture is another potential source of contamination and subsequent BSIs, with contamination rates ranging from 0% to 14%.\textsuperscript{40} Poretz et al.\textsuperscript{41} reported a contamination rate of 10.9% for admixtures prepared on the nursing unit, compared with a contamination rate of 5.5% for admixtures prepared under a laminar-airflow hood. Van Graafhorst et al.\textsuperscript{32} simulated the risk of infusate contamination, comparing syringes prepared by nurses in the ICU to those prepared by pharmacy technicians. Each group prepared syringes, first using an ampul and then using a multidose vial. The median contamination rate was 22% for ICU nurses using ampuls, compared with 1% for pharmacy technicians. The contamination rates with a multidose vial were 2% for ICU nurses and 0% for pharmacy technicians. These results suggest that shifting preparation to the pharmacy may help reduce contamination rates.

Implementation of the United States Pharmacopeia (USP) chapter 797 requirements in the pharmacy and strict attention to aseptic technique may help lower the risk of contamination; however, contamination can still occur. A 0.1% rate of contamination has been reported with low-level-risk compounding.\textsuperscript{42} Thomas et al.\textsuperscript{43} examined the effect of personnel versus location on admixture contamination rates by comparing preparations made in a traditional practice setting with those made in a class 1000 cleanroom by a...
pharmacist and a pharmacy technician. Contamination rates between the two sites were not significantly different (0.296% versus 0.344%), but there was a significant difference in the number of contaminated samples prepared by the pharmacist (2 of 2057) versus the technician (11 of 2000 samples) \( p = 0.012 \). The investigators concluded that the aseptic technique of personnel could be more significant than the environment in which the compounding occurred.

**Strategies for reducing extraluminal causes of BSIs.** IHI’s 5 Million Lives campaign has focused on reducing central-line-associated bacteremias by creating a central-line bundle.\(^{43,44}\) A bundle is a collection of evidence-based interventions that, when implemented together, produce superior outcomes compared to separate implementation of the components. A bundle has five key components: hand hygiene, maximal barrier precautions, chlorhexidine skin antisepsis, optimal catheter-site selection, and daily review of line necessity with prompt removal of unnecessary lines. This bundle has been captured as an element of performance in NPSG 07.04.01. The National Quality Forum endorsed IHI’s central-line bundle, transformed it into a quality measure, and is developing a quality measure to report CLABSIs.\(^{45}\)

Across 108 ICUs, primarily in Michigan, a bundled intervention of hand washing, full barrier precautions during catheter insertion, skin cleansing, avoidance of femoral access, and early removal of unnecessary catheters reduced the mean prevalence of catheter-related BSIs per 1000 catheter days from 7.7 at baseline to 1.4 at 16 and 18 months after implementation.\(^{46}\) This decrease was significant at large and small hospitals, at teaching hospitals, and at nonteaching hospitals. Similarly, a four-year CDC and Pittsburgh Regional Healthcare Initiative reduced ICU BSIs 68%, from 4.31 per 1000 central-line days in 2001 to 1.36 in 2005.\(^{27}\) Their program comprised five elements: (1) guidelines for catheter insertion based on evidence of effectiveness, (2) CLABSI and insertion education, (3) design and use of a standard data collection instrument, (4) use of standardized and complete catheter insertion kits, and (5) data measurement and confidential feedback to each unit. North Shore–Long Island Jewish Health System (NS-LIJ) reduced prevalence of CLABSIs from 5 cases per 1000 central-line days in 2005 to 1.68 in 2007.\(^{48}\) NS-LIJ developed evidence-based standards, protocols, training in these protocols, and standardized insertion kits. A patient safety simulation center was used to practice, observe, and correct insertion techniques. Data collection, monitoring, and feedback occurred with each CVC insertion. The strategies employed in these initiatives can be expected to have the greatest effect on extraluminal contamination of the system, the most common cause of CLABSIs for catheters used for fewer than seven days.

**Strategies for reducing intraluminal and mixed causes of BSIs.** For catheters in place for over seven days, hub and infusate contamination and mixed intraluminal and extraluminal sources become prominent. Prevention strategies focus on aseptic management of the hub, ports, and lines and aseptic infusate preparation. To prevent hub contamination, novel technologies intervene at the point of connection between the i.v. system and the intravascular device and include a needleless hub device or catheter system, an antiseptic hub, and antibiotic lock prophylaxis. The effectiveness of the needleless hub has been inconsistent, and CDC does not currently recommend its use. Antimicrobial catheter lock solutions have been studied with varying results. Vancomycin lock solution has been studied in cancer patients with inconsistent results. However, a prophylactic antibiotic lock solution is recommended for patients who develop recurrent BSIs despite optimal aseptic technique.\(^{20}\) Two randomized controlled trials studied the efficacy of a 1% chlorhexidine–75% alcohol solution versus a novel impregnated sponge dressing for cutaneous antisepsis.\(^{24}\) The contamination source in the control group was 60% extraluminal, 12% intraluminal (including hub and infusate), and 28% indeterminate. In the study group, the amount of extraluminal contamination decreased to 10% and intraluminal increased to 60%; 30% was indeterminate. The authors concluded that strategies that reduce cutaneous extraluminal contamination can markedly reduce the risk of CLABSIs in short-term catheter use. In these settings, hub contamination and infusate contamination remain as the causes of CLABSIs.

Chelators such as ethylenediaminetetraacetic acid and citrate have been found to enhance the activity of antimicrobial drugs against organisms embedded in the biofilm.\(^{25}\) Other solutions that may help reduce CVC infections include minocycline, taurolidine, and ethanol.

Many hospitals are increasing their use of ready-to-use (RTU) products, such as premixed and frozen i.v. products, and point-of-care (POC) activated devices.\(^{49}\) The premixed and frozen products eliminate the need for invasive product manipulation before dispensing and administration, thus reducing the risk for intraluminal or infusate contamination. POC activated parenteral products can be assembled in the pharmacy or on the unit by the nursing staff.

Interventions to reduce infusate contamination focus on the use of premixed solutions, preparation of admixtures and syringes in the pharmacy, use of single-dose vials whenever possible, use of aseptic technique at all times when preparing infusates on the unit and in the pharmacy, and...
use of novel technologies, including infusate packaging and delivery that reduce the risk of in-hospital contamination (e.g., RTU products, POC activated products).\textsuperscript{16,25,49}

**Challenges for pharmacists.** External standards, guidelines, and payment policies are dictating professional practice to a greater degree than ever before. In 2004, USP published chapter 797 on compounding sterile preparations, the standard used by the Joint Commission when surveying hospitals. In 2008, chapter 797 was revised, establishing standards to reduce the opportunity for errors, control the compounding environment, and minimize opportunities for contamination.\textsuperscript{50} When a licensed pharmacy is onsite, the Joint Commission requires that only the pharmacy compound or admix all sterile medications, i.e., mixtures, and other drugs, except in emergencies or when not feasible (e.g., a product’s stability is brief). With the urgency of implementing the new NPSG guidelines, the drug delivery system’s goal is to reduce infusate-related BSIs. Pharmacists manage the drug delivery system and are expected to ensure safe manufacture of, delivery of, and dose calculations for sterile products. Pharmacists have three options: (1) prepare more parenteral products in the pharmacy, (2) purchase POC activated or commercially prepared RTU medications, and (3) outsource preparation to a pharmacy compounding center.

**Pharmacy-prepared infusates.** Even two years after a blueprint was published providing guidance on implementing change, pharmacists have struggled with chapter 797 requirements.\textsuperscript{51} Although pharmacists and pharmacy technicians have an important role in reducing BSIs, a recent survey on compounding sterile preparations suggests how much remains to be done. Using the “ASHP Guidelines on Quality Assurance for Pharmacy-Prepared Sterile Products” from the American Society of Health-System Pharmacists as the standard,\textsuperscript{52} the survey found that only 35.2% of respondents had a cleanroom meeting required standards, 5.2% were fully compliant with guideline garb requirements, 22.5% validated aseptic technique using media-fill test methods, and just 4.7% were fully compliant with documentation guidelines for high-risk preparations.\textsuperscript{53,54} Respondent pharmacists reported pharmacy budget increases, with the most common increase being for I.V. room supplies and equipment; only 22.6% reported staffing changes. Overall, respondents experienced negative effects on workload, efficiency, and the ability to provide excellent patient service. Although USP chapter 797 is frequently interpreted to apply only to pharmacists, it covers all health care providers, including nurses and physicians. However, nursing practice in preparing sterile doses in patient care areas was evaluated in only about 46% of hospitals.\textsuperscript{54}

**Drug delivery selection.** Pharmacists have expanded their roles on medical teams and increased their clinical interventions, but their responsibility for selecting a drug delivery system cannot be relinquished to materials or supply management. A number of RTU and POC activated drug delivery systems exist to reduce pharmacy compounding. Most pharmacy administrators (94.7%) have reported that their institution uses some form of RTU and POC activated parenteral products.\textsuperscript{49} Despite the availability of these systems for many years, their effects on BSIs have not been evaluated. Using a 36-point scale quantifying the risks of an adverse drug event and of employee or patient infection, a Consensus Development Conference on the Safety of Intravenous Drug Delivery Systems ranked RTU products most safe (36 points) and POC products the next safest (31 points) but did not report individual product scores.\textsuperscript{55} Potentially relevant product differences include the surface area that may come into contact with a patient and exposure to airborne and touch contamination.\textsuperscript{55}

Head-to-head comparisons of these systems’ cost, efficiency, workload, and ease of use have not been performed. The user activation failure rate and misadministration rate for POC activated systems are unknown. A recent survey found that about one third of pharmacies assemble these doses, and approximately 50% activate the dose before it is available for administration.\textsuperscript{49} Whether these activities are best performed in a cleanroom environment or in ambient air has not been studied. An optimum strategy would use one delivery system universally throughout a facility; however, this is not currently possible because each system has a limited product line and limited formulations for special populations (e.g., neonates, pediatrics).

Closed infusion systems have replaced open systems in North America, as they have a lower rate of contamination and CVC-related BSIs.\textsuperscript{56} A closed infusion system consists of a collapsible container that does not require any external vent to empty the solution. The container must ensure a consistent and even infusion rate throughout the administration process without the assistance of a mechanical device. The integrity of the product must be maintained during extreme usage conditions and should not leak. Finally, injection ports should be self-sealing.

**Outsourcing compounding services.** The rise in outsourced compounding pharmacy providers is a result of USP chapter 797. Outsourcing infusate preparation reduces the need for compounding expertise within the pharmacy and may allow resources to be reallocated to other clinical or operational areas. However, outsourcing transfers contamination responsibility and risk at an incremental cost. Most hospitals (65.2%) are now reducing high-risk...
compounding.\textsuperscript{54} Outsourcing may be a viable option for complex, high-risk i.v. admixtures; for high-volume, standardized dosage forms; or for products whose beyond-use dating may be improved with timely delivery.\textsuperscript{57} Outsourcing facilities are state licensed and federally registered. While these facilities may meet or even exceed USP chapter 797 requirements, there are no studies to support whether outsourced providers are safer or reduce BSIs. Lacking outcomes data, due diligence before purchasing such products requires an onsite visit and the auditing of licenses, certifications, competency records, and quantitative and qualitative stability, sterility, and pyrogenicity documentation.\textsuperscript{57}

**Antimicrobial stewardship.** Antibiotic stewardship programs aim to ensure appropriate antibiotic use.\textsuperscript{58,59} As part of a stewardship program, infection-control initiatives to eliminate BSIs include surveillance of hospital-specific and unit-specific antibiotic susceptibility patterns, implementation of formulary restriction, use of antibiotic guidelines, physician and nurse education programs, and individual physician feedback on prescribing practices.\textsuperscript{60,61} Pharmacists have a role in obtaining appropriate cultures, analyzing sensitivity data, selecting the ideal antibiotic, and tailoring a dosing regimen to produce the optimum outcome. The goals of a stewardship program are to limit antimicrobial-resistant pathogens and their associated morbidity, mortality, and costs.\textsuperscript{52,63}

**Discussion.** Pharmacists and health-system executives face unrelenting pressure to reduce costs, balance efficiency and safety, and improve quality. They now must address the challenges of eliminating HAIs while aligning institutional goals, departmental investments, and the pharmacists’ annual line-item budget accountability.\textsuperscript{64}

More organizations are acting to eliminate CLABSIs and are responding to data-reporting requirements. Because the NPSG expectations focus on insertion and extraluminal catheter-related causes of CLABSIs, the rate of CLABSIs is likely to decrease. This may also raise health care organizations’ awareness of intraluminal and mixed-cause BSIs.\textsuperscript{20,24} The NPSG raises attention to the CLABSIs in the hospital, but it does not address the entire clinical picture nor does it address the piece most critical to the pharmacist—how to reduce the rate of CLABSIs from intraluminal sources. For that, administrators and pharmacists need to look to CDC guidelines and USP chapter 797 for guidance on reducing contamination during the preparation of sterile products.

For CLABSIs, clinical practice, policy, and economics are converging to favor prevention. While preparing more parenteral products in the pharmacy is an important step in reducing contamination, increasing infusate preparation will be impossible without adequate resources. The priority of keeping pharmacy practice within full regulatory compliance remains; therefore, alternative strategies may be required to supplement existing compounding operations. The extent to which outsourcing is considered will depend on the threshold for total annual costs that a pharmacy manager can accept.

Facilities with less-varied patient populations may find a single-system RTU or POC system capable of meeting all drug delivery needs. For larger facilities, more than one system may be necessary. Product implementation costs, nursing staff education, staff turnover rates, and patient safety concerns may prevent these products from being interchanged or substituted on a daily or routine basis. While many manufacturers are involved, none has a delivery system currently capable of fully satisfying the infusate needs for all hospitals.

**References**

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COMMENTARY

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