

Preventing Central Line–Associated Bloodstream Infections



A Global Challenge, A Global Perspective

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The use of central venous catheters (CVCs) is an integral part of modern health care throughout the world, allowing for the administration of intravenous fluids, blood products, medications, and parenteral nutrition, as well as providing access for hemodialysis and hemodynamic monitoring. However, their use is associated with the risk of bloodstream infection caused by microorganisms that colonize the external surface of the device or the fluid pathway when the device is inserted or manipulated after insertion. These serious infections, termed central line–associated bloodstream infections, or CLABSIs, are associated with increased morbidity, mortality, and health care costs. It is now recognized that CLABSIs are largely preventable when evidence-based guidelines are followed for the insertion and maintenance of CVCs.

This monograph includes information about the following:

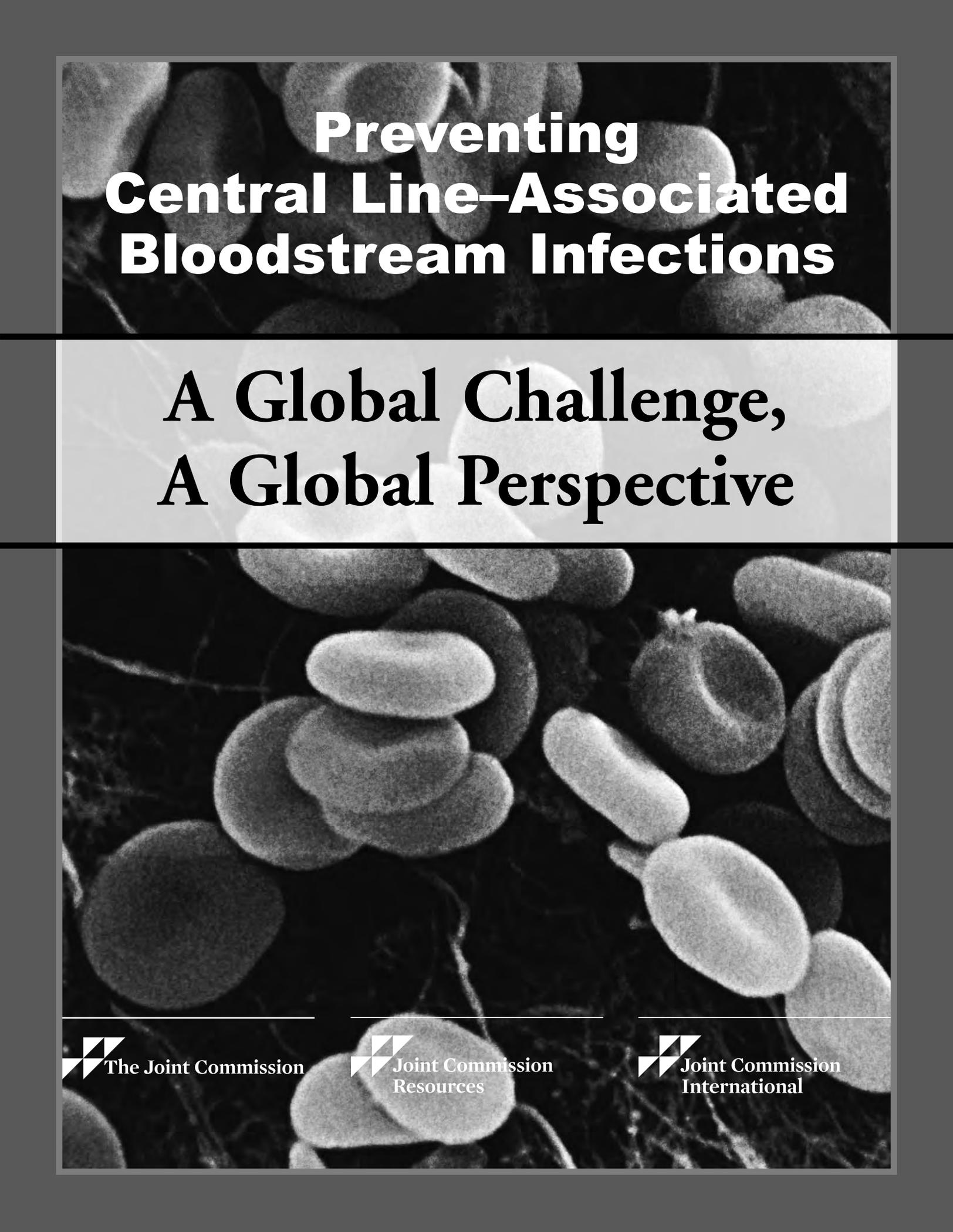
- The types of central venous catheters and risk factors for and pathogenesis of CLABSIs
- The evidence-based guidelines, position papers, patient safety initiatives, and published literature on CLABSI and its prevention
- CLABSI prevention strategies, techniques and technologies, and barriers to best practices
- CLABSI surveillance, benchmarking, and public reporting
- The economic aspects of CLABSIs and their prevention, including the current approaches to developing a business case for infection prevention resources

This monograph was authored by The Joint Commission, Joint Commission Resources, and Joint Commission International. They partnered with infection prevention leaders from the following organizations:

- Association for Professionals in Infection Control and Epidemiology
- Association for Vascular Access
- Infectious Diseases Society of America
- International Nosocomial Infection Control Consortium
- National Institutes of Health
- Society for Healthcare Epidemiology of America

Additionally, several international and US infection prevention leaders lent their expertise to the writing of this publication and were also instrumental in the development of the monograph. International representatives were from Argentina, Australia, Egypt, Saudi Arabia, Switzerland, and Thailand.

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A black and white scanning electron micrograph (SEM) showing numerous rod-shaped bacteria, likely Gram-negative bacilli, scattered across the field. The bacteria vary in orientation and focus, with some appearing sharp and others blurred in the background. The overall texture is granular and detailed.

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INTRODUCTION

Use of vascular catheters is common in both inpatient and outpatient care. In the United States, it is estimated that almost 300 million catheters are used each year; nearly 3 million of these are central venous catheters (CVCs), also known as central lines. In the United Kingdom, about 250,000 CVCs are used annually.¹ CVCs play an integral role in modern health care, allowing for the administration of intravenous fluids, blood products, medications, and parenteral nutrition, as well as providing hemodialysis access and hemodynamic monitoring; their use, however, is associated with a risk of bloodstream infection caused by microorganisms colonizing the external surface of the device or the fluid pathway when the device is inserted or in the course of its use.² CVCs are the most frequent cause of health care–associated bloodstream infections.³

The terms used to describe intravascular catheter–related infections can be confusing. Two terms, *central line–associated bloodstream infection* (CLABSI) and *catheter-related bloodstream infection* (CRBSI), should be distinguished in the following way^{4,5}:

- CLABSI is the term used by the US Centers for Disease Control and Prevention’s (CDC’s) National Healthcare Safety Network (NHSN)⁶ (see NHSN CLABSI information at http://www.cdc.gov/nhsn/psc_da.html). A CLABSI is a primary bloodstream infection (that is, there is no apparent infection at another site) that develops in a patient with a central line in place within the 48-hour period before onset of the bloodstream infection that is not related to infection at another site. Culturing the catheter tip or peripheral blood is not a criterion for CLABSI.
- CRBSI is a more rigorous clinical definition and requires specific laboratory testing to identify the catheter as the source of the bloodstream infection, such as culturing the catheter tip or a more elaborate method such as time-to-positivity.

The CLABSI definition is more practical than the CRBSI definition for surveillance. However, it may overestimate the true rate of CVC–related infections, as it can sometimes be difficult to determine infections related to the central line rather than remote unrecognized infections (for example, urinary tract infections, pneumonia, intra-abdominal abscess). Interobserver variability and a lack of standardization in CLABSI surveillance are other important limitations.^{7,8}

Throughout this monograph, the term used for intravascular catheter–related infections is CLABSI.

Health Care–Associated Infections: The Magnitude of the Problem

Infections that patients develop while they are receiving care in a health care setting for another condition are termed *health care–associated infections* (HAIs).⁹ HAIs occur throughout the world, affecting hundreds of millions of patients each year.¹⁰ These infections are not only costly to individuals and health care systems; they can significantly increase morbidity and mortality in developed countries¹¹ and in developing countries.^{12,13} Seriously ill patients are particularly vulnerable to serious complications due to HAIs, likely due to factors such as progressively more invasive medical technology and complex medical procedures, increasing immunocompromised status and elderly age, and the rising incidence of antimicrobial resistance.¹⁴ The encouraging news is that many HAIs are preventable when evidence-based guidelines are incorporated into patient care.^{15–17}

It has been a decade since the Institute of Medicine (IOM) report on the state of American health care brought attention to the need to develop processes and systems to improve patient safety in hospitals.^{18,19} The IOM reported that, even by modest estimates, preventable patient events in hospitals (including HAIs) exceeded the number of deaths due to AIDS, breast cancer, and motor vehicle accidents each year. The IOM’s 2003 report included prevention of HAIs in its list of the 20 “Priority Areas for National Action.”²⁰ More recently the US Department of Health and Human Services (HHS) developed the HHS Action Plan to Prevent Healthcare-Associated Infections, which sets specific national targets for monitoring and preventing HAIs²¹ (see <http://www.hhs.gov/ash/initiatives/hai/infection.html>). Despite all this emphasis on HAIs, limited progress has actually been made in preventing them. In many developing countries it is still difficult to document both the burden of these infections and the actual improvement in patient outcomes due to difficulties in obtaining reliable data, especially in high-risk groups such as children and neonates.^{10,22,23}

In the United States, 75% of all HAIs are due to four types of infections: urinary tract infections, surgical site infections, bloodstream infections, and pneumonia (see Sidebar I-1 at right).²⁴ These infections are a significant patient safety concern in health care today and are among the leading causes

of morbidity and mortality in US hospitals, as illustrated by the following statistics:

- The CDC estimates that 5% to 10% of hospitalized patients develop an HAI.²⁵
- There were an estimated 1.7 million infections and 99,000 associated deaths in hospitals in 2002.²⁶
- Another estimated 1.6 million to 3.8 million infections occur in long term care facilities each year.²⁷

The percentage of patients who develop HAIs in Western Europe is similar to that in the United States,²⁸ with about 4.1 million patients developing HAIs.²⁹ HAIs result in 16 million added hospital days and 37,000 attributable deaths, and they contribute to 110,000 additional deaths in Europe each year.¹⁰

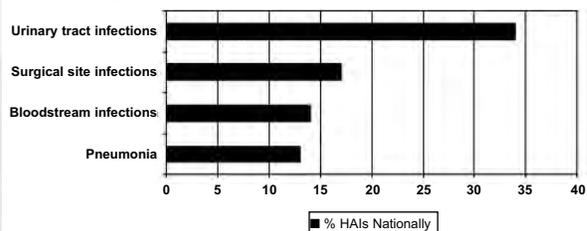
Available data on the global impact of HAIs have been more limited, particularly in many resource-constrained areas. Countries of low and middle income generally do not have adequate resources to conduct surveillance of HAIs.^{22,30,31} This is a significant gap, as 144 out of 209 countries are categorized by the World Bank as low- and lower-middle-income economies (also referred to as low-resource, or developing, countries), representing more than 75% of the world population.³² Researchers who have attempted to quantify HAI rates in developing countries have found rates

Sidebar I-1

More than 75% of all HAIs in hospitals are caused by four types of infections:

1. Urinary tract infections (34%)
2. Surgical site infections (17%)
3. Bloodstream infections (14%)
4. Pneumonia (13%)

Leading Types of Healthcare-Associated Infections in Hospitals



Source: US Department of Health and Human Services. HHS Action Plan to Prevent Healthcare-Associated Infections: Introduction. Jun 2009. Accessed Mar 16, 2012. <http://www.hhs.gov/ash/initiatives/hai/introduction.html>.

to be much higher than in developed countries, and their impact on patients and health care delivery systems is both severe and underestimated.^{22,32–37} Allegranzi et al. found that developed areas had rates of HAIs that were often much lower than those of developing countries, as illustrated by the following comparisons²²:

- Average prevalence of HAIs in Europe was 7.1 per 100 patients.
- Estimated incidence in the United States was 4.5 per 100 patients.
- Pooled prevalence of HAIs in resource-limited areas was 15.5 per 100 patients.

This difference was even more profound in settings with vulnerable and critically ill patients. Allegranzi et al. estimated that the pooled density of HAIs in adult intensive care units (ICUs) per 1,000 patient-days in developing countries was 47.9, more than 3 times the estimated incidence of 13.6 per 1,000 patient-days in US ICUs.²² Rosenthal et al. found neonatal bloodstream infection rates to be 5 times higher in resource-limited countries than in developed countries.³⁰ Zaidi et al. found neonatal HAI rates to be 3 to 20 times higher in resource-limited countries than in developed countries.³⁸ Reasons for the differences in the degree of burden of HAIs in developing countries include the following:

- Limited knowledge and training in basic infection prevention and control^{31,38}
- Limited awareness of the dangers associated with HAIs³⁹
- Inadequate infrastructure and limited resources^{31,32,38,40}
- Poor adherence to routine hand hygiene^{22,32}
- Reuse of equipment (for example, needles, gloves)^{22,38}
- Poor environmental hygiene and overcrowding^{22,32}
- Understaffing^{22,30,32}
- Inappropriate and prolonged use of antimicrobials and invasive devices^{22,31}
- Limited local and national policies and guidelines^{22,31}
- Variable adherence to official regulations or legal frameworks, where they exist³²
- Insufficient administrative support³²

Given these constraints, it is not too difficult to see why the available limited resources are seldom shunted into the development of surveillance systems for HAIs. Simply put, many developing countries lack the resources necessary to support those surveillance systems, including staff with the necessary expertise.²²

To better understand some of these issues, the International Nosocomial Infection Control Consortium (INICC) was

founded by Dr. Victor Rosenthal in Argentina in 1998, with process and outcome surveillance for HAIs performed in three hospitals. In 2002 the INICC became a nonprofit multicenter international collaborative HAI control program. It is the first multinational research network established to control HAIs in hospitals in resource-limited countries as well as in hospitals in developed countries that have limited experience in HAI surveillance and control.⁴¹ Currently INICC member organizations from 36 resource-limited countries are using standardized definitions and methods to conduct HAI surveillance.^{32,34,36,37,41} The INICC methodology includes validation of its findings.⁴¹

Figures I-1 and I-2 on pages viii and ix depict international HAI prevalence and incidence rates from a review of the literature conducted by the World Health Organization (WHO).⁴² It should be pointed out that some methodological differences are inherent in the data from the various countries that are considered in the figures (for example, differences in case definitions, rate calculation methods, intensity of surveillance or scope), and more current data are available for several developing countries (see Appendix B at the end of the book).

The costs associated with HAIs include direct costs of care; indirect costs, such as productivity and nonmedical costs; and intangible costs related to quality of life.⁴³ The following estimated US costs have been put forward, considering only direct hospital costs for treatment of HAIs:

- In the United States, \$28 to \$33 billion is expended for HAIs each year.⁴³
- A 2010 report by the HHS Office of Inspector General estimated that temporary and adverse harm events associated with hospital care (including HAIs) cost Medicare more than \$300 million in just a single month in 2008. Most of these costs were associated with additional lengths of stay due to the harm of the events.²⁶

In Europe, the annual financial burden of direct costs associated with HAIs has been estimated to be €7 million (about \$10 million US equivalent).⁴²

Imperatives for the Elimination of HAIs

There is growing recognition that many HAIs are largely preventable when evidence-based practices are followed consistently over time. Recently a joint “call to action” to move toward the elimination of HAIs was set forth by the CDC and the Association for Professionals in Infection Control and Epidemiology (APIC), the Society for

Healthcare Epidemiology of America (SHEA), the Infectious Diseases Society of America (IDSA), the Association of State and Territorial Health Officials (ASTHO), the Council of State and Territorial Epidemiologists (CSTE), and the Pediatric Infectious Diseases Society (PIDS).⁴⁴ In this joint statement, the definition of *elimination* was derived from an international public health conference on global disease elimination and eradication,⁴⁵ stated as the maximal reduction of “the incidence of infection caused by a specific agent in a defined geographical area as a result of deliberate efforts; continued measures to prevent re-establishment of transmission are required.”^{45(p. 24)} The authors note that this public health definition can be easily adapted to HAIs. Achieving the goal of eliminating HAIs will require a focused intention to succeed through consistent adherence to evidence-based practices, alignment of financial incentives, enhanced personal and organizational accountabilities, and a collaborative process among private and public stakeholders.⁴⁴

CLABSI–Related Morbidity, Mortality, and Costs

It has been estimated that 80,000 CLABSIs occur in ICUs in the United States each year⁴⁶; however, if patients outside ICUs are also included, the estimate increases to 250,000 cases of CLABSI each year.³ CLABSIs are serious but often preventable infections when evidence-based guidelines are followed for the insertion and maintenance of central lines. This preventability is even more acutely apparent in developing countries, where use of these devices may occur in the absence of the most basic infection prevention and control practices and limited availability of supplies.^{38,40}

A more recent CDC report showed some encouraging improvement in the following numbers, particularly in ICUs, although CLABSI criteria changed somewhat during the study period⁴⁷:

- In 2009 there were 18,000 CLABSIs in ICUs, a 58% reduction from 43,000 CLABSIs in 2001.

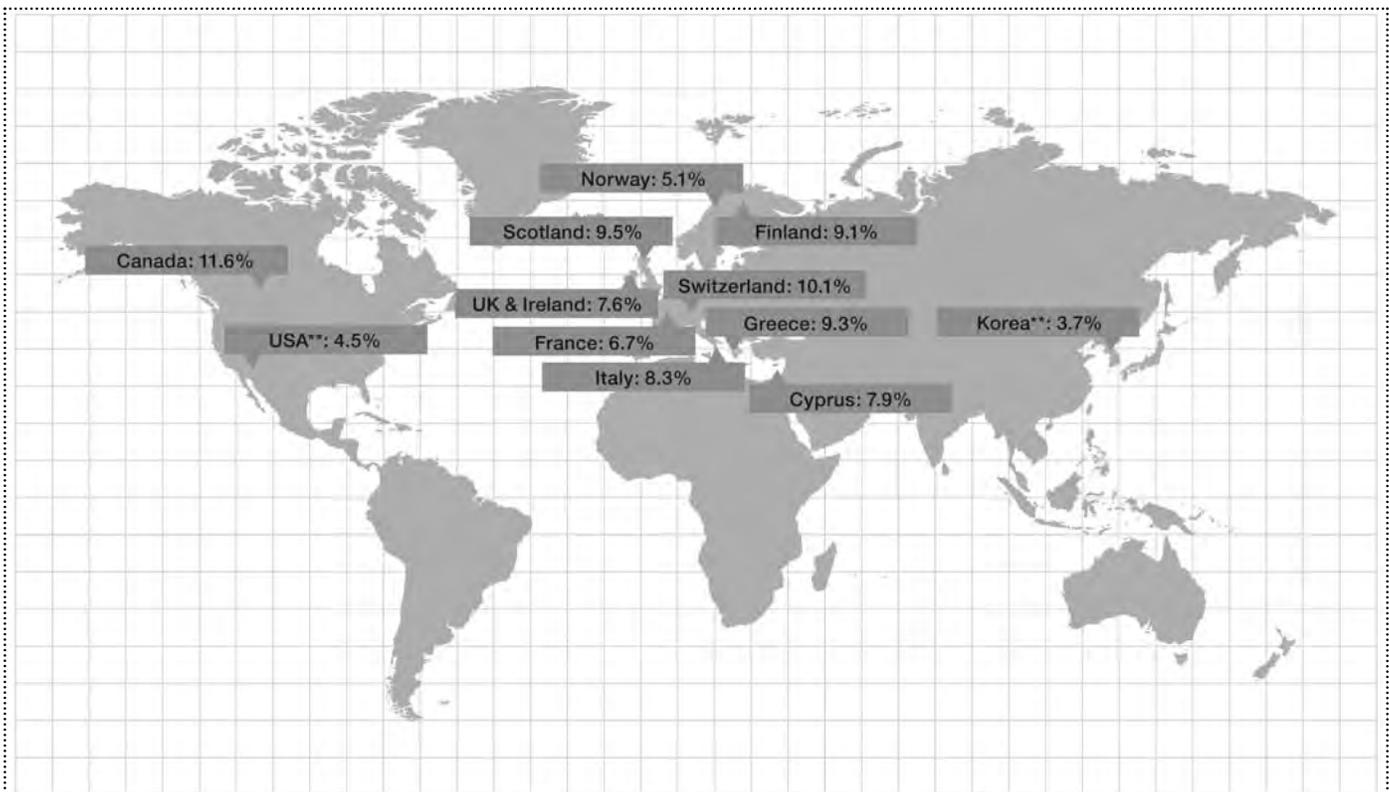


Figure I-1. Prevalence of HCAI in Developed Countries*

* Systematic review conducted by WHO, 1995–2008; HCAI: health care–associated infection.

** Incidence

Source: World Health Organization, Geneva.

- This decrease in the incidence of CLABSIs in the United States is thought to represent as many as 6,000 lives saved and \$414 million in potential excess health care costs in 2009—and almost \$2 billion in cumulative excess costs since 2001.

However, there is still much work to be done. There were 23,000 CLABSIs in non-ICU inpatient wards,⁴⁷ which supports the ongoing concern that the majority of CLABSIs are occurring outside ICUs.^{48–50} The CDC also estimates that, in 2008 alone, 37,000 CLABSIs occurred among patients receiving outpatient hemodialysis.⁴⁷

The European Union declared HAI prevention a top-priority policy in a 2008 report from the Commission of the European Communities to the European Parliament.²⁹ The commission's proposal included recommendations to improve surveillance systems, education and training of health care personnel in infection prevention and control,

and better patient education. The 27 European Member States were encouraged to develop plans to reduce the incidence of adverse events (including HAIs) in all health care settings.

As with other HAIs, CLABSIs also increase the cost of health care and prolong hospital lengths of stay by up to three weeks.^{1,12,13,51–53} Non-inflation-adjusted costs associated with CLABSIs have varied from \$3,700 per infection to \$36,441 per infection.^{12,43,46,52,54} A recent CDC estimate set the cost of each CLABSI at \$16,550.⁴⁷ Detailed comparisons of studies between diverse countries are difficult, due to differences in hospital billing systems. In all studies, however, the excess costs are considered substantial and economically relevant.⁵³

Most researchers have not been successful in linking CLABSIs independently with increased mortality because patient deaths often have multiple causes, and the impact

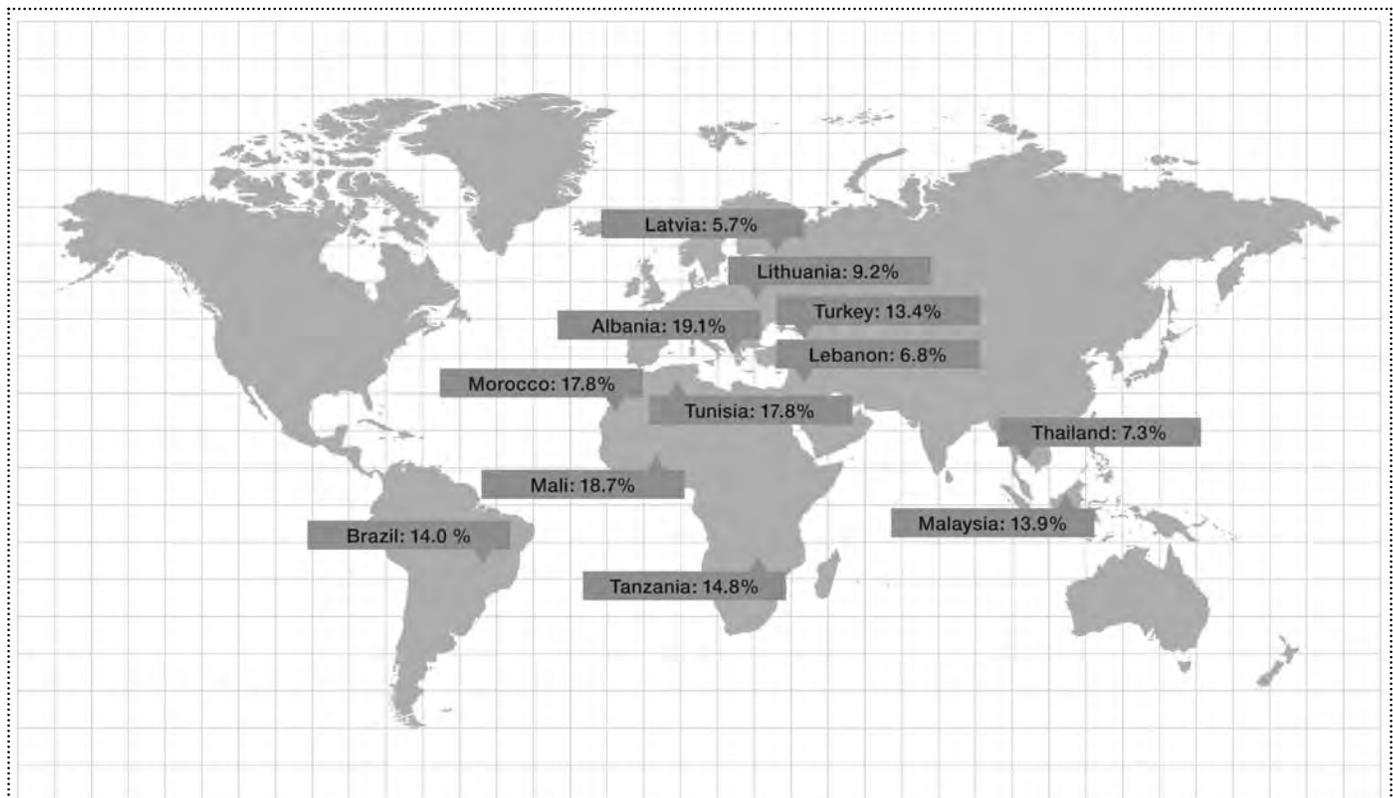


Figure I-2. Prevalence of HCAI in Developing Countries*

* Systematic review conducted by WHO, 1995–2008; HCAI: health care–associated infection.

Source: World Health Organization, Geneva.

of an infection may not always be clear.⁵⁵ Carrico and Ramírez point out that it can be challenging to differentiate between patients who die “with” an infection and those who die “because of” an infection.⁵⁶ Klevens et al. used three national data sources in the United States to estimate the number of deaths either caused by or associated with HAIs. These researchers estimated the annual number of deaths associated with HAIs to be 98,987. Nearly one third of these HAIs were due to CLABSIs, with an associated case fatality rate of 12.3%.⁵⁷ Morgan et al. conducted a study at one medical center over a five-year period and determined that HAIs were an important factor in nearly one third of unexpected in-hospital deaths, with CLABSIs being one of the most common such infections.⁵⁸ In developing countries, mortality rates may be as high as 50%.³³ More recently Lipitz-Snyderman et al. found about a 10% reduced mortality in patients over age 65 in ICUs that had implemented a statewide CLABSI quality improvement initiative over organizations in another state that had not.⁵⁹

Preventability of CLABSIs

For many years most harm that occurred in health care was considered inevitable; fortunately, that way of thinking has been replaced in the developed world by one that categorizes harm as largely preventable. The progress that has been made in recent years in reducing CLABSIs points to their preventability, as illustrated by the following examples:

- Umscheid et al. estimated that as many as 65% to 70% of CLABSIs may be preventable with the implementation of evidence-based strategies.⁵⁵
- Pronovost and colleagues from the Johns Hopkins Quality and Safety Research Group demonstrated, initially in 103 ICUs in Michigan, that increased use of evidence-based interventions and an improved culture of patient safety can prevent CLABSIs. At the end of the 36-month study period, there was a 60% overall reduction in the baseline CLABSI rate.⁶⁰ As a result, \$200 million and an estimated 2,000 lives were saved.¹⁷ The Pronovost model spawned a national effort in the United States, supported by the Agency for Healthcare Research and Quality (AHRQ), to implement the program in all US states.⁶¹
- WHO is working with the Pronovost team to implement the program throughout England and Spain. The Spanish project, called the Bacteriemia Zero project, was successful in reducing the incidence of CLABSIs by approximately 50% in 192 ICUs in Spain between 2008 and 2010.⁶² The program will also be pilot tested in

several Peruvian hospitals.⁶¹ (More information about the Pronovost model can be found in Chapter 1.)

Efforts to track, report, and prevent bloodstream infections in the United States have improved in recent years. As part of its Action Plan to Prevent HAIs,²¹ HHS has a national goal of reducing CLABSIs by 50% by 2013, as monitored through the NHSN. Federal, state, facility, and provider collaborations have proven to be successful in preventing CLABSIs and improving patient safety.

Even in resource-limited countries, improving CLABSI rates is possible. The INICC, established in 2002 in 15 developing countries, has been successful in reducing CLABSI incidence by 54% and mortality by 58% by improving adherence to infection prevention and control measures. The investigators instituted process and outcome surveillance, coupled with staff education and performance feedback to personnel working in 86 ICUs, to facilitate the improvements in CLABSI rates.¹⁵

Overall, the high morbidity and mortality associated with CLABSI, improved understanding of its pathogenesis and preventability, and the growing unwillingness of patients, payers, and patient advocates to look at HAIs as an acceptable risk has led to the emergence of a “zero tolerance” mind-set—an emphasis that organizations set the goal at eliminating HAIs rather than being comfortable with meeting national or local averages.^{63–66} Employing relatively simple evidence-based practices to reduce, if not eliminate, CLABSIs appears to be within the reach of even resource-limited settings.⁶⁷ Within this framework, HAIs—and CLABSIs in particular—are more and more being viewed as “preventable” events.

Scope and Content of the Monograph

The Joint Commission, Joint Commission Resources (JCR), and Joint Commission International (JCI) have developed this monograph aimed at reducing CLABSIs in the domestic and international arenas. The overarching goal of the project is to provide the most current information and guidance on practices and technology, as well as the most appropriate tools, resources, and education, to assist health care organizations in reducing the current burden associated with CLABSIs.

The scope of this monograph is central lines only—not peripheral lines or arterial lines. The intended audience consists of health care personnel who insert and care for

intravascular catheters and who are responsible for the surveillance, prevention, and control of infections in all health care settings.

The chapters that follow provide more detailed information:

- Chapter 1 reviews the types of central venous catheters and describes the risk factors for and pathogenesis of CLABSIs.
- Chapter 2 provides background information on CLABSIs and an overview of the various guidelines, position papers, and initiatives on their prevention. Barriers to the implementation of best practices at the staff, unit, and organizational levels are also addressed.
- Chapter 3 focuses on evidence-based strategies and techniques for preventing CLABSIs. Approaches not recommended for CLABSI prevention are also briefly discussed.
- Chapter 4 explores the challenges of translating evidence into practice and the factors that affect the success of CLABSI improvement initiatives.
- Chapter 5 highlights surveillance and surveillance systems and discusses CLABSI surveillance methods, as well as process and outcome performance measures related to CLABSIs and their prevention.
- Chapter 6 reviews the economic aspects of CLABSIs and their prevention. The currently recommended approaches for creating a compelling business case for HAI prevention resources are also presented.

A glossary of terms used in this monograph is included at the end of the book.

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CHAPTER 1

Types of Central Venous Catheters and Risk Factors for and Pathogenesis of CLABSIs

In this chapter factors that put patients at risk of infection and the pathogenesis of central line–associated bloodstream infections (CLABSIs) are reviewed. Successful CLABSI prevention efforts require a clear understanding of both the factors that influence infection risk and the sequence of events from catheter insertion to the onset of CLABSI.

Background on Central Venous Catheters

Central venous catheters (CVCs) are essential components in the care of many patients, including those who are chronically or critically ill and those requiring hemodialysis.¹ It is believed that the first central venous line was inserted in the right ventricle in the late 1920s, with the subclavian vein approach published in the literature in the early 1950s.² Hermosura was the first to use the internal jugular vein as the point of insertion.³ Although mechanical complications (for example, air embolisms, catheter leaks, hub separation) were common in the early years of CVC use, CLABSIs quickly became recognized as a serious complication associated with the

use of these catheters.² In this chapter we discuss the different types of CVCs and prevention of infection associated with their use. Although many bloodstream infections are due to CVCs, arterial catheters and peripheral venous catheters also cause substantial numbers of bloodstream infections.^{4,5}

According to the National Healthcare Safety Network (NHSN), a central venous catheter, or central line, is “an intravascular catheter that terminates at or close to the heart or in one of the great vessels which is used for infusion, withdrawal of blood, or hemodynamic monitoring.” The great vessels are the aorta, pulmonary artery, superior vena cava, inferior vena cava, brachiocephalic veins, internal jugular veins, subclavian veins, external iliac veins, common iliac veins, femoral veins, and, in neonates, the umbilical artery/vein.⁶

Types of CVCs

Several types of CVCs are available, and they come in various sizes and catheter materials; they also are available as single, double, triple, or quadruple lumen. The terminology used to identify the various types of catheters can be confusing, as different aspects of a catheter may be used by clinicians for informal reference. For example, a catheter may be designated by its intended life span (short term or temporary versus long term or permanent); its site of insertion (internal jugular, subclavian, femoral); and its pathway from the skin to the blood vessel (tunneled versus nontunneled).⁷ According to the US Centers for Disease Control and Prevention (CDC), all pertinent aspects of a specific type of catheter should be described to accurately define the type of catheter.⁷

The type of catheter chosen depends on the specific needs and preferences of the patient and the health care provider, including the duration and frequency of CVC use. While every intravenous device carries with it the risk of infection, the magnitude of risk varies and depends on the type of device.⁸ Based on their design, CVCs can be divided into the following major types^{1,9}:

- *Nontunneled catheters* are inserted into the subclavian, jugular, or femoral vein via a peripheral venipuncture, and the catheter tip is advanced until it rests in the superior vena cava. These short-term (used less than three weeks) catheters may be made of silicone or polyurethane. They can be inserted in outpatient or inpatient settings and can be exchanged over a guidewire. They are used to measure central venous pressure and for the administration of fluids and/or hyper- or hypo-osmolar drugs in patients with limited peripheral access and for short-term hemodialysis.
- *Tunneled CVCs*, such as Hickman and Broviac catheters, are long-term (used weeks to months) catheters that are inserted into a vein at one location (such as the jugular or subclavian vein) that are then surgically tunneled under the skin to exit the body several inches away from the vein. The tip of the catheter rests in the lower third of the superior vena cava at the right atrial junction. The proximal end exits the subcutaneous tunnel at the lower anterior chest wall and is equipped with a Dacron cuff that sits within the skin tunnel. The cuff induces an inflammatory response that results in the growth of fibrous tissue that anchors the catheter in place. The cuff also acts as a mechanical barrier to microorganisms. These catheters are used for drug and fluid administration, antibiotic therapy, chemotherapy, nutritional therapy, hemodialysis, and bone marrow transplantation. These catheters are more comfortable and discreet for the patient than nontunneled catheters, but they require a minimally invasive surgical procedure that carries with it attendant risks, such as hemorrhage, pneumothorax, and infection.¹⁰ These catheters are made of polyurethane and silicone material.
- *Implantable ports*, such as portacaths, are surgically placed completely under the skin, usually as a central subclavian port in the subcutaneous pocket of the upper chest wall. These are useful for long-term or permanent vascular access and carry with them a lower infection risk, as they are not external to the body. Indications for use are the same as for tunneled CVCs. The port, which is made of plastic, titanium, or stainless steel, is a hollow reservoir with a silicone septum and an outlet that connects to a polyurethane or silicone catheter that enters one of the central veins. To administer treatment, a Huber needle is used to puncture the skin and the septum over the reservoir. These ports can be punctured up to 2,000 times and have been reported to be in place for several years.
- *Peripherally inserted central catheters (PICCs)*, such as the Groshong, have gained in popularity since they were introduced in the 1970s. There is a lack of robust, prospective, randomized studies of infectious and thrombotic complications of PICCs versus CVCs in intensive care unit (ICU) and non-ICU settings, so a comparison of risk between these two devices is difficult.^{11–13} They are increasingly being used in the delivery of many treatment modalities, particularly chemotherapy.⁹ They are used for long-term therapy that will generally last a year or less, and the CDC recommends that PICCs be used instead of short

peripheral catheters when the duration of intravenous (IV) therapy will likely exceed six days.⁷ PICCs are inserted into a vein in the arm (usually the basilic, brachial, or cephalic vein) rather than a vein in the neck or chest. The catheter is then advanced to the

distal superior vena cava/proximal right atrium.⁹ PICCs are made of polyurethane or silicone.⁹

Table 1-1 below summarizes the types of catheters and their characteristics.

Table 1-1.
Comparison of the Major Types of Central Venous Catheters (CVCs)

Catheter Type	Entry Site	Duration of Use	Advantages	Disadvantages	Comments
Nontunneled CVCs	Percutaneously inserted into central veins (internal jugular, subclavian, or femoral vein)	Short term*	<ul style="list-style-type: none"> ■ Percutaneous insertion ■ Relatively safe and inexpensive 	<ul style="list-style-type: none"> ■ Require local anesthesia ■ May be inserted in the operating room ■ Dressing required over site ■ Risk of infection 	<ul style="list-style-type: none"> ■ Account for the majority of central line-associated bloodstream infections (CLABSIs) ■ More commonly used than long-term CVCs
Tunneled CVCs	Implanted into internal jugular, subclavian, or femoral vein	Long term †	<ul style="list-style-type: none"> ■ Dressing not needed after healed 	<ul style="list-style-type: none"> ■ Require surgical insertion ■ Require local or general anesthesia ■ Increased cost 	<ul style="list-style-type: none"> ■ Lower rate of infection than nontunneled CVCs ■ Dacron cuff inhibits migration of organisms into catheter tract when ingrown
Implantable ports	Inserted in the subclavian or internal jugular vein. Tunneled beneath the skin; subcutaneous port accessed with a noncoring needle.	Long term	<ul style="list-style-type: none"> ■ Improved body image (low visibility of port) ■ Patient comfort ■ Local catheter site care and dressing not needed when not in use 	<ul style="list-style-type: none"> ■ Require surgical insertion and removal ■ Require general anesthesia ■ Increased cost 	<ul style="list-style-type: none"> ■ Lowest risk for CLABSI
Peripherally inserted central catheter (PICC)	Inserted percutaneously into basilic, brachial, or cephalic vein and enters the superior vena cava	Usually short to intermediate	<ul style="list-style-type: none"> ■ Ease of insertion, usually at the bedside by a specially trained registered nurse ■ Relatively inexpensive and safe 	<ul style="list-style-type: none"> ■ Can be difficult to position in central vein ■ Potential for occlusion 	<ul style="list-style-type: none"> ■ Lower rate of infection than nontunneled CVCs

* Short term: usually less than three weeks.

† Long term: weeks to months.

Sources: Adapted from O’Grady NP, Alexander M, Burns LA, Dellinger EP, Garland J, Heard SO, Lipsett PA, Masur H, Mermel LA, Pearson ML, Raad II, Randolph AG, Rupp ME, Saint S; Healthcare Infection Control Practices Advisory Committee (HICPAC). Guidelines for the prevention of intravascular catheter-related infections. *Clin Infect Dis*. 2011 May;52(9):e162–193. Epub 2011 Apr 1; Larson SD, Mancini MC. Vascular access, surgical treatment. *Medscape Reference*. Jan 25, 2010. Accessed Mar 16, 2012. <http://emedicine.medscape.com/article/1018395-overview#showall>.

In addition, venous and arterial umbilical catheterization can be a life-saving procedure in newborns who require vascular access in the first few days of life. Once in place, the tip of the catheter lies in the superior vena cava or aorta. Either the vein or artery can be used for exchange transfusions. Umbilical venous access is most often used for fluid and medication administration, blood sampling, and measurement of central venous pressure; umbilical artery access may be used to monitor arterial pressure or blood gases and to administer fluids and medications.¹⁴ Generally, umbilical artery catheters should not be left in place for more than 5 days, while umbilical vein catheters may be used up to 14 days if managed aseptically.⁷ Umbilical catheters are made of polyvinyl chloride or polyurethane.¹⁵

A discussion of CVCs coated with antimicrobial agents or heparin can be found in Chapter 3.

Risk Factors for CLABSI

Risk factors can be intrinsic (nonmodifiable characteristics that patients have) or extrinsic (modifiable factors associated with CVC insertion or maintenance, or the environment in which the patient is receiving care).^{2,16} Characteristics of the CVC, its insertion, and its postinsertion maintenance have the greatest impact on the overall risk of CLABSI^{17,18} (also see Table 1-2 below):

■ *Intrinsic risk factors*

- Age: CLABSIs rates are higher among children than

adults, particularly in neonates.^{2,19} Except for adults in burn or trauma critical care units, pediatric ICUs had the highest CLABSI rates, as reported in the most recent NHSN device-associated module data summary report (5.3 and 2.6 CLABSIs per 1,000 catheter-days for burn and trauma ICU, respectively, versus 2.2 to 2.6 for pediatric cardiothoracic, medical, or medical/surgical ICUs per 1,000 catheter-days). Very low birth weight infants (< 750 g) had a pooled mean CLABSI rate of 3.4 per 1,000 catheter-days).²⁰

- Underlying diseases or conditions—hematological and immunological deficiencies, cardiovascular disease, and gastrointestinal diseases—have been associated with an increased risk for CLABSI.^{21–24}
- Male gender has been identified as a factor associated with increased risk of CLABSI.^{25,26}
- *Potentially modifiable risk factors* (all associated with increased risk)
 - Prolonged hospitalization before CVC insertion²⁴
 - Multiple CVCs^{24,25,27}; Almuneef et al. found a tenfold increase in CLABSI risk in pediatric ICU patients with multiple CVCs.¹⁹
 - CVC duration, with the risk increasing with CVC dwell time^{21,23,24,28,29}
 - Parenteral nutrition administration^{19,21,23,28,30,31}
 - Femoral or internal jugular access site rather than subclavian in adult patients^{7,19,24,32}

Table 1-2.
Intrinsic and Extrinsic Risk Factors for CLABSI

Intrinsic Risk Factors (nonmodifiable characteristics of the patient)	Extrinsic Risk Factors (potentially modifiable factors associated with CVC insertion or maintenance)
Patient's age	Prolonged hospitalization before CVC insertion
Underlying diseases or conditions	Multiple CVCs
Patient's gender	Parenteral nutrition
	Femoral or internal jugular access site
	Heavy microbial colonization at insertion site
	Multilumen CVCs
	Lack of maximal sterile barriers for CVC insertion
	CVC insertion in an ICU or emergency department

Note: CVC: central venous catheter, ICU: intensive care unit.

- Heavy microbial colonization at insertion site, which is closely related to the site chosen for insertion; density of skin flora is higher at the base of the neck, where internal jugular CVCs are inserted, than at the upper chest, where subclavian CVCs are inserted.^{24,33,34}
- Multilumen CVCs^{7,24}
- Lack of maximal sterile barriers (cap, mask, sterile gown, sterile gloves, and a sterile full body drape) for the insertion of CVCs or guidewire exchange^{35,36}
- CVC insertion in an ICU or emergency department^{23,25,37,38}

Also, as will be described in Chapter 2, staff who insert and maintain CVCs must receive education and training to ensure competence and minimize the risk of CLABSI in their patients; a sufficient nurse-to-patient ratio is also important to minimize risks for patients with CVCs. A more in-depth discussion regarding education and training and their roles in patient safety initiatives can be found in Chapter 4.

Chapter 3 contains a comprehensive review of the recommended strategies and techniques for preventing CLABSIs.

Pathogenesis of CLABSIs

CVCs can become contaminated with microorganisms via two major routes^{7,39-42} (also see Figure 1-1 below):

1. Extraluminally:

- The patient's skin organisms at the insertion site can migrate along the surface of the catheter into the cutaneous catheter tract surrounding the catheter, resulting in colonization at the catheter tip. For short-term catheters (nontunneled CVCs in place less than 10 days), this is the most common source of infection.

2. Intraluminally

- Most commonly, direct contamination of the catheter or at any point along the fluid pathway when the IV system is manipulated (as might occur when health care personnel have hand contact with IV solution connection sites, access hubs, needleless connectors, or tubing junctions, or contamination with the patient's own body fluids or skin). This route has been associated with more prolonged CVC dwell time (for example, in place for more than 10 days), including tunneled CVCs such as Hickman- and Broviac-type catheters and PICCs.

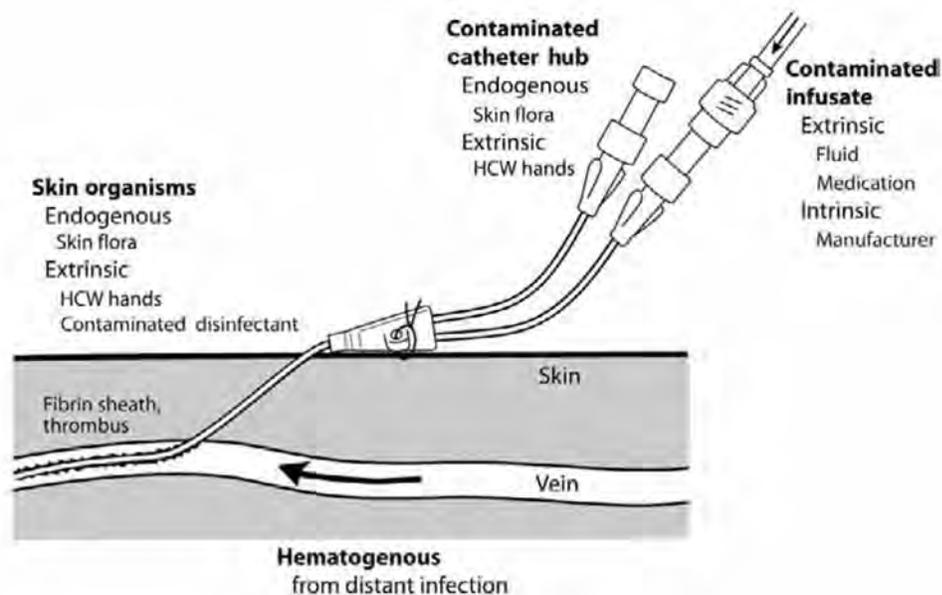


Figure 1-1. Routes for Central Venous Catheter Contamination with Microorganisms

Potential sources of infection of a percutaneous intravascular device (IVD): the contiguous skin flora, contamination of the catheter hub and lumen, contamination of infusate, and hematogenous colonization of the IVD from distant, unrelated sites of infection. HCW: health care worker.

Source: Crnich CJ, Maki DG. The promise of novel technology for the prevention of intravascular device-related bloodstream infection. I. Pathogenesis and short-term devices. *Clin Infect Dis*. 2002 May 1;34(9):1232-1242. Used with permission.

- Less commonly, catheters can become seeded via the hematogenous route from an infection at another site, such as a urinary tract infection or pneumonia.
- Rarely, contamination of the infusate (such as par-enteral fluid, intravenous medications, or blood products) can be the source of infection. Infusate can become contaminated during the manufacturing process (intrinsic contamination) or during its preparation or administration in the patient care setting (extrinsic contamination). This is a rare event, but it is the cause of most epidemic IV-device-related bloodstream infections.^{43,44}

After the catheter is inserted into the bloodstream, plasma proteins begin to adhere to it, which can result in the formation of a fibrin sheath around the catheter.^{7,41} When microorganisms gain access to the intraluminal or extraluminal surface of the catheter, they become irreversibly adherent and begin to produce a biofilm that incorporates the microorganisms and provides a protective environment against the host defenses (that is, polymorphonuclear leukocytes) and antibiotics. Dispersal of single-cell microorganisms or clumps from the biofilm results in hematogenous dissemination of biofilm bacteria.^{39,41,42} Microorganisms that are dispersed as single cells can be killed by host defenses, but if the dissemination becomes extensive or if host defenses are compromised, true CLABSI occurs.⁴¹ Biofilm dispersed in clumps remains resistant to host defenses and antimicrobials and may result in serious focal infections such as endocarditis.⁴¹

Both extraluminal and intraluminal routes are important in the pathogenesis of CVC–related bloodstream infections. A focus on infection prevention during catheter insertion, as discussed in more detail in Chapter 3, minimizes CVC–related bloodstream infections that occur within the first few days of the catheter’s insertion (associated with the extraluminal route of contamination). A focus on proper catheter maintenance is important in minimizing infections that occur with longer dwell times (associated with the intraluminal route of contamination).³⁹

It is also important to understand the role that CVC catheters themselves play in the pathogenesis of infection. Earlier in this chapter the different categories of CVCs and the infection risks associated with each type were described (see Table 1-1 on page 3). Maki et al. conducted a review of the literature to determine the relative risks of bloodstream infection associated with various types of intravenous

devices in adults. The rates of bloodstream infections associated with CVCs varied from 4.8 infections per 1,000 catheter-days for temporary, noncuffed CVCs to 1.6 infections per 1,000 catheter-days for long-term cuffed and tunneled hemodialysis catheters and cuffed and tunneled CVCs.⁸

The catheter material can also influence the development of bloodstream infection.⁷ Some catheters have irregularities that can enhance the adherence of certain microorganisms (for example, *Staphylococcus epidermidis* and *Candida albicans*). Other catheters and their construction materials contribute to the formation of fibrin sheaths, which is why silastic catheters have a higher risk of infection associated with their use than do polyurethane catheters. Silicone elastomer catheter surfaces allow biofilm formation by *C. albicans* more readily than do polyurethane catheters. Finally, some catheters are more thrombogenic (tend to produce blood clots) than others, which may predispose them to colonization and infection.⁷

Gram-positive skin organisms often comprise the most commonly reported causative microorganisms of bloodstream infections.^{1,36,45,46} Data from a nationwide surveillance study in the United States found that coagulase-negative staphylococci and *Staphylococcus aureus* account for 31% and 20%, respectively, of all health care–associated bloodstream infections. *Enterococcus* and *Candida* species ranked third and fourth, at 9% each.⁴⁵ One quarter of the infections were caused by Gram-negative organisms, with *Escherichia coli* (6%) and *Klebsiella* species being the most common. Gram-negative organisms, however, have been found to be a more important cause of CLABSIs in some areas of the world.⁴⁷ For example, Taiwan, the Czech Republic, and Egypt have reported bloodstream infections more often due to Gram-negative organisms (50%, 64.8%, and 66% of CLABSIs, respectively), most often due to *E. coli*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa*.⁴⁸

Antimicrobial resistance is a problem with all common pathogens that cause CLABSIs, particularly in ICUs⁷:

- Methicillin-resistant *Staphylococcus aureus* (MRSA) accounts for more than 50% of all *S. aureus* isolates obtained in ICUs.
- Resistance to third-generation cephalosporins has increased significantly among *E. coli* and *K. pneumoniae* isolates.
- Ceftazidime and imipenem resistance is increasingly being found among *P. aeruginosa* isolates.

- Fluconazole resistance is increasingly being seen in *Candida* species.

In neonates, bloodstream infections are classified as early onset (within 72 hours of birth) or late onset (more than 72 hours after birth)^{7,49,50}:

- Early-onset bloodstream infections (non-device-related) are acquired in the birth canal and are often multisystem in nature, with high mortality rates. Risk factors associated with early-onset sepsis include prolonged rupture of membranes, prematurity and low birth weight, maternal fever, and chorioamnionitis. The most common causative organisms are Group B *Streptococcus*, followed by *E. coli* and *Staphylococcus* species; less commonly isolated are non-*E. coli* Gram-negative bacteria.
- Late-onset bloodstream infections are usually associated with CVCs. Risk factors for late-onset bloodstream infections include low birth weight and parenteral nutrition therapy. Neonates of very low birth weight (VLBW; < 1,500 g) who develop late-onset bloodstream infections have a mortality rate that is three times that of VLBW neonates who do not.⁵¹ These infections are most often caused by coagulase-negative staphylococci, followed by *C. albicans* and *E. coli*. MRSA and extended-spectrum β -lactamase (ESBL) organisms are emerging problems in nurseries.⁵⁰ Invasive fungal infections are also a rising concern in VLBW infants and are associated with higher mortality than invasive bacterial infections.⁵⁰

Summary of Key Points

This chapter provides a review of factors that put patients at risk of infection and the pathogenesis of CLABSIs. Key points to keep in mind include the following:

- Although CVCs, introduced in the late 1920s, experienced a number of mechanical problems in their early years, CLABSIs quickly became recognized as a serious complication associated with their use.
- The major types of CVCs, based on their design, are nontunneled catheters, tunneled catheters, implantable ports, and peripherally inserted central catheters.
- Risk factors for CLABSI can be *intrinsic* (nonmodifiable characteristics that patients have, such as age or underlying diseases or conditions) or *extrinsic* (modifiable factors associated with CVC insertion or maintenance).
- CVCs can become contaminated with microorganisms either *extraluminally* (that is, the patient's own skin organisms migrate along the surface of the CVC) or *intraluminally* (that is, direct contamination of the CVC

or any point along the fluid pathway when the intravenous system is manipulated).

- The catheter material can also influence the development of bloodstream infection.
- Antibiotic resistance is a problem with all common pathogens causing CLABSIs, particularly in intensive care units.

In this chapter we have reviewed the risk factors for and pathogenesis of CLABSIs. The next chapter will provide background on CLABSIs, including clinical practice guidelines, position papers, initiatives on CLABSI prevention, and barriers to best practices.

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CHAPTER 2

Background on CLABSIs: Clinical Practice Guidelines, Position Papers, Initiatives on CLABSI Prevention, and Barriers to Best Practices

Addressing the issue of central line–associated bloodstream infections (CLABSIs) is challenging. This chapter provides background on CLABSIs, including clinical practice guidelines, position papers, initiatives on CLABSI prevention, and barriers to best practices.

Clinical Practice Guidelines Regarding CLABSIs and Their Prevention

Clinical practice guidelines (CPGs) are “statements that include recommendations intended to optimize patient care. They are informed by a systematic review of evidence and an assessment of the benefits and harms of alternative options.”¹ CPGs are based on a systematic review of the evidence and are rated on both the quality and the strength of the recommendations. These guidelines represent a multidisciplinary approach to practice and reflect a transparent process that minimizes bias and conflicts of interest.¹ CPGs are intended to translate findings from health research into recommended practices that, when implemented, could improve health care quality and patient outcomes.²

Several countries, regions, and organizations have established CPGs pertaining to the prevention of central line–associated bloodstream infections (CLABSIs), authored by governmental, professional, and public health organizations. The CPGs have been published either as stand-alone documents or in publications that include CLABSIs as well as other health care–associated infections (HAIs). The quality of the CPGs and the strength of the link between the recommendations and evidence, however, varies significantly.³ Differences also exist in how CPGs are disseminated and implemented, likely due to differences in political and cultural factors and health care delivery systems.⁴ Although a comprehensive discussion of this topic area is beyond the scope of this monograph, Table 2-1 on pages 13–15 contains a high-level overview of a few examples of international CPGs pertaining to CLABSI prevention, and Table 2-2 on pages 15–21 contains examples of relevant CPGs published by organizations or professional societies.

Position Papers Regarding CLABSIs and Their Prevention

A position paper presents an opinion about an issue, with the goal of convincing the audience that the opinion promoted is valid and worth considering. It promotes one side of an argument and provides evidence to support that view.⁵

Position papers are often developed by professional organizations or societies to indicate their stance or recommendations on a topic area.⁶ Table 2-3 on pages 21–22 contains examples of position papers organizations have published relative to central venous catheters (CVCs) and/or the prevention of CLABSIs.

CLABSI Initiatives and Campaigns

HAI prevention is one of the 20 “priority areas” identified in the Institute of Medicine’s (IOM’s) 2003 report *Transforming Health Care Quality*.⁷ That publication further focused the attention of the public, policy makers, and the health care community on opportunities to improve patient safety that were previously reported in the IOM’s 2000 report *To Err Is Human: Building a Safer Health System*.⁸ Even countries with limited resources can implement no- and low-cost infection prevention measures that can have a demonstrable impact on the incidence of HAIs.^{9–11} Implementing evidence-based practices, including combining several measures into a CVC insertion “prevention bundle,” has resulted in improved CLABSI rates in both single- and multicenter studies.^{12–14} As described in this section, successful initiatives and campaigns are often

multifaceted, using several different techniques or approaches to decrease CLABSIs.

Several recent international, national, regional, state, and single-organizational campaigns and initiatives have highlighted the preventability of CLABSIs by adhering to evidence-based preventive practices. An in-depth review is beyond the scope of this chapter, but several are summarized in the next few sections. A brief overview of several others follows.

The International Nosocomial Infection Control Consortium (INICC) Strategy on CLABSI Rates

The INICC, founded in 2002, is an international nonprofit, multicenter, collaborative HAI infection control program with a surveillance system based on the National Healthcare Safety Network (NHSN) of the US Centers for Disease Control and Prevention (CDC). It is the first multinational research network established to control HAIs in hospitals by analyzing data collected voluntarily by member hospitals. It is the only source of aggregate standardized international data on HAIs in developing countries¹⁵ and has been publishing its data since 2003.^{16–34} There are now more than 300 intensive care units (ICUs) in approximately 40 countries on 4 continents that participate in the INICC (see <http://www.inicc.org/eng/consorcio.php>).³⁵ The INICC’s successes in improving HAI rates have been published in several peer-reviewed publications.^{15,36–41}

The consortium focuses on the surveillance and control of device-associated infections, including CLABSIs. It provides basic education on infection prevention and control practices, surveillance for CLABSIs and process surveillance, and continuous feedback of infection rates and process measures in each ICU.¹⁵ At the conclusion of the INICC’s first 8 years, the organization conducted a time-sequence analysis of CLABSI rates and associated deaths in 86 ICUs in 15 developing countries; each ICU included in the analysis had been a member of the consortium for a minimum of 6 months and had submitted monthly surveillance data through December 2008. Infection prevention and control practices (for example, hand hygiene, use of maximal sterile barriers at catheter insertion, chlorhexidine skin antisepsis) were assessed via periodic surveys, and trends in process surveillance for hand hygiene and vascular care, as reported monthly, were analyzed. The 3-month baseline period was compared to the 24-month intervention period.¹⁵ The list on page 23 summarizes some of the significant findings.

Table 2-1.
Examples of International Clinical Practice Guidelines
That Include CLABSI Prevention Strategies

Guideline Title	Developer/Website	Background	Applicable Settings
Country/Region: Australia			
Australian Guidelines for the Prevention and Control of Infection in Healthcare Year published: 2010	Australian government's National Health and Medical Research Council (NHMRC) http://www.nhmrc.gov.au	The Australian Commission on Safety and Quality in Health Care (ACSQHC) requested NHRMC develop the guidelines. In addition to providing information regarding hand hygiene, standard and transmission-based precautions and aseptic technique, the guidelines include a review of the processes of care for insertion, maintenance, and replacement of intravascular access devices. These guidelines update a 2004 publication. Available at http://www.nhmrc.gov.au/guidelines/publications/cd33	A variety of settings, including hospitals, long term care facilities, ambulatory settings, and home and community health care settings
Country/Region: England			
epic2: National Evidence-Based Guidelines for Preventing Healthcare-Associated Infections in NHS Hospitals in England Year published: 2007	The Department of Health (United Kingdom) commissioned a guidelines advisory group to update the 2001 guidelines it had previously developed. http://www.dh.gov.uk/en/index.htm The guidelines have been endorsed by the Department of Health.	A multiprofessional team of clinicians and researchers wrote the guidelines, which were initially published in 2001. The guidelines contain detailed information on the standard principles for preventing HAIs (for example, hand hygiene, use of personal protective equipment, safe use and disposal of sharps), and preventing infections associated with the use of indwelling urinary catheters and central venous catheters.* The guidelines were subsequently reviewed and updated to incorporate new technological advances and evidence from research. The pathogenesis of catheter-related bloodstream infections, general asepsis, catheter selection, maximal sterile barriers, and general principles for catheter management are among the 9 intervention categories that provide 47 specific recommendations for the prevention of bloodstream infections. Available at http://www.neli.org.uk/integratedcrrd.nsf/5fbbcc8a843b38108025755b005ea3f0/74e975b7665fcea802572170036d353?OpenDocument . * Pratt RJ, Pellowe CM, Wilson JA, Loveday HP, Harper PJ, Jones SR, McDougall C, Wilcox MH. epic2: National evidence-based guidelines for preventing healthcare-associated infections in NHS hospitals in England. <i>J Hosp Infect.</i> 2007 Feb;65 Suppl 1:S1–64.	Hospitals and other acute care settings
Country/Region: Europe			
(In development)	The European Centre for Disease Prevention and Control (ECDC) is developing scientific guidance on the effective prevention of HAIs, with input from international	In June 2009 the Council of the European Union invited Member States to ensure that proper infection prevention and control practices are implemented in all health care settings. In February 2010 key priority topic areas for developing evidence-based guidelines were determined. To strengthen national HAI prevention strategies and improve coordination, the ECDC was given the mandate to develop guidance on	Initially the ECDC guidelines will focus on acute inpatient care settings, with broader

Continued on next page

Note: All guidelines accessed Mar 17, 2012. HAI: health care–associated infection; CLABSI: central line–associated bloodstream infection.

Table 2-1. (Continued)

Guideline Title	Developer/Website	Background	Applicable Settings
Country/Region: Europe (continued)			
	<p>experts (including representatives of the World Health Organization) on evidence-based practices.</p> <p>http://www.ecdc.europa.eu/en/Pages/home.aspx</p>	<p>those priority HAIs, which included surgical site infections, ventilator-associated pneumonia, and catheter-related bloodstream infections. An executive summary of the February 2010 meeting is available at http://www.ecdc.europa.eu/en/publications/Publications/1006_MER_HAI_final_meeting.pdf. Information about the European Member States is available at http://europa.eu/about-eu/countries/index_en.htm.</p> <p>Of interest, researchers in Europe are attempting to identify practices that have been adopted by European hospitals to prevent HAIs and to determine if those practices are effective. Led by Professor Didier Pittet from the University of Geneva Hospitals in Geneva, Switzerland, the Prevention of Hospital Infections by Intervention and Training (PROHIBIT) project will synthesize all information gathered to develop recommendations for policy makers, managers, and medical professionals. The 48-month-long project began in January 2010. The ECDC has established communication with the PROHIBIT project leaders with an expectation that their findings will help inform the ECDC guidelines. More information about the PROHIBIT project is available at http://ec.europa.eu/research/health/public-health/clinical-outcome-into-practice/projects/prohibit_en.html.</p>	<p>expansion to other health care settings. Ultimately the goal is to have guidelines that are applicable across the continuum of care.</p>
Country/Region: United States			
<p>Guidelines for the Prevention of Intravascular Catheter–Related Infections, 2011</p> <p>Year published: 2011</p>	<p>The Centers for Disease Control and Prevention (CDC) and the Healthcare Infection Control Practices Advisory Committee (HICPAC)</p> <p>http://www.cdc.gov</p>	<p>Replacing the CDC guideline published in 2002, the new edition was developed by a working group led by the Society of Critical Care Medicine (SCCM), in collaboration with the Infectious Diseases Society of America (IDSA), Society for Healthcare Epidemiology of America (SHEA), Surgical Infection Society (SIS), American College of Chest Physicians (ACCP), American Thoracic Society (ATS), American Society of Critical Care Anesthesiologists (ASCCA), Association for Professionals in Infection Control and Epidemiology (APIC), Infusion Nurses Society (INS), Oncology Nursing Society (ONS), American Society for Parenteral and Enteral Nutrition (ASPEN), Society of Interventional Radiology (SIR), American Academy of Pediatrics (AAP), Pediatric Infectious Diseases Society (PIDS), and the HICPAC of the CDC.</p> <p>These guidelines are intended to provide evidence-based recommendations for preventing intravascular catheter–related infections. Major areas of emphasis include (1) educating and training health care personnel who insert and maintain catheters; (2) using maximal sterile barrier precautions during central venous catheter insertion; (3) using a > 0.5% chlorhexidine skin preparation with alcohol for antiseptics; (4) avoiding routine replacement of central venous catheters as a strategy to</p>	<p>Hospitals, outpatient settings, and home care</p>

Continued on next page

Table 2-1. (Continued)

Guideline Title	Developer/Website	Background	Applicable Settings
Country/Region: United States (continued)			
		prevent infection; and (5) using antiseptic/antibiotic-impregnated short-term central venous catheters and chlorhexidine-impregnated sponge dressings if the rate of infection is not decreasing despite adherence to other strategies (education and training, maximal sterile barrier precautions, and > 0.5% chlorhexidine preparations with alcohol for skin antisepsis). These guidelines also emphasize performance improvement by implementing bundled strategies, and documenting and reporting rates of compliance with all components of the bundle as benchmarks for quality assurance and performance improvement. The guidelines are available at http://www.cdc.gov/hicpac/BSI/BSI-guidelines-2011.html .	

Table 2-2.
Examples of Clinical Practice Guidelines or Practice Standards
Developed by Organizations or Professional Societies
Regarding Aspects of CLABSI Prevention or Diagnosis

About the Organization/Society and Website Address	Guideline Citation, Publication Topic, Year	Summary	Applicable Settings
Organization or Professional Society: World Health Organization (WHO)–World Alliance for Patient Safety			
WHO is the directing and coordinating authority for health within the United Nations system. It is responsible for providing leadership on global health matters, setting norms and standards, articulating evidence-based policy options, providing technical support to countries, and monitoring and assessing health trends. WHO experts produce health guidelines and standards and help countries address public health issues. WHO's membership is comprised of 193 countries and two associate members. WHO's Constitution came into force on April 7, 1948—a date	World Health Organization (WHO): <i>WHO Guidelines on Hand Hygiene in Health Care</i> . Geneva: WHO, 2009. Publication topic: Hand hygiene Year published: 2009	Hand hygiene is a primary measure to reduce infections, including CLABSIs. A core part of WHO Patient Safety work is related to Global Patient Safety Challenges. These challenges are international campaigns that bring together expertise and evidence on important aspects of patient safety. Recommendations are developed to ensure the safety of patients receiving care globally. WHO Patient Safety works to make these recommendations widely available and provides tools to implement the recommendations in a variety of health care settings worldwide. To date there have been two Global Patient Safety Challenges: "Clean Care Is Safer Care" and "Safe Surgery Saves Lives." The WHO guidelines on hand hygiene are a	All settings, from high-technology hospitals in developed countries to remote clinics in resource-poor villages

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Note: All guidelines accessed Mar 17, 2012. CLABSI: central line–associated bloodstream infection; CVC: central venous catheter; PIVC: peripherally inserted venous catheter; HAI: health care–associated infection; MRSA: methicillin-resistant *Staphylococcus aureus*; CVAD: central venous access device; PICC: peripherally inserted central catheter.

Table 2-2. (Continued)

About the Organization/Society and Website Address	Guideline Citation, Publication Topic, Year	Summary	Applicable Settings
Organization or Professional Society: World Health Organization (WHO)–World Alliance for Patient Safety (continued)			
<p>now celebrated every year as World Health Day.</p> <p>http://www.who.int</p>		<p>product of the “Clean Care Is Safer Care” Global Patient Safety Challenge, launched in 2005.</p> <p>The hand hygiene guidelines are available at http://whqlibdoc.who.int/publications/2009/9789241597906_eng.pdf.</p>	
Organization or Professional Society: American Society for Parenteral and Enteral Nutrition (ASPEN)			
<p>ASPEN was founded in 1975 for the purpose of providing optimal nutrition to all people under all conditions at all times. ASPEN has been publishing clinical guidelines, statements, standards, and other documents for more than 20 years in order to assist practitioners in providing safe, efficacious nutrition care to patients.</p> <p>ASPEN publishes two journals, the <i>Journal of Parenteral and Enteral Nutrition (JPEN)</i> and <i>Nutrition in Clinical Practice (NCP)</i>.</p> <p>http://nutritioncare.org</p>	<p>Mirtallo J, Canada T, Johnson D, Kumpf V, Petersen C, Sacks G, Seres D, Guenter P; Task Force for the Revision of Safe Practices for Parenteral Nutrition. Safe practices for parenteral nutrition. <i>JPEN J Parenter Enteral Nutr.</i> 2004 Nov–Dec;28(6):S39–70. Erratum in: <i>JPEN J Parenter Enteral Nutr.</i> 2006 Mar–Apr;30(2):177.</p> <p>Publication topic: Parenteral nutrition</p> <p>Year published: 2004</p>	<p>These guidelines update the 2002 guidelines and include topic areas such as sterile compounding of parenteral nutrition formulations as well as venous access selection, care, and assessment</p> <p>The guidelines (and others) are available at http://www.nutritioncare.org/Library.aspx.</p>	<p>All health care settings in which patients are receiving parenteral nutrition</p>
Organization or Professional Society: Australasian Society for Parenteral and Enteral Nutrition (AuSPEN)			
<p>Founded in 1974, AuSPEN has members from Australia, New Zealand, and the Asia-Pacific region.</p> <p>AuSPEN is a multidisciplinary society focusing on clinical nutrition. Members include physicians, surgeons, intensivists, dietitians, pharmacists, nurses, and scientists. AuSPEN promotes an evidence-based approach to nutrition in clinical practice and provides clinical nutrition expertise in an advisory capacity to other nutrition organizations, health professionals, and government bodies.</p> <p>http://www.auspen.org.au</p>	<p>Gillanders L, Angstmann K, Ball P, Chapman-Kiddell C, Hardy G, Hope J, Smith R, Strauss B, Russell D; Australasian Society of Parenteral and Enteral Nutrition. AuSPEN clinical practice guideline for home parenteral nutrition patients in Australia and New Zealand. <i>Nutrition.</i> 2008 Oct;24(10):998–1012. Epub 2008 Aug 16. Erratum in: <i>Nutrition.</i> 2009 Jun;25(6):685.</p> <p>Publication topic: Parenteral nutrition</p> <p>Year published: 2008</p>	<p>The guidelines for home parenteral nutrition were commissioned by AuSPEN and developed by a multidisciplinary group. The guidelines make recommendations in four domains: patient selection, patient education, formulation and monitoring regimens, and preventing and managing complications.</p> <p>Available at http://www.auspen.org.au/assets/Uploads/Documents/guidelines-2/WEBSITE-AUSPEN-BEST-PRACTICE-GUIDELINES-FOR-HOME-PARENTERAL-NUTRITION.pdf.</p>	<p>Home care setting</p>

Continued on next page

Table 2-2. (Continued)

About the Organization/Society and Website Address	Guideline Citation, Publication Topic, Year	Summary	Applicable Settings
Organization or Professional Society: Centre for Healthcare Related Infection Surveillance and Prevention (CHRISP)			
<p>The prevention, monitoring, and reporting of HAIs is part of a program to reduce preventable harm in Queensland Health hospitals in Australia. CHRISP provides clinical governance, leadership, and expert advice through its advisory groups, networks, and provision of statewide systems and processes that underpin quality improvement and patient/staff safety. Work undertaken by CHRISP, in collaboration with Health Service Districts and counterparts in other divisions within Queensland Health, focuses on evidence-based, clinician-driven change and the empowerment of those involved in clinical care.</p> <p>http://www.health.qld.gov.au/chrisp</p>	<p>Centre for Healthcare Related Infection Surveillance and Prevention (CHRISP). I-Care Program. Australia: CHRISP (2007).</p> <p>http://www.health.qld.gov.au/chrisp/icare/about.asp</p> <p>Publication topic: The CHRISP I-Care Program has consolidated CLABSI prevention interventions into one document called Recommended Practices, for the main types of intravascular devices (IVD), including:</p> <ul style="list-style-type: none"> ■ Percutaneous CVC ■ Tunneled CVC ■ PICC ■ PIVC ■ Hemodialysis catheters ■ Port <p>Year published: 2007</p>	<p>A large number of interventions have been developed to prevent health care–associated intravascular device–related bloodstream infections. The I-Care acronym stands for:</p> <ul style="list-style-type: none"> ■ I—IV device management ■ C—Clean your hands ■ A—Access: Use alcoholic chlorhexidine to prepare the insertion site, and use sterile alcohol swabs to clean the injection port before accessing ■ R—Review the need for the IV device on a daily basis and remove when no longer required ■ E—Educate everyone about I-Care: staff, patients, and caregivers <p>The Recommended Practices have been specifically tailored for the Queensland Health environment and are broad statements used to guide policy and procedure development in specific work environments.</p>	All settings
Organization or Professional Society: International Federation of Infection Control (IFIC)			
<p>Founded in 1987, IFIC is an umbrella organization of associations and societies of health care professionals in infection control and related fields worldwide. IFIC strives to minimize the risk of infection within the health care setting worldwide through development of an infection control communication network to facilitate consensus building, education, and sharing of expertise. Organizations that join IFIC are designated as member societies. Currently IFIC has 66 member societies from 51 countries.</p> <p>http://www.theific.org</p>	<p>Heeg P. Prevention of intravascular device–associated infections. In Friedman C, Newsom W, editors. <i>IFIC Basic Concepts in Infection Control</i>, 2nd ed. International Federation of Infection Control, 2011, 247–255.</p> <p>Publication topic: Basic infection prevention and control concepts and recommended practices</p> <p>Year published: 2011</p>	<p>Authored by experts in infection prevention and control, microbiology, and epidemiology, IFIC's infection prevention and control book provides a scientific foundation of basic infection prevention and control principles and strategies. Chapter 17, "Prevention of Intravascular Device-Associated Infections," includes practices and strategies to minimize the risks associated with CVCs.</p> <p>This book is not connected to any country's laws, regulations, or traditions and therefore has international applicability.</p> <p>Available at http://www.theific.org/basic_concepts/index.htm.</p>	

Continued on next page

Table 2-2. (Continued)

About the Organization/Society and Website Address	Guideline Citation, Publication Topic, Year	Summary	Applicable Settings
Organization or Professional Society: European Society for Clinical Nutrition and Metabolism (ESPEN)			
<p>ESPEN is dedicated to the field of clinical nutrition and metabolism. The society promotes basic and clinical research, basic and advanced education, and organization of consensus statements about clinical care and care quality control. ESPEN encourages the dissemination of knowledge and its application in the field of parenteral and enteral nutrition. ESPEN sponsors the journal <i>Clinical Nutrition</i>.</p> <p>http://www.espen.org</p>	<p>Pittiruti M, Hamilton H, Biffi R, MacFie J, Pertkiewicz M; ESPEN. ESPEN Guidelines on Parenteral Nutrition: Central venous catheters (access, care, diagnosis and therapy of complications). <i>Clin Nutr</i>. 2009 Aug;28(4):365–377.</p> <p>Publication topic: Parenteral nutrition</p> <p>Year published: 2009</p>	<p>The guidelines provide general recommendations about the indications for and use of the various types of venous access devices available for parenteral nutrition. Topic areas covered include choosing the best route for intravenous nutrition and type of catheter device, ultrasound-guided venipuncture, strategies to reduce the risk of catheter-related infection, and diagnosis and treatment of catheter-related infections.</p> <p>Available at http://www.sciencedirect.com/science/article/pii/S0261561409000788.</p>	<p>All settings in which health care personnel care for patients who require parenteral nutrition, including acute care and home care</p>
Organization or Professional Society: Infectious Diseases Society of America (IDSA)			
<p>IDSA represents scientists, physicians, and other health care professionals who specialize in infectious diseases. IDSA's purpose is to improve the health of individuals, communities, and society by promoting excellence in patient care, research, education, public health, and prevention relating to infectious diseases.</p> <p>http://www.idsociety.org</p>	<p>Mermel LA, Allon M, Bouza E, Craven DE, Flynn P, O'Grady NP, Raad II, Rijnders BJA, Sheretz RJ, Warren DK. Clinical practice guidelines for the diagnosis and management of intravascular catheter-related infection: 2009 Update by the Infectious Diseases Society of America. <i>Clin Infect Dis</i>. 2009 Jul;49:1–45.</p> <p>Publication topic: Diagnosis and management of catheter-related infections</p> <p>Year published: 2009</p>	<p>These guidelines update those published in 2001. Topic areas covered include when and how to perform blood cultures and management of catheter-related infections.</p> <p>Available at http://cid.oxfordjournals.org/content/49/1/1.full.pdf+html.</p>	<p>Settings in which health care personnel care for patients who have intravascular catheter–related infections or who are at risk for them</p>
Organization or Professional Society: Infectious Diseases Society of America (IDSA) and Society for Healthcare Epidemiology of America (SHEA)			
<p>(See above information for IDSA.)</p> <p>SHEA is a professional society with more than 1,900 physicians and other health care professionals around the world. Since its founding in 1980, SHEA has remained dedicated to advancing the science and practice of health care epidemiology and preventing</p>	<p>Marschall J, Mermel LA, Classen D, Arias KM, Podgorny K, Anderson DJ, Burstin H, Calfee DP, Coffin SE, Dubberke ER, Fraser V, Gerding DN, Griffin FA, Gross P, Kaye KS, Klompas M, Lo E, Nicolle L, Pegues DA, Perl TM, Saint S, Salgado CD, Weinstein RA, Wise R,</p>	<p>In addition to discussing CLABSIs, this compendium of practice recommendations synthesizes the best evidence for the prevention of surgical site infections, catheter-associated urinary tract infections, ventilator-associated pneumonia, <i>Clostridium difficile</i>, and MRSA. The compendium was sponsored and authored by SHEA and IDSA. Partners in this work were the</p>	<p>Acute care hospitals</p>

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Table 2-2. (Continued)

About the Organization/Society and Website Address	Guideline Citation, Publication Topic, Year	Summary	Applicable Settings
Organization or Professional Society: Infectious Diseases Society of America (IDSA) and Society for Healthcare Epidemiology of America (SHEA) (continued)			
<p>and controlling worldwide the morbidity, mortality, and costs associated with HAIs.</p> <p>http://www.shea-online.org</p>	<p>Yokoe DS. Strategies to prevent central line–associated bloodstream infections in acute care hospitals. <i>Infect Cont Hosp Epidemiol</i>. 2008 Oct;29 Suppl 1:S22–30.</p> <p>Publication topic: Prevention of CLABSIs</p> <p>Year published: 2008</p>	<p>Association for Professionals in Infection Control and Epidemiology (APIC), The Joint Commission, and the American Hospital Association (AHA). The compendium also does the following:</p> <ul style="list-style-type: none"> ■ Highlights basic HAI prevention strategies plus advanced approaches for outbreak management and other special circumstances ■ Recommends performance and accountability measures to apply to individuals and groups working to implement infection prevention practices <p>The entire compendium, available in English, Spanish, and Portuguese, can be downloaded at http://www.shea-online.org/GuidelinesResources/CompendiumofStrategiestoPreventHAIs.aspx. It is also published in the October 2008 supplemental issue of the SHEA journal <i>Infection Control and Hospital Epidemiology</i>.</p>	
Organization or Professional Society: Infusion Nurses Society (INS)			
<p>INS, located in Norwood, Massachusetts, is a national non-profit organization founded in 1973. Membership is open to all health care professionals from all practice settings who are involved in or interested in the practice of infusion therapy. INS is dedicated to advancing the delivery of quality therapy to patients, enhancing the specialty through stringent standards of practice and professional ethics, and promoting research and education in the infusion nursing practice.</p> <p>http://www.ins1.org</p>	<p>Infusion Nursing Standards of Practice. <i>J Infus Nurs</i>. 2011 Jan–Feb;34 Suppl 1:S1–110.</p> <p>Publication topic: Prevention of catheter-related infections</p> <p>Year published: 2011</p>	<p>The INS publication <i>Infusion Nursing Standards of Practice</i> provides a framework that guides clinical practice. The standards are used to define and develop organizational infusion-based policies and procedures for all practice settings. The comprehensive contents include standards of nursing practice and patient care practices, vascular access device selection and placement, use of access devices, site care and maintenance, and infusion-related complications.</p> <p>Available for purchase at http://www.ins1.org/i4a/ams/amsstore/category.cfm?category_id=7.</p>	<p>All patient settings and patient populations</p>

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Table 2-2. (Continued)

About the Organization/Society and Website Address	Guideline Citation, Publication Topic, Year	Summary	Applicable Settings
Organization or Professional Society: Intravenous Nurses New Zealand (IVNNZ)			
<p>IVNNZ is a voluntary organization for registered nurses/midwives and allied health professionals. IVNNZ was founded in 1993, with the goal of establishing IV therapy as a specialty in nursing practice. IVNNZ promotes excellence in IV therapy by providing education (conferences, workshops, seminars), maintaining IV standards of best practice, and offering preceptorship, research, and networking.</p> <p>IVNNZ is an international affiliate of the Infusion Nurses Society (INS) of America.</p> <p>http://www.ivnnz.co.nz</p>	<p>IVNNZ Standards of Infusion Nursing</p> <p>Publication topic: All aspects of CVAD management and complication prevention</p> <p>Year published: 2012</p>	<p>The standards were launched on March 30, 2012, at the IVNNZ conference.</p> <p>Contact standards@ivnnz.co.nz with any questions.</p> <p>The standards are available at http://www.ivnnz.co.nz/about-ivnnz-inc./Infusion-Standards-of-Practice.</p>	<p>All patient settings and patient populations</p>
Organization or Professional Society: British Committee for Standards in Hematology (BCSH)			
<p>BCSH is a subcommittee of the British Society for Hematology and provides up-to-date evidence-based guidelines for both clinical and laboratory hematologists on the diagnosis and treatment of hematological disease.</p> <p>http://www.bcsguidelines.com</p>	<p>Bishop L, Dougherty L, Bodenham A, Mansi J, Crowe P, Kibbler C, Shannon M, Treleaven J. Guidelines on the insertion and management of central venous access devices in adults. <i>Int J Lab Hematol</i>. 2007 Aug;29(4):261–278.</p> <p>Publication topic: Prevention of CVC–related infection</p> <p>Year published: 2006</p>	<p>These guidelines are a review of basic principles and relevant research for medical and nursing staff involved in the care of patients with CVADs. They complement existing guidelines for nursing staff (from the Royal College of Nursing, 2005, updated in 2010). The BCSH guidelines pertain to the insertion and management of nontunneled and skin-tunneled CVCs, implanted ports, and PICCs.</p> <p>The guidelines are available at http://www.bcsguidelines.com/documents/central_venous_access_management_guidelines_2006.pdf.</p>	<p>Adult patients in various clinical settings</p>

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Table 2-2. (Continued)

About the Organization/Society and Website Address	Guideline Citation, Publication Topic, Year	Summary	Applicable Settings
Organization or Professional Society: Royal College of Nursing (RCN)			
RCN was founded in 1916 as a professional organization for trained nurses and has evolved into a professional union. For almost a century the RCN has pioneered professional standards for nurses in their education, practice, and working conditions. Today the RCN has more than 400,000 members in England, Northern Ireland, Scotland, and Wales. http://www.rcn.org.uk	Royal College of Nursing, IV Therapy Forum. <i>Standards for Infusion Therapy</i> , 3rd ed. London: Royal College of Nursing, 2010. Publication topic: Infusion therapy Year published: 2010	The standards address all aspects of infusion therapy, including infusion equipment, site selection, and care. Specific topic areas include staff education, patient education, hand hygiene, and selection and placement of CVCs. The guidelines are available at http://www.scribd.com/doc/49770787/IV-THERAPY .	Inpatient, outpatient, and home care settings
Organization or Professional Society: National Institute for Health and Clinical Excellence (NICE)			
NICE is part of the English National Health System (NHS). It produces guidance for both the NHS and patients on the use of medicines, medical equipment, diagnostic tests, and clinical and surgical procedures. http://www.nice.org.uk	National Institute for Clinical Excellence (NICE). <i>Guidance on the Use of Ultrasound Locating Devices for Placing Central Venous Catheters</i> . Technology Appraisal Guidance 49. London: NICE, 2002. Publication topic: Ultrasonic placement of CVCs Year published: 2002	NICE was asked to look at the available evidence on ultrasound locating devices for placing CVCs and provide guidance that would help the NHS in England and Wales decide when they should be used. The technology for and proper use of ultrasound for this purpose is covered. The guideline is available at http://guidance.nice.org.uk/TA49/Guidance/pdf/English .	Any setting in which CVCs are placed

Table 2-3. Position Papers Related to CVCs, CLABSI, and Their Prevention

About the Organization/Society and Website Address	Title of Position Paper, Year	Summary
Organization or Professional Society: Association for Vascular Access (AVA)		
Founded in 1985, AVA is an international association of health care professionals that promotes the emerging vascular access specialty. Its multi-disciplinary membership advances research and professional and public education to shape practice and enhance patient outcomes. AVA also partners with the device manufacturing community to foster evidence-based innovations in vascular access. http://www.avainfo.org	The Use of Ultrasound Guidance by Registered Nurses for Central Venous Catheter Insertion Year published: 2010	The position paper supports ultrasound use by registered nurses (RNs) who insert CVCs, as a standard practice in the optimal insertion of the catheters. They note that the US Centers for Disease Control and Prevention (US CDC), the UK's National Institute for Health and Clinical Excellence (NICE), and the US Agency for Healthcare Research and Quality (AHRQ) recognize ultrasound guidance as the current state of the art for placement of CVCs. RNs place about 70% of the nearly 3 million PICCs that are inserted annually in the United States. Available at http://www.avainfo.org/website/article.asp?id=1441 .

Note: All position papers accessed Mar 17, 2012. CVC: central venous catheter, PICC: peripherally inserted central catheter.

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Table 2-3. (Continued)

About the Organization/Society and Website Address	Title of Position Paper, Year	Summary
Organization or Professional Society: Association for Professionals in Infection Prevention and Epidemiology (APIC)		
<p>Founded in 1972, APIC’s mission is to improve health and patient safety by reducing risks of infection and other adverse outcomes. The association’s more than 14,000 members have primary responsibility for infection prevention and control and hospital epidemiology in health care settings around the globe. APIC’s members include nurses, epidemiologists, physicians, quality and patient safety professionals, health care executives, microbiologists, clinical pathologists, laboratory technologists, and public health practitioners. The organization, based in Washington, DC, advances its mission through education, research, consultation, collaboration, public policy, practice guidance, and credentialing.</p> <p>http://www.apic.org</p>	<p>Safe Injection, Infusion, and Medication Vial Practices in Health Care</p> <p>Year published: 2010</p>	<p>This position paper promotes essential safe injection, infusion, and vial practices to prevent microbial contamination of products administered to patients. The paper notes outbreaks that have occurred when proper infection prevention measures were not taken or adhered to by health care personnel. Included is a discussion of the United States Pharmacopeia (USP) revised USP General Chapter 797 Pharmaceutical Compounding—Sterile Preparations, which APIC cites in its support of preparing parenteral medications as close to the time of administration as possible, with proper technique being key to preventing accidental contamination in the preparation process. Other topics included in the paper are aseptic technique in a less than ISO 5 environment, proper use of IV solutions and infusion supplies, and use of vials and syringes.</p> <p>Available at http://www.apic.org/Resource_/TinyMceFileManager/Position_Statements/AJIC_Safe_Injection0310.pdf.</p>
Organization or Professional Society: American Society for Parenteral and Enteral Nutrition (ASPEN)		
<p>ASPEN was founded in 1975 for the purpose of providing optimal nutrition to all people under all conditions at all times. ASPEN has been publishing clinical guidelines, statements, standards, and other documents for more than 20 years in order to assist practitioners in providing safe, efficacious nutrition care to patients.</p> <p>ASPEN publishes two journals, the <i>Journal of Parenteral and Enteral Nutrition (JPEN)</i> and <i>Nutrition in Clinical Practice (NCP)</i>.</p> <p>http://nutritioncare.org</p>	<p>ASPEN Statement on Parenteral Nutrition Standardization</p> <p>Year published: 2007</p>	<p>This position paper supports a standardized process in the procurement and use of parenteral nutrition (PN). A standardized process may include use of standardized PN formulations (including standardized, commercial PN products) as well as aspects of ordering, labeling, screening, compounding, and administration of PN. ASPEN’s statement notes that a safe PN system that minimizes procedural incidents and maximizes the ability to meet individual patient requirements is essential. ASPEN also encourages using clinicians with nutrition support therapy expertise, which will contribute to a safe PN system. The statement presents the published literature associated with standardized PN formulations, provides recommendations, and identifies areas in need of future research.</p> <p>This statement has been endorsed by the Council on Public Policy, American Society of Health-System Pharmacists.</p> <p>Available at http://www.nutritioncare.org/wcontent.aspx?id=5706.</p>

- Overall CLABSI rate in the 86 ICUs:
 - Baseline: 14.5 per 1,000 central line–days
 - 6 months into intervention period: 9.7 per 1,000 central line–days
 - 12 months into intervention period: 10.0 per 1,000 central line–days
 - 18 months into intervention period: 9.8 per 1,000 central line–days
- All-cause deaths in patients with CLABSIs decreased by 58% by month 24.
- Adherence to hand hygiene improved from 50% at baseline to 60% in the intervention period.
- Use of maximal sterile barriers at catheter insertion improved from 46% at baseline to 85% by month 24.
- Limiting the duration of central line use improved from 4.1 days to 3.5 days.

Overall, the researchers were able to demonstrate significant improvements in CLABSI rates and process indicators with a simple surveillance and performance feedback program. They realize, however, that 7 CLABSIs per 1,000 central line–days is still too high. They believe that a further reduction in CLABSI rates is achievable by continuing to strengthen the existing program.¹⁵

US Department of Health and Human Services (HHS)

HHS is the US government’s principal agency for protecting the health of all Americans and providing essential human services, especially for those who are least able to help themselves. In 2009 HHS published the *HHS Action Plan to Prevent Healthcare-Associated Infections*.⁴² Phase 1 of the plan

provides the road map for HAI prevention in acute care hospitals. (Phase 2, published in late 2009, expands efforts to include ambulatory surgical centers and end-stage renal disease facilities; it also includes a plan to increase influenza vaccination among health care personnel.) The plan contains nine metrics with corresponding five-year goals to focus efforts in reducing health care–associated infections, including two CLABSI–related goals⁴³ (details are available at http://www.hhs.gov/ash/initiatives/hai/appendices.html#appendix_g; the source of the data is the NHSN’s Device-Associated Module, which receives hospital-specific data on CLABSIs⁴⁴):

- A five-year goal to reduce CLABSIs by at least 50% in ICU and ward-located patients. A progress assessment in September 2010 estimated that, in 2009, at the current rate of reduction, the 2013 goal will be surpassed, for a 63% reduction in infections.⁴⁵ An update in the fall of 2011 demonstrated further reductions in CLABSIs over the 2009 assessment.⁴⁶
- A five-year goal of 100% adherence to central line insertion practices. In the baseline year (2009) there was 92% adherence to the recommended practices. Progress on this measure in September 2011 showed continued improvement in adherence to insertion practices.

Table 2-4 below summarizes the progress made on these two CLABSI-related goals.

In April 2011 HHS announced a new national patient safety initiative to improve care and lower costs for Americans. The Partnership for Patients initiative brings together leaders of major hospitals, employers, consumers,

Table 2-4.
Summary of Progress Toward HHS CLABSI–Related Goals

Metric	National Five-Year Prevention Target	2009 Assessment	2010 Assessment	2011 Assessment	On Track to Meet 2013 Targets?
CLABSI	50% reduction (SIR 0.50)	18% reduction (SIR 0.82)	33% reduction (SIR 0.67)	N/A	Yes
Central line insertion practices (CLIP)	100% adherence	92.2%	94.5% (up 2.5% from 2009)	95.7% (up 3.8% from 2009)	Yes

Note: SIR = Standardized Infection Ratio.

Source: Adapted from US Department of Health and Human Services. National Targets and Metrics: Monitoring Progress Toward Action Plan Goals: A Mid-Term Assessment. 2011. Accessed Mar 18, 2012. <http://www.hhs.gov/ash/initiatives/hai/nationaltargets/index.html>.

physicians, nurses, and patient advocates, along with state and federal governments, in a shared effort to make hospital care safer, more reliable, and less costly.⁴⁷ Participation in the initiative is voluntary. Following are the two overarching goals of this new partnership:

- *Keep patients from getting injured or sicker.* The goal is that, by the end of 2013, preventable hospital-acquired conditions would decrease by 40% compared to 2010. Achieving this goal would mean approximately 1.8 million fewer injuries to patients, with more than 60,000 lives saved over three years.
- *Help patients heal without complication.* By the end of 2013, the expectation is that preventable complications during a transition from one care setting to another would be decreased so that all hospital readmissions would be reduced by 20% compared to 2010. Achieving this goal would mean that more than 1.6 million patients would recover from illness without suffering a preventable complication requiring rehospitalization within 30 days of discharge.

The Partnership for Patients has nine areas of focus, including CLABSI prevention. The CLABSI-specific goal reflects the goal of the HHS action plan: reduce CLABSIs in hospitals by 50% by 2013. Hospitals are encouraged to join the initiative and are asked to pledge to work to attain the goals of the initiative and commit to building on work already under way to achieve safe, high-quality care by utilizing tools and processes that improve safety for patients.

Institute for Healthcare Improvement (IHI) 5 Million Lives Campaign

IHI is an independent not-for-profit-organization based in Cambridge, Massachusetts, that focuses on building partnerships with both patients and health care professionals to ensure the broadest possible adoption of best practices and effective innovations.⁴⁸ IHI has partnerships with hundreds of faculty around the world who share their knowledge under the philosophy of “all teach, all learn.” (For more information about IHI, go to <http://www.ihl.org>.) IHI’s 5 Million Lives campaign (formerly the 100,000 Lives Campaign) was a voluntary initiative to protect patients from 5 million incidents of medical harm.⁴⁹ Between December 2006 and December 2008, IHI challenged US hospitals to adopt any or all of 12 interventions that save lives and reduce patient injuries, including CLABSIs. Each of the interventions had multiple resources available to support hospitals that

undertook interventions, such as how-to guides, PowerPoint presentations with facilitator notes, access to “mentor hospitals” that provided support and tips to hospitals seeking help with implementation efforts, and various improvement tools submitted by participating hospitals. Detailed process and outcome measure information was also provided. Although a national “harms avoided” number was not announced at the conclusion of the campaign, IHI is studying the progress of campaign hospitals in reducing mortality and harm in other ways and is also working with other national organizations to tap into existing databases to measure changes in specific types of harm (for example, medication error, infection, surgical complication). IHI also has begun to collect information on hospitals “getting to zero”—reducing adverse event rates to zero for extended periods of time—in several appropriate intervention areas. For example, Rhode Island hospitals that were active in the campaign reported a 74% decrease in CLABSIs from 2006 to 2008, and several hospitals reported going a year or more without a CLABSI in at least one of their ICUs.⁵⁰ Materials for the CLABSI intervention can be found at <http://www.ihl.org/explore/CentralLineInfection/Pages/default.aspx>, including the CLABSI bundle and checklist developed by Peter Pronovost.⁵¹

Canadian Patient Safety Institute (CPSI) Safer Healthcare Now!

CPSI is a not-for-profit organization that exists to raise awareness and facilitate implementation of best practices to improve patient safety. Safer Healthcare Now! is a national campaign (<http://www.saferhealthcarenow.ca/EN/Pages/default.aspx>) that supports Canadian health care organizations in their patient safety improvement efforts, including those directed at preventing CLABSIs.⁵² The focus of the campaign is reducing avoidable harm by implementing evidence-based interventions. The campaign is supported by IHI and is patterned after IHI’s 5 Million Lives Campaign. CPSI has issued an open invitation to all Canadian hospitals to participate in one or more of the nine Safer Healthcare Now! interventions, such as rapid response teams, ventilator-associated pneumonia (VAP), or CLABSI. Each intervention includes resources and tools that are customizable, reliable, tested, and based on five years of improving care and designed to provide everything needed to implement, measure, and evaluate the patient safety initiatives. Reporting of rates is voluntary, and hospitals that report data are included in aggregated reports that are publicly available.

The CLABSI intervention has tools for both insertion and maintenance of CVCs, and it encourages organizations to measure their CLABSI rates over time.⁵³ The how-to guide includes such topic areas as the importance of using a multi-disciplinary team approach, using data to define and monitor CLABSIs, setting time-specific and measurable goals, educating staff, and using techniques for overcoming barriers. CLABSI intervention information is available at <http://www.saferhealthcarenow.ca/EN/Interventions/CLI/Pages/default.aspx>.

The Michigan Keystone Intensive Care Unit Project

This project was the first statewide effort to improve ICU quality and patient safety.⁵⁴ A research team from Johns Hopkins University School of Medicine developed a comprehensive quality improvement model that included a change in safety culture, rigorous measurement, and use of evidence-based interventions to reduce the rate of CLABSIs.⁵⁵ From September 2003 to September 2005 the Johns Hopkins team partnered with the Michigan Health and Hospital Association in a large-scale initiative involving 103 ICUs in Michigan, funded by the Agency for Healthcare Research and Quality (AHRQ).¹³ The initiative included employing the Comprehensive Unit-Based Safety Program (CUSP) techniques, along with a strategy to translate evidence into practice and measurement and feedback of infection rates:

- At each hospital, teams were formed that included, at a minimum, a senior executive, the ICU director and nurse manager, an ICU nurse and physician, and a department administrator; each team committed to implement the evidence-based interventions, collect and submit required data, participate in monthly conference calls, and attend biannual conferences.⁵⁶
- Before the interventions, each participating ICU measured the culture of safety using the Safety Attitudes Questionnaire; this survey was repeated annually to reassess the culture.⁵⁶ This was an important step, as understanding the culture within ICUs was believed to be necessary before teams could redesign care.⁵⁴
- CUSP is a process that targets senior leaders, ICU directors, and health care personnel to improve patient safety through enhanced communication and teamwork. CUSP provides just enough structure to allow health care organizations to develop a broad improvement strategy that is flexible, permitting staff to adapt the strategy to meet their own needs. The teams also implement tools, such as conducting morning briefings and setting daily goals. The goal of CUSP is to move toward focusing on a few

hazards and redesigning the system in which work is performed to mitigate the hazards rather than just reporting and superficially reviewing multiple hazards.⁵⁶

- Five interventions that were supported by strong evidence were chosen, with the intent to convert them into behaviors.⁵⁶ This intervention “bundle” consisted of the following:
 1. Hand hygiene
 2. Use of full barrier precautions
 3. Chlorhexidine skin preparation
 4. Avoiding insertion of lines into the femoral vein
 5. Prompt removal of CVCs
- Monthly throughout the study, data on the number of CLABSIs and central line–days were collected by the hospital infection preventionists, using the US CDC’s National Nosocomial Infections Surveillance (NNIS) system methods and definitions (now the National Healthcare Safety Network). To help ensure standardization in data collection, staff received education on the definitions used for the outcome measures and the data collection process; standardized data collection forms were used; and quarterly infection rates were calculated, expressed as the number of infections per 1,000 central line–days.⁵⁶
- To ensure that patients received the interventions, and to facilitate the execution of the interventions, a checklist was created. Nurses assisting with CVC placement were empowered to ensure physician adherence to all five interventions in the bundle. In addition, a CVC cart was created to bring all needed supplies to one location. The teams also evaluated each CLABSI that did occur, to determine whether it could have been prevented.⁵⁶

This initiative resulted in a dramatic decrease in CLABSI rates across the 103 participating ICUs. The mean and median CLABSI rates decreased as follows:

- At baseline: mean rate 7.7 (median 2.7)
- At 16–18 months: mean rate 1.3 (median zero)

Taking the study a step further, the researchers also conducted a study to determine the extent to which the ICUs sustained the CLABSI reductions. They found that the reduced rates of infection in the initial 18-month implementation period were sustained for an additional 18 months; at 34–36 months the mean CLABSI rate was 1.1, and the median remained zero.⁵⁷

The successful Michigan project was replicated in Rhode Island between 2006 and 2008, in collaboration with

consultants from Johns Hopkins University. Each of the 23 ICUs in 11 hospitals participated in the Rhode Island ICU Collaborative, with a 74% drop in the mean CLABSI rate over the course of the study period (3.73 CLABSIs per 1,000 catheter-days at baseline to 0.97 CLABSIs per 1,000 catheter-days in 2008).⁵⁰

The On the CUSP: Stop BSI Project

This project is an outgrowth of the aforementioned Michigan Keystone project and was also funded by AHRQ.⁵⁸ As part of HHS's Action Plan to Prevent Healthcare-Associated Infections, AHRQ expanded the program as a national effort to prevent CLABSIs. This national effort includes partnership with the Health Research and Educational Trust (a nonprofit research and educational affiliate of the American Hospital Association); Johns Hopkins Quality and Safety Research Group; and the Michigan Health and Hospital Association's Keystone Center for Patient Safety and Quality. The project is the first federally funded national effort in the United States with the quantifiable and measurable goal of reducing CLABSI rates to less than 1 per 1,000 central line–days across all participating US hospitals.⁵⁹

Each participating state has a lead organization (usually a state hospital association) that works with hospitals across the state to implement the cultural and clinical changes to reduce CLABSIs. The project, initially implemented in 10 US states in 2009, had grown by mid-2011 to include 44 states, as well as the District of Columbia and Puerto Rico, with more than 1,000 hospitals and 1,775 hospital teams participating.⁵⁹

Focusing on the 22 states that began participating in the On the CUSP: Stop BSI project in 2009, AHRQ published a progress report to highlight the results of the first 2 years of the project:

- After 10–12 months of participation, CLABSI rates decreased in the participating ICUs by 33%, from the baseline rate of 1.87 infections per 1,000 central line–days to 1.25 infections per 1,000 central line–days.
- Even at baseline, many ICUs had CLABSI rates below the national mean and were still able to reduce their rates.
- The percentage of units with no quarterly CLABSIs increased from 27.3 at baseline to 69.5.
- The project demonstrates that further improvement is achievable, even among hospitals that already have low CLABSI rates.⁵⁹

The US CDC recently reported a decrease in ICU CLABSI rates, from 3.64 per 1,000 central line–days in 2001 to 1.65 in 2009.⁶⁰ The initial progress in the On the CUSP: Stop BSI project is well aligned with the 2011 CDC findings. The national team continues to closely monitor the progress of the project, to see which units are realizing declining CLABSI rates and which are not and attempting to better understand what changes need to be made to maximize the impact for each participating hospital.⁵⁹

The On the CUSP: Stop BSI project is now being implemented throughout Europe and England and is being pilot tested in several Peruvian hospitals.⁵⁸

The World Health Organization (WHO) Bacteremia Zero project

The Bacteremia Zero project was a collaboration between WHO Patient Safety and the Spanish Ministry of Health, Social Policy and Equity (SMoH), in collaboration with the Spanish Society of Intensive and Critical Care Medicine and Coronary Units and the Johns Hopkins Quality and Safety Research Group.⁶¹ Its purpose was to assess the applicability and effectiveness of the Michigan Keystone ICU project interventions in reducing CLABSI rates throughout Spanish ICUs. This multifactorial nationwide intervention project was implemented between April 2008 and June 2010, with data collected at regular intervals to evaluate the progress of the project. A total of 192 ICUs (68% of all Spanish ICUs) participated in the project. The intervention was effective in reducing the incidence of CLABSI by approximately 50% in hospitals of all types with different structural, social, economic, and cultural characteristics.⁶¹

Other Initiatives

Table 2-5 on pages 27–30 presents a selection of other initiatives that have highlighted the preventability of CLABSIs through adherence to evidence-based preventive practices.

Barriers to Implementation of Best Practices to Prevent CLABSIs

Government bodies, professional societies, health care organizations, and individuals throughout the world are focusing attention on the preventability of CLABSIs by implementing evidence-based practices outlined in the scientific literature. This chapter has described several multimodal interventions that used evidence-based practices to reduce CLABSI rates in international, national, multicenter, and single-organization initiatives. The success stories showing how CLABSI rates can be reduced, even to zero, continue to grow in number.

Table 2-5.
Examples of Other CLABSI Initiatives

Scope/Developed by/ Time Frame	Citation or Web Address for the Initiative	Description of Initiative
Initiative: VA Inpatient Evaluation Center (IPEC)–Led CLABSI Initiative		
<p>Scope of the initiative: National (US)</p> <p>All 174 VA ICUs participated</p> <p>Developed by: Department of Veterans Affairs (VA, formerly the Veterans Administration, which includes the Veterans Health Administration [VHA])</p> <p>Time frame: 2006–2009</p>	<p>Render ML, Hasselbeck R, Freyberg RW, Hofer TP, Sales AE, Almenoff PL; VA ICU Clinical Advisory Group. Reduction of central line infections in Veterans Administration intensive care units: An observational cohort using a central infrastructure to support learning and improvement. <i>BMJ Qual Saf.</i> 2011 Aug;20(8):725–32. Epub 2011 Apr 2.</p>	<p>The VHA of the VA is the largest US health care system, with 174 ICUs in 123 hospitals across the country. This was an observational quality improvement project in which adherence to the IHI's CLABSI bundle elements was monitored, as part of the VA's participation in the Saving 100,000 Lives Campaign in 2006. CLABSI rates were also tracked monthly across all ICUs in the VA. This national project began with a two-hour Web-based conference call for the participating ICU teams, led by senior VA leadership, during which the importance of the initiative was stressed and experts reviewed the evidence for prevention of CLABSIs. The key components of the project were:</p> <ul style="list-style-type: none"> ■ Employing a physician champion ■ Use of a central line insertion cart ■ Use of an insertion checklist ■ Use of a daily ICU goal sheet, to remind physicians to evaluate the need for continuation of the central line ■ Feedback to frontline staff on CLABSI rates and bundle adherence <p>Adherence to the bundle practice improved from 85% in 2006 to 98% in 2009; CLABSI rates improved from 3.85 per 1,000 central line–days in 2006 to 1.8 per 1,000 central line–days in 2009.</p>
Initiative: National Association of Children's and Related Institutions (NACHRI) PICU CA-BSI Collaborative		
<p>Scope of the initiative: Multi-institutional across the United States</p> <p>29 PICUs across the United States</p> <p>Developed by: NACHRI</p> <p>Time frame: October 2006–September 2007</p>	<p>Miller MR, Griswold M, Harris JM 2nd, Yenokyan G, Huskins WC, Moss M, Rice TB, Ridling D, Campbell D, Margolis P, Muething S, Brill R. Decreasing PICU catheter-associated bloodstream infections: NACHRI's quality transformation efforts. <i>Pediatrics.</i> 2010 Feb;125(2):206–213.</p>	<p>Twenty-seven NACHRI member hospitals worked collaboratively to reduce catheter-associated bloodstream infection (CA-BSI) rates among their 29 pediatric intensive care units (PICUs). Baseline data were obtained retrospectively for the period 2004–2006. PICU teams included a senior PICU leader/physician champion, quality improvement leaders, infectious disease physicians, PICU nursing leaders, and/or infection preventionists. From October 2006 through September 2007, the teams implemented insertion and maintenance bundles. Mean CA-BSI rates were reduced by 43% across the 29 PICUs (5.4 vs. 3.1 CA-BSIs per 1,000 central line–days) over the course of the study. By the end of the first year, sustained insertion bundle adherence was 84% and maintenance bundle compliance was 82%.</p> <p>This is believed to be the first study regarding the impact of insertion-related practices versus maintenance-related practices on bloodstream infection rates in either adult or pediatric populations.</p>

Continued on next page

Table 2-5. (Continued)

Scope/Developed by/ Time Frame	Citation or Web Address for the Initiative	Description of Initiative
Initiative: New York State NICU CLABSI Study		
<p>Scope of the initiative: Regional multi-institutional</p> <p>All 18 regional referral NICUs in New York State</p> <p>Developed by: New York State Regional Perinatal Care Centers</p> <p>Time frame: 2007 (baseline)</p> <p>January–December 2009 (postintervention)</p>	<p>Schulman J, Stricof R, Stevens TP, Horgan M, Gase K, Holzman IR, Koppel RI, Nafday S, Gibbs K, Angert R, Simmonds A, Furdon SA, Saiman L; New York State Regional Perinatal Care Centers. Statewide NICU central-line-associated bloodstream infection rates decline after bundles and checklists. <i>Pediatrics</i>. 2011 Mar;127(3):436–444.</p>	<p>By late 2008 each of the 18 regional NICUs had adopted the use of checklists to monitor adherence to the newly implemented central line insertion and maintenance bundles, in an effort to standardize central line care. The teams used repetitive, structured social interactions such as conference calls, e-mails, and workshops to share stories about checklist and bundle successes and barriers, and to receive updated information on performance data. Each NICU reported CLABSI and central line utilization data and insertion and maintenance checklist use. CLABSI rates decreased 40% across all NICUs, from 3.5 to 2.1 CLABSIs per 1,000 central line–days, although no NICU achieved an overall CLABSI rate of zero. Maintenance bundle use varied between 10% and 100% across the NICUs; study design did not enable the researchers to evaluate adherence to the insertion bundle.</p>
Initiative: Pennsylvania ICU CLABSI Intervention		
<p>Scope of the initiative: Regional multi-institutional</p> <p>69 ICUs in 32 southwestern Pennsylvania hospitals</p> <p>Developed by: Pittsburgh Regional Healthcare Initiative (PRHI)</p> <p>Time frame: April 2001–March 2005</p>	<p>US Centers for Disease Control and Prevention. Reduction in central line–associated bloodstream infections among patients in intensive care units—Pennsylvania, April 2001–March 2005. <i>MMWR Morb Mortal Weekly Rep</i>. 2005 Oct;54(40):1013–1016.</p>	<p>In 2001 PRHI invited the US CDC to provide technical assistance for an intervention to prevent CLABSIs in ICU patients in southwestern Pennsylvania. This voluntary intervention was designed collaboratively, led by infection preventionists and medical staff from the participating hospitals. The components of the intervention were the following:</p> <ul style="list-style-type: none"> ■ Use of an evidence-based insertion bundle ■ An educational module on CLABSIs and their prevention ■ Use of a checklist to record adherence to insertion practices ■ Use of a standardized list of contents for catheter insertion supplies ■ Measurement and feedback of CLABSI rates <p>CLABSI rates decreased by 68% over the four-year study period, from 4.31 to 1.36 infections per 1,000 central line–days.</p>
Initiative: University of Geneva Hospital, Intervention—Geneva, Switzerland		
<p>Scope of the initiative: Single organization</p> <p>18-bed medical ICU in a tertiary care center</p> <p>Developed by: University of Geneva Hospital</p> <p>Time frame: October 1995–February 1997 (baseline period)</p> <p>March 1997–November 1997 (intervention period)</p>	<p>Eggimann P, Harbarth S, Constantin MN, Touveneau S, Chevrolet JC, Pittet D. Impact of a prevention strategy targeted at vascular-access care on incidence of infections acquired in intensive care. <i>Lancet</i>. 2000 May 27;355(9218):1864–1868.</p>	<p>The University of Geneva Hospital is a 1,500-bed primary and tertiary care center. In 1997 the hospital implemented a multimodal, multidisciplinary prevention strategy to decrease the incidence of infections, including those associated with vascular-access catheters (including CLABSIs) in its medical ICU. The intervention included the following:</p> <ul style="list-style-type: none"> ■ An educational campaign for ICU staff on infection prevention for the insertion and maintenance of central lines ■ An emphasis on hand hygiene before and after insertion ■ Maximum barrier precautions (sterile gloves and gown, cap, mask, and large drape) ■ Prompt removal of devices when no longer needed <p>CLABSI rates before the intervention of 6.6 per 1,000 catheter-days were reduced to 2.3 per 1,000 catheter-days after the intervention.</p>

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Table 2-5. (Continued)

Scope/Developed by/ Time Frame	Citation or Web Address for the Initiative	Description of Initiative
Initiative: University Hospital of Zurich Impact Study—Zurich, Switzerland		
<p>Scope of the initiative: Single organization</p> <p>5 adult ICUs</p> <p>Developed by: Researchers from the University of Geneva Hospitals, Geneva, Switzerland; General Hospital, Langenthal, Switzerland; and University Hospital, Zurich, Switzerland</p> <p>Time frame: September–December 2003 (baseline period)</p> <p>March–July 2004 (intervention period)</p>	<p>Zingg W, Imhof A, Maggiorini M, Stocker R, Keller E, Ruef C. Impact of a prevention strategy targeting hand hygiene and catheter care on the incidence of catheter-related bloodstream infections. <i>Crit Care Med.</i> 2009 Jul;37(7):2167–2173.</p>	<p>The University of Zurich Hospital is a 960-bed tertiary care referral center. The researchers studied the impact of a multimodal intervention that included educational programs stressing hand hygiene, proper catheter care, and aseptic intravenous drug preparation on CVC–related bloodstream infections. At baseline they identified differences in health care personnel performance of catheter maintenance care; education focused, therefore, on current evidence-based practices. Additionally, while the overall adherence to proper hand hygiene did not improve significantly between the two periods (59.1% at baseline versus 65% in the intervention period), the rate of hand hygiene that was <i>correctly performed</i> did improve significantly (22.5% versus 42.6%). The overall infection rate at baseline of 3.9 per 1,000 catheter-days improved significantly to 1.0 per 1,000 catheter-days in the intervention period. This study is important in that it demonstrates the impact of proper postinsertion catheter care on the rates of CVC–related bloodstream infections.</p>
Initiative: Hospital Israelita Program to Prevent CLABSIs—São Paulo, Brazil		
<p>Scope of the initiative: Single organization</p> <p>38-bed medical/surgical ICU and two 20-bed step-down units (SDUs)</p> <p>Developed by: Hospital Israelita, São Paulo, Brazil</p> <p>Time frame: March 2005–March 2007 (baseline period)</p>	<p>April 2007–April 2009 (intervention period)</p> <p>Marra AR, Cal RG, Durão MS, Correa L, Guastelli LR, Moura DF Jr, Edmond MB, Pavao Dos Santos OS. Impact of a program to prevent central line–associated bloodstream infection in the zero tolerance era. <i>Am J Infect Control.</i> 2010 Aug;38(6):434–439.</p>	<p>While full barrier precautions at insertion, 2% chlorhexidine skin preparation prior to catheter insertion, and periodic feedback on adherence to recommended practices were in place in the baseline period (phase 1), the hospital's chief executive officer announced a zero tolerance for CLABSI initiative in April 2007 (phase 2). IHI's central line bundle was implemented in the ICU and the two SDUs, which included creation of a central line cart, emphasis on hand hygiene, optimal catheter site selection (avoiding femoral vein), and daily review of line necessity. Feedback was provided on adherence to the bundle as well as CLABSI rates over time.</p> <p>The CLABSI rate per 1,000 catheter-days in the ICU in phase 1 was 6.4, and in phase 2 it had decreased to 3.2; the rate in the SDUs decreased from 4.1 to 1.6 per 1,000 catheter-days.</p> <p>This study suggests that the same prevention principles and evidence-based practices that decrease CLABSIs in the ICU can be applied to the non-ICU setting as well.</p>

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Table 2-5. (Continued)

Scope/Developed by/ Time Frame	Citation or Web Address for the Initiative	Description of Initiative
Initiative: Thammasat University Hospital—Pratumthani, Thailand		
<p>Scope of the initiative: Single organization</p> <p>All units and all patients over 15 years of age</p> <p>Developed by: Researchers at Thammasat University Hospital, Pratumthani, Thailand, and Washington University School of Medicine, St. Louis, Missouri</p> <p>Time frame: July 2005–June 2006 (baseline)</p> <p>July 2006–June 2007 (intervention period, bundle implementa- tion—period 2)</p> <p>July 2007–June 2008 (bundle with intensified hand hygiene interven- tion—period 3)</p>	<p>Apisarnthanarak A, Thongphubeth K, Yuekyen C, Warren DK, Fraser VJ. Effectiveness of a catheter-associated bloodstream infection bundle in a Thai tertiary care center: A 3-year study. <i>Am J Infect Control.</i> 2010 Aug;38(6):449–455.</p>	<p>Thammasat University Hospital is a 500-bed tertiary care university hospital in central Thailand. The hospitalwide intervention included education on hand hygiene, the use of maximum sterile barriers during CVC insertion, skin preparation with chlorhexidine, avoidance of femoral insertion sites, and daily review of the need for continued CVC use. The third period included an intensified hand hygiene effort that provided continuous education on hand hygiene and feedback to staff of hand hygiene adherence rates and adherence to the use of maximum sterile barriers. A significant, progressive decrease in the CVC–related bloodstream infection rate was noted over the three years:</p> <ul style="list-style-type: none"> ■ Baseline rate: 14 infections per 1,000 catheter-days ■ Period 2 rate: 6.4 infections per 1,000 catheter-days (54.3% reduction over the baseline period) ■ Period 3: 1.4 infections per 1,000 catheter-days (an additional 78% reduction) <p>This intervention demonstrates how an inexpensive and feasible intervention can be highly successful in reducing CVC–related bloodstream infections in a resource-limited setting.</p>

The US CDC recently published data showing that there were 18,000 CLABSIs in ICUs in 2009, a 58% reduction from 2001's 43,000 CLABSIs.⁶⁰ CLABSI rates have also decreased in INICC organizations¹⁵ and in German hospitals.⁶² Although adherence to evidence-based practices reduces inconsistencies in practice and can significantly improve patient safety and quality of care,^{63,64} health care organizations often find it difficult to implement best practices, meeting various barriers that impede their success.⁶⁵ In the United States, adherence to evidence-based practices varies considerably, estimated generally to be anywhere from 20% to 100%.⁶⁶ Identifying and removing barriers to adherence to these practices is essential to a successful implementation strategy.⁶⁶ Here we outline some of the common barriers to implementation of best practices to reduce or eliminate CLABSIs.

Barriers at the Organizational Level

■ **Lack of leadership support and commitment**

The importance of leadership involvement in, and support of, any effort to promote organizational change to improve patient safety cannot be overstated. Leadership support must start at the highest levels of the organization.⁶⁷ Lack of accountability by hospital leaders has been a major impediment to achieving zero HAI tolerance.⁶⁸ Organizational leaders can ensure, for example, that policies are in place, cost and barriers to access are reduced or eliminated, and a culture exists in which CLABSI reduction is an important component of patient safety. This commitment, however, must be a shared one, with the board of trustees and all senior management supportive of the common goal.⁶⁹ Further, senior leaders demonstrate their support of HAI prevention efforts when they hold unit/service and ward directors accountable for HAIs that occur in patients in their respective patient care areas.⁶⁸

It should be pointed out that the active involvement and support of senior management can be a bigger issue in developing countries, where there may be no local surveillance data available to assess the scope of HAIs and to perform cost–benefit analyses that are needed to convince management that HAI prevention efforts are needed.¹⁰

Further, although the literature cited here has been associated with hospital settings, this discussion is not intended to suggest that strong leadership is important only in hospitals. Strong organizational or facility leader-

ship is essential to patient safety in all types of settings, including outpatient settings, long term care facilities, home care, and others.

■ **Lack of a safety culture**

Culture of safety and *safety culture* refer to an organization's or facility's commitment to patient safety that is evident at all levels, from health care personnel who work at the bedside to senior leadership. The IOM brought safety culture to the forefront in 1999 when it recommended that hospitals improve their "culture of safety."⁸ Safety culture is often defined by considering the values, norms, attitudes, beliefs, behaviors, practices, and politics of health care personnel, or "the way we do things here."⁷⁰ The characteristics of organizations with a strong safety culture have been identified in studies both in health care organizations^{71–73} and in fields outside health care that have exemplary performance with respect to safety.^{74,75} Some of the characteristics that have been suggested to be associated with strong safety cultures include the following⁷⁶:

- A blame-free environment in which individuals are able to report errors or near misses without fear of reprimand or punishment
- Acknowledgment of the high-risk, error-prone nature of an organization's activities
- An expectation of collaboration across ranks to seek solutions to vulnerabilities
- A willingness on the part of the organization to direct resources for addressing safety concerns

Pronovost and Sexton point out that it is important to understand the sources of variation in culture, which may include staff characteristics, characteristics of the patient care area, or the organization as a whole.⁷⁰ This is a necessary first step in determining where efforts need to be focused to improve culture.⁷⁰ In the Michigan Keystone ICU project, improving ICU culture was necessary before teams could redesign care to improve clinical outcomes. The teams implemented the six-step Comprehensive Unit-Based Safety Program (CUSP) process to assess and improve the culture in the ICUs, which included using the Safety Attitudes Questionnaire.⁵⁴

■ **Lack of available resources**

Prevention of infection in low- and middle-income countries is substantially different than in developed countries. Adequate supplies of all types, including those

for preventing CLABSIs, may not be available.^{15,24,77} It can be a challenge to obtain certain supplies, such as chlorhexidine or large sterile drapes.^{15,24} Some researchers have suggested that use of the insertion bundles, which has been shown to result in reduced CLABSI rates in developed countries, would likely not be sufficient in countries with limited resources, where use of outdated technology (such as the ongoing use of open rather than closed intravenous infusion systems) is not uncommon and sufficient skilled staffing is lacking.^{15,24,78} Reuse of equipment, including such things as gloves and needles, can be widespread in resource-poor countries.⁷⁹ Still, application of inexpensive and practical infection prevention efforts, such as improved hand hygiene and removal of CVCs when they are no longer needed, can have a major impact on CLABSI rates.^{9,10,15} The cornerstone of WHO’s “Clean Care Is Safer Care” campaign, the “My 5 Moments for Hand Hygiene” approach, has resulted in the development of resources, including localized country-specific tools, to facilitate adherence to hand hygiene guidelines.⁸⁰

Key human resources, in the form of trained infection preventionists, are also often lacking in developing countries. Also, lack of ongoing surveillance for infections results in delays in detecting outbreaks, which causes increases in costs and infection-associated mortality.^{15,77}

Barriers at the Unit Level

- Nurse staffing variables, such as nurse-to-patient staffing ratios and use of nonpermanent staff, can adversely affect patient safety in the following ways:
 - Of all health care personnel, nurses have the most direct, ongoing role in the care of patients and the interventions or procedures that put patients at risk of infection.⁸¹ The nurse-to-patient staffing ratio is a measure of the intensity of nursing care.⁸² Inadequate nurse staffing has been linked to increased risk of errors and injuries in patient care, including HAIs, in critically ill patients in particular.^{24,82–87} In a review of the literature conducted by Stone et al., researchers found a significant association between nurse staffing and HAIs in 31 of 38 studies reviewed.⁸¹ A significant link between nurse staffing levels and CLABSIs has also been reported by other researchers.^{88,89} These staffing ratios are typically much lower in ICUs in developing countries than in developed countries.^{19,90} A vicious circle can form when nurses are unable to cope with the work burden and are absent from

work, which adds to the burden of the remaining nurses.⁸⁴

- Use of nonpermanent nursing staff, or “float” nurses, has also been associated with a significant risk of HAI. In a study conducted in eight ICUs over a two-year period, researchers found that the risk of patients developing a CLABSI was 2.6 times greater in patients cared for by float nurses more than 60% of the time.⁸⁹ This is in line with the findings of Pronovost et al. in the Michigan Keystone ICU project, which identified the importance of strong interdisciplinary teamwork and good communication—relationships temporary staff may not have.⁵⁴ Temporary staff may also not be familiar with organizational policies and procedures and may lack awareness of evidence-based practices.

Barriers at the Staff Level

■ **Education, training, experience, and competence of staff**

Health care personnel who insert or maintain CVCs must clearly understand their indications for use and the potential for complications, as well as the evidence-based practices that should be part of all CVC insertion and maintenance procedures. Several researchers have recognized that even experienced staff may not be knowledgeable about risk factors for CLABSIs and best practices to prevent them.^{91–93} Studies have demonstrated that educational programs and intensified training reduce the risk of infection associated with CVC use.^{14,37,82,94} Pérez Parra et al. identified lack of awareness of, or familiarity with, infection prevention guidelines to be a major barrier; after implementing an education program as a sole intervention, they observed a 30% reduction in CLABSIs (4.22 CLABSIs per 1,000 catheter-days before staff education versus 2.94 CLABSIs per 1,000 catheter-days after staff education, $p = .03$).⁹⁵ The same researchers found that the greatest number of incorrect responses on the preeducation questionnaire were those on the use of full sterile barriers during CVC insertions, the most common assumption being that small drapes are sufficient to prevent CLABSIs.

Inexperienced staff who insert CVCs have been associated with lower adherence to CVC insertion guidelines and a greater risk of complications.^{92,94} Barsuk et al. found that the use of simulation-based training for CVC insertions for physician trainees before actual patient insertions ultimately resulted in improved patient

outcomes and dramatically lower CLABSI rates.^{94,96} They also found that this method of training resulted in substantial retention of skill at six months and one year following the simulation-based training; competence retention, however, cannot be assured over time, so periodic retesting and refresher training sessions are recommended.

Having competent, adequately educated and trained staff who insert and maintain central lines may be a bigger challenge in resource-poor areas of the world. Damani points out that lack of trained infection preventionists in developing countries is a key barrier to the implementation of evidence-based practices.¹⁰ Education and training for staff are often minimal and highly variable,⁷⁷ and funds for infection prevention can be very limited.¹⁵ Even in resource-poor areas, however, researchers have found that basic education—and in particular, education with feedback of CLABSI rates to staff—can result in lower CLABSI rates.^{15,94}

In spite of the many, major efforts to improve patient safety by lowering CLABSI rates, a significant number of patients continue to experience preventable harm. Removing barriers to the implementation of evidence-based guidelines is vital to ensuring the safest possible care for patients with CVCs.

Summary of Key Points

This chapter provides background on CLABSIs, including clinical practice guidelines, position papers, initiatives on CLABSI prevention, and barriers to best practices. Key points to keep in mind include the following:

- Clinical practice guidelines (CPGs) are statements of recommended practices intended to optimize patient care, based on a systematic review of the evidence by experts. Several countries, regions, and organizations have established CPGs pertaining to the prevention of CLABSIs, authored by governmental, professional, and public health organizations.
- Position papers, typically developed by professional organizations or societies, present evidence to support their own opinion, stance, or recommendation on a given issue—such as a particular CVC practice used in CLABSI prevention—with the goal of convincing the audience that the opinion promoted is valid and worth considering.
- Recent international, national, regional, state, and single-organizational campaigns and initiatives that have highlighted the preventability of CLABSIs by adhering to

evidence-based preventive practices include those of the International Nosocomial Infection Control Consortium (INICC), the US Department of Health and Human Services (HHS), the Institute for Healthcare Improvement (IHI), the Canadian Patient Safety Institute (CPSI), the World Health Organization (WHO), and several other organizations.

- Common barriers to implementation of best practices to reduce or eliminate CLABSIs include lack of leadership support, lack of a safety culture, unavailability of resources, and issues with staffing, such as suboptimal nurse-to-patient ratios and inadequate education, training, and competence of health care personnel.

In this chapter, we have examined background on the issue of CLABSIs. The next chapter will focus on strategies, techniques, and technologies useful in the prevention of CLABSIs.

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CHAPTER 3

CLABSI Prevention Strategies, Techniques, and Technologies

In recent years great strides have been made toward the prevention of central line–associated bloodstream infections (CLABSIs). From relatively simple interventions, such as the use of bundle strategies and their associated components, to more complex interventions, such as use of antimicrobial lock solutions and antimicrobial dressings and central venous catheters (CVCs), reported rates of CLABSI have been markedly reduced.^{1,2} In this chapter the various strategies that can prevent CLABSIs in adult and pediatric patients are presented, along with evidence that supports each of the strategies.

Throughout this chapter, CLABSI rate reductions from the published literature are cited in the discussions of the various CLABSI reduction strategies presented. Although case definitions, surveillance methodologies, risk-adjustment strategies, and rate calculations may be consistent within individual research studies, they are not consistent across studies.³ However, reductions in CLABSI rates achieved in individual reported studies support the value of using evidence-based interventions.

Education and Training of Health Care Personnel

As was presented in Chapter 2, any effort to reduce CLABSI rates begins with competent staff members being trained to insert and maintain CVCs. Even in resource-poor areas of the world, researchers have found that basic education, and particularly education with feedback of CLABSI rates to

staff, can result in lower CLABSI rates.^{4–9} Other studies conducted in developing countries demonstrating the impact of education on CLABSI rates are summarized in Table 3-1 below. Before the specific strategies to prevent CLABSI are outlined in the remainder of this chapter, the essential roles of education and training of health care personnel must be emphasized.

Table 3-1.
Examples of Studies from Developing Countries
Regarding Education and Reduced CLABSI Rates

Citation	Summary
Rosenthal VD, Guzman S, Pezzotto SM, Crnich CJ. Effect of an infection control program using education and performance feedback on rates of intravascular device–associated bloodstream infections in intensive care units in Argentina. <i>Am J Infect Control</i> . 2003 Nov;31(7):405–409.	The researchers conducted a prospective cohort sequential study to analyze the impact of an infection control program for central line–associated bloodstream infections (CLABSIs) in adult intensive care units (ICUs) in Argentina. Rates of CLABSI determined during a period of active surveillance without education or performance feedback (phase 1) were compared to rates after the sequential implementation of education and performance feedback. Compliance with central venous catheter (CVC) site care improved significantly from baseline during the study period. Overall rates of CLABSI were lowered significantly from baseline after the sequential implementation of education and performance feedback (11.10 versus 46.63 CLABSIs per 1,000 CL–days; $p < .0001$).
Lobo RD, Levin AS, Gomes LM, Cursino R, Park M, Figueiredo VB, Taniguchi L, Polido CG, Costa SF. Impact of an educational program and policy changes on decreasing catheter-associated bloodstream infections in a medical intensive care unit in Brazil. <i>Am J Infect Control</i> . 2005 Mar;33(2):83–87.	The study team sought to determine the impact of an educational program in a medical ICU in Brazil. There were 20 CLABSIs per 1,000 CL–days before the intervention; after the intervention, the rate of CLABSI dropped to 11 per 1,000 CL–days ($p < .01$).
Higuera F, Rosenthal VD, Duarte P, Ruiz J, Franco G, Safdar N. The effect of process control on the incidence of central venous catheter–associated bloodstream infections and mortality in intensive care units in Mexico. <i>Crit Care Med</i> . 2005 Sep;33(9):2022–2027.	Higuera et al. conducted a prospective before/after trial at adult ICUs in Mexico in which rates of CLABSI identified during a period of active surveillance without process control (phase 1) were compared with rates of CLABSI after implementing an infection control program applying process control (phase 2). Compliance with CVC site care and hand hygiene improved significantly. After the intervention, rates of CLABSI were lowered significantly from baseline (19.5 vs. 46.3 CLABSIs per 1,000 CL–days; $p = .0001$). Overall rates of crude mortality were also lowered significantly (48.5% versus 32.8% per 100 discharges, $p = .01$).
Yilmaz G, Caylan R, Aydin K, Topbas M, Koksai I. Effect of education on the rate of and the understanding of risk factors for intravascular catheter–related infections. <i>Infect Control Hosp Epidemiol</i> . 2007 Jun;28(6):689–694.	The researchers conducted a sequential study at a university hospital in Turkey, which involved three separate periods: preeducation, education, and posteducation. During the preeducation period, the CLABSI rate was 8.3 infections per 1,000 CL–days. During the posteducation period, the CLABSI rate was 4.7 infections per 1,000 CL–days.

Note: CL–days: central line–days.

All health care personnel who insert and maintain CVCs should be knowledgeable and competent regarding care related to the prevention of CLABSIs. Although health care personnel must remain current regarding technological advances in the prevention of CLABSIs, the importance of proper technique and procedures for CLABSI prevention is essential. Staff members who are experienced with the insertion and maintenance of CVCs may not be knowledgeable about risk factors for CLABSIs or evidence-based practices to prevent them.^{10–12} Competence should be assessed at the time of initial employment, on a periodic ongoing basis, when new technology or equipment is introduced, and when the staff member's scope of practice changes.¹³

There is much evidence in the literature published throughout the period from the 1970s to today that standardization of aseptic care decreases the risk for CLABSI.^{7,14–17} The key elements a CLABSI education program should include are the following^{14,18–20}:

- The appropriate indications for CVC insertion: Health care personnel should understand what constitutes reasonable indications for CVC placement, which include the following:
 - Administration of medications, such as chemotherapy or antibiotics
 - Administration of fluids, including blood or blood products
 - Monitoring of central venous pressure
 - Providing parenteral nutrition
 - Providing hemodialysis
- Best practices for the insertion of CVCs: Health care personnel should be knowledgeable about evidence-based best practices in the insertion of CVCs.
- Appropriate care and maintenance measures: Health care personnel should understand the appropriate care and maintenance needed to prevent infection after the CVC is inserted, as proper care of the CVC postinsertion is critical to preventing CLABSIs.

Health care personnel should also consider the expected duration of therapy prior to CVC insertion, as in some cases peripheral intravenous (IV) access may be adequate.

The educational methods chosen should take into consideration the preferred methods of learning, principles of adult education, resources available, cultural norms, and languages spoken by health care personnel. Education can be delivered in many ways, including the following:

- Pérez Parra et al. found that a 15-minute lecture for all ICU health care personnel, highlighting 10 of the evidence-based strategies in the US Centers for Disease Control and Prevention's (CDC's) 2002 guidelines, resulted in a reduction in CLABSIs from 4.22 infections to 2.94 infections per 1,000 catheter-days. No other interventions to impact CLABSI rates were undertaken beyond this education.⁴
- In addition to traditional lecture formats, video training or computerized e-learning can be valuable methods for delivering education.^{21–23} Comer et al. found Web-based CLABSI training useful as a stand-alone educational method in improving clinician knowledge and retention of knowledge over time.²¹ Guerra et al. found e-learning to be an important and effective tool in bringing updated information to health care personnel in a resource-limited country.²³
- Self-study modules, which allow health care personnel to read materials at their own convenience and pace, can also be utilized; this approach to education, along with lectures and posters, was successful in reducing CLABSI rates from 4.9 to 2.1 infections per 1,000 catheter-days in one organization over a two-year period.²⁴
- Combining didactic education with hands-on training can be useful in assuring that staff members have both the necessary knowledge and ability to perform given tasks, as didactic instruction alone, while useful in transferring knowledge, may not always change behavior.¹
- Simulation-based training is becoming more widely used, replacing the “see one, do one, teach one” apprenticeship model that facilitates inconsistencies in practice and the potential promotion of incorrect practices; this method of training allows for realistic and repetitive practice in a controlled environment while avoiding patient harm.^{25,26} Researchers have found this method of education and training to be effective in reducing CLABSIs; Barsuk et al. reduced CLABSIs by 84%, from 3.2 to 0.5 infections per 1,000 catheter-days,¹⁵ and Khouli et al. reduced CLABSIs by 71%, from 3.5 to 1.0 infections per 1,000 catheter-days.²⁵

Furthermore, only trained health care personnel who have demonstrated competence in the insertion and maintenance of CVCs should be allowed to insert or care for CVCs. Organizations should periodically assess the knowledge of these staff members and their adherence to evidence-based guidelines.^{14,18,19} Finally, institutional policies should outline all standardized education programs for health care personnel.

Hand Hygiene

Hand hygiene is a key component of any effective patient safety and infection prevention program. Hand hygiene is generally accepted as the single most important measure in preventing the spread of infection. Both soap and water and alcohol-based hand rub products can be used to achieve proper hand hygiene.^{13,14,19,27} It is essential that health care personnel be knowledgeable of the recommended practices for hand hygiene and that they consistently adhere to them.^{27–31} Health care organizations need to integrate hand hygiene into routine procedures and have strong systems in place to support, monitor, and promote the correct behavior.³²

Several researchers have evaluated the impact of hand hygiene on the risk of health care–associated infections (HAIs), including CLABSIs.^{6,28–34} The US CDC’s Healthcare Infection Control Practices Advisory Committee (HICPAC) and the World Health Organization (WHO) have provided guidelines that present a broad review of the scientific literature on the practices and rationale for hand hygiene.^{27,28} The guidelines also describe the proper techniques that should be used, as well as when to use soap and water instead of hand rub. WHO developed the “My 5 Moments for Hand Hygiene” model to aid in hand hygiene training, observation, and performance measurement in all health care settings worldwide.²⁸ The “5 Moments,” as depicted in Figure 3-1 on page 43, are as follows:

- **Moment 1:** Before touching a patient. Hand hygiene at this moment is aimed at preventing colonization of the patient with microorganisms that staff have on their hands from touching the health care environment.
- **Moment 2:** Before a clean or aseptic procedure. Hand hygiene at this moment is aimed at preventing HAIs, as health care personnel have contact with surfaces in the immediate patient area before clean or aseptic procedures.
- **Moment 3:** After body fluid exposure risk. Hand hygiene is important at this moment for two reasons. First, it protects health care personnel from colonization or infection with microorganisms that may be present even if their hands are not visibly soiled. Second, it minimizes the risk of spread of microorganisms from a colonized to a clean body site within the same patient.
- **Moment 4:** After touching a patient. This moment occurs after the last contact with the patient and subsequent hand contact with any other surface in the health care setting.
- **Moment 5:** After touching a patient’s surroundings. A variation of Moment 4, this moment refers to any hand

contact health care personnel have with any surface in the patient’s surroundings after touching the patient.

To minimize the risk of CLABSI associated with direct contact of the hands of health care personnel, the 2011 US CDC guideline recommends that hand hygiene be performed at the following times¹⁴:

- Before and after palpating the site of catheter insertion
- Before and after inserting the catheter
- Before and after accessing, replacing, repairing, or dressing the catheter

In addition, after the antiseptic has been applied to the site, further palpation of the insertion site should be avoided, unless aseptic technique is maintained.

Although most health care personnel would likely acknowledge the importance of hand hygiene in the prevention of infection, most hand hygiene adherence studies indicate a much more limited acceptance of this in practice. Adherence to hand hygiene guidelines by health care personnel has been the subject of observational studies, with rates generally averaging less than 40%.²⁷ Improving staff adherence to proper hand hygiene is most likely to be successful with a multimodal approach, using a combination of education, system change, motivation, and feedback on rates.^{29–32}

Aseptic Technique

Aseptic technique is a method used to prevent contamination with microorganisms.³⁵ Aseptic technique is applicable in all health care settings where providers perform surgery or other invasive procedures, including the insertion of CVCs or urinary catheters. Aseptic technique is recommended by the evidence-based guidelines for all instances of CVC insertion and care.^{13,14,19}

Aseptic technique is also referred to as *sterile technique* and is used to keep objects and areas *free* of microorganisms and thereby minimize infection risk for the patient. *Clean technique*, on the other hand, can be used to *reduce* the overall number of microorganisms present. While both aseptic technique and clean technique involve meticulous hand hygiene, they are separate and distinct in the following ways³⁰:

- Aseptic technique requires the use of various barriers, such as sterile gloves, sterile gowns, sterile drapes, and masks, to prevent the transfer of microorganisms from health care personnel and the environment to the patient during a procedure.

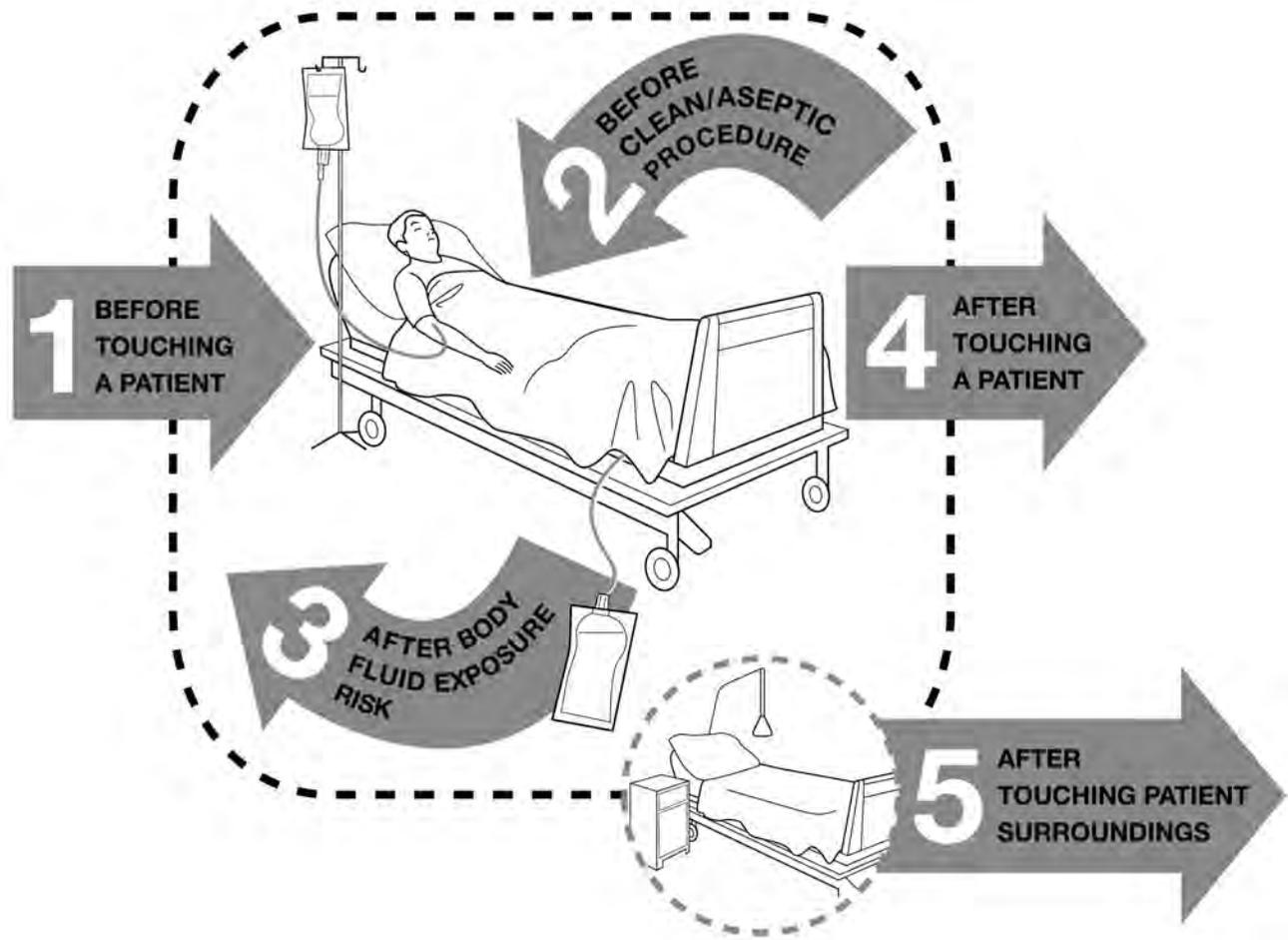


Figure 3-1. World Health Organization’s “My 5 Moments for Hand Hygiene”

Source: World Health Organization (WHO): *WHO Guidelines on Hand Hygiene in Health Care*. Geneva: WHO, 2009. Accessed Mar 18, 2012. http://whqlibdoc.who.int/publications/2009/9789241597906_eng.pdf. Used with permission.

- Aseptic technique also involves antiseptic skin preparation of the patient at the time of the procedure, as well as the use of sterile instruments, equipment, and devices.
- Environmental controls that are part of aseptic technique include keeping doors closed during operative procedures, minimizing traffic into and out of operating rooms, and excluding unnecessary personnel during procedures.
- In aseptic technique, only sterile-to-sterile contact is allowed; sterile-to-nonsterile contact must be avoided.
- In contrast, clean technique involves reducing the numbers of microorganisms in order to minimize the risk of transmission from the environment or health care personnel, and it includes appropriate hand hygiene. In clean technique, clean gloves are used and efforts are

made to prevent direct contamination of supplies and materials; the patient’s environment also undergoes routine cleaning. No sterile-to-sterile rule applies. For example, clean gloves are worn by health care personnel when inserting peripheral intravenous catheters.

Anytime a CVC is inserted when adherence to aseptic technique cannot be ensured, as might occur during a medical emergency, it is essential that the catheter be replaced as soon as possible, preferably within 48 hours.^{13,14}

CVC Insertion Preparation

There are a number of factors to take into consideration when preparing to insert a CVC. As described in the

sections that follow, health care personnel should be attentive to maximal sterile barrier precautions, skin preparation, catheter selection, and use of catheter kits or carts.

Maximal Sterile Barrier Precautions

Maximal sterile barrier (MSB) precautions require the CVC inserter to wear a mask and cap, a sterile gown, and sterile gloves and to use a large (head-to-toe) sterile drape over the patient during the placement of a CVC or exchange of a catheter over a guidewire.^{13,14,18,19,36} Several studies have demonstrated the benefit, either alone or as part of multimodal CLABSI prevention strategies, of using MSB precautions during CVC placement to reduce the risk of CLABSIs:

- In 1994 Raad et al. conducted a prospective randomized trial in a 500-bed cancer center to determine whether MSB precautions were superior to using only sterile gloves and a small sterile drape for the insertion of CVCs. The control group infection rate was six times higher than the MSB precaution group ($p = 0.03$).³⁷ The MSB group also had infections that occurred much later (6 weeks or longer) than the control group and were caused by Gram-negative rather than Gram-positive microorganisms, suggesting that the infections were not related to contamination occurring during placement of the CVC. In contrast, the control group had onset of infection within 12 days of insertion in one third of the patients, with the remaining two thirds detected within 6 weeks; 83% of the bloodstream infections in this group were caused by skin organisms.
- An earlier study by Mermel et al. of pulmonary artery catheter insertions showed a twofold lower risk of catheter-related infection when MSB precautions were used.³⁸
- Sherertz et al. sought to standardize CVC insertion practices, particularly MSB precautions, by introducing an educational program for medical students and physicians completing their first postgraduate year.¹⁷ The perceived need to use full body drapes was 22% in the year preceding the education and 73% 6 months after the education. The CLABSI rate decreased from 4.51 infections per 1,000 patient-days before the education to 2.92 infections per 1,000 patient-days 18 months after the education.
- A research team from Johns Hopkins University School of Medicine developed a comprehensive statewide quality improvement model that included the use of evidence-based interventions, including MSB precautions, to reduce the rate of CLABSIs.³⁹ This initiative resulted in a

dramatic decrease in CLABSI rates across the 103 participating intensive care units (ICUs). The mean and median CLABSI rates decreased as follows:

- At baseline: Mean rate 7.7 (median 2.7)
 - At 16–18 months into the initiative: Mean rate 1.3 (median zero)
- A research team from the International Nosocomial Infection Control Consortium (INICC) developed a comprehensive multinational improvement model that included process and outcome surveillance and feedback of infection rates.⁵ Adherence of ICUs to MSB precautions increased from 45% to 85% during the study period. CLABSI rates also declined, with a 54% cumulative reduction from baseline (from 16.0 to 7.4 CLABSIs per 1,000 central line–days), during the first 24 months of the study.

Skin Preparation

Reducing colonization at the insertion site is a critical component of CLABSI prevention. The importance of skin microorganisms in the pathogenesis of CLABSIs was described in Chapter 1 of this monograph. Over the past 20 years several studies have tried to determine the best antiseptic for skin cleansing before insertion and during CVC manipulation. While iodophors (for example, povidone-iodine, tincture of iodine) have been frequently used in the United States, a number of studies have shown that chlorhexidine gluconate preparations are superior to both iodophors and alcohol for skin antiseptics.^{40–44} A recent meta-analysis of more than 4,000 catheters found that the use of chlorhexidine reduced the risk of bloodstream infection by almost 50% when compared to the use of povidone-iodine.⁴⁵ However, a recent study by Furuya et al. identified the importance of allowing chlorhexidine to dry fully before CVC insertion in order to optimize the use of this agent.⁴⁶ An economic analysis suggested that using chlorhexidine rather than povidone-iodine would result in a 1.6% decrease in CLABSIs and a 0.23% decrease in mortality, as well as save \$113 per catheter used.⁴⁰ Chlorhexidine is believed to have an advantage over povidone-iodine due to its prolonged antimicrobial effect and its lack of inactivation when exposed to blood and serum; there is also evidence that adding alcohol to chlorhexidine (chlorhexidine tincture) results in a synergistic effect against bacteria, due to the rapid bactericidal activity of the alcohol.¹ Based on the available evidence, chlorhexidine is the preferred antiseptic for skin preparation for reducing the risk of CLABSIs in patients over the age of 2 months. While infection pre-

vention guidelines do not endorse the use of chlorhexidine in children under the age of 2 months or who have a birth weight of less than 1,000 grams, a recent national US survey of its use in neonatal ICUs found that most use chlorhexidine gluconate, though often with some restrictions.⁴⁷ More recently, another group of researchers found that lower concentrations of chlorhexidine were well tolerated by preterm low-birth-weight infants.⁴⁸ At least one group of researchers found a significant reduction in CVC-related colonization and infection in adult patients using 5% povidone-iodine in 70% ethanol solution compared to an aqueous solution of 10% povidone-iodine.⁴⁹ There have been no comparisons of the clinical efficacy of using tincture of chlorhexidine versus tincture of iodine. In continental Europe, octenidine is increasingly being used as a substitute for chlorhexidine in water- or alcohol-based skin, mucosa, and wound antiseptics, though it is not available in the United States.⁵⁰

The following summarizes current recommendations for skin antiseptics prior to CVC insertion and during dressing changes.^{13,14,18,19,36}

- Apply antiseptics to clean skin.
- Apply chlorhexidine/alcohol in a concentration greater than 0.5% in alcohol.
- If there is a contraindication to chlorhexidine, apply tincture of iodine, an iodophor, or alcohol as an alternative.
- Allow the antiseptic solution to dry before placing the catheter.

It should be noted, however, that in some countries, chlorhexidine availability may be an issue, in which case povidone-iodine should be used.⁵¹

Catheter Selection

Several types of CVCs are available that come in various sizes and catheter materials; they also are available as single, double, triple, or quadruple lumen. The choice of type of catheter depends on the specific needs and preferences of the patient and the health care provider, including the duration and frequency of CVC use.⁵² While every intravenous device carries with it the risk of infection, the magnitude of risk varies and depends on the type of device (see the discussion of types of CVCs in Chapter 1 and the summary in Table 1-1 on page 3).^{53,54} The various characteristics of CVCs and factors that influence their selection include the number of lumens and antimicrobial- or antiseptic-impregnated catheters.

Number of Lumens

Multilumen catheters reduce the need for several insertion sites, but they carry with them an increased risk of infection (and deep vein thrombosis) as compared with single-lumen catheters. CVCs with multiple ports potentially increase the frequency of catheter manipulation by health care personnel, which enhances the risk that microorganisms will gain access to the IV system and bloodstream. Evidence-based guidelines recommend that a CVC with the minimum number of lumens necessary for the management of the patient be used.^{14,19,36}

Antimicrobial- or Antiseptic-Impregnated Catheters

Some CVC catheters and cuffs are directly coated or impregnated with antimicrobials (for example, minocycline/rifampin) or antiseptics (for example, chlorhexidine/silver sulfadiazine) to prevent CVC colonization and CLABSIs. Evidence-based guidelines strongly support the use of antimicrobial- or antiseptic-impregnated catheters if CLABSI rates are not decreasing after the implementation of a comprehensive strategy to reduce those rates.^{13,14,18,19,36} Such a comprehensive strategy should include, at a minimum, the following:

- Educating health care personnel who insert and maintain CVCs
- Using maximal sterile barrier precautions
- Using a greater than 0.5% chlorhexidine preparation with alcohol for skin preparation prior to CVC insertion

Other evidence-based guidelines also recommend the use of antimicrobial- or antiseptic-impregnated catheters as just described, adding that patients with limited venous access and a history of recurrent CLABSI, as well as patients at higher risk for severe sequelae from a CLABSI (for example, patients who have recently had such vascular devices as aortic grafts or prosthetic heart valves implanted), would also be candidates for their use.^{13,18,19}

Should CLABSI rates not be reduced with the aforementioned strategies, evidence-based guidelines recommend the use of chlorhexidine/silver sulfadiazine or minocycline/rifampin-impregnated CVCs for use in patients expected to have a CVC in place for an extended period of time, though the suggested time frame varies—from “more than 5 days”¹⁴ to “from 1 to 3 weeks.”¹⁹ A brief description of the evidence supporting the use of these two types of catheters is provided here:

- Chlorhexidine/silver sulfadiazine catheters: Chlorhexidine and silver act synergistically to reduce

microbial colonization, active primarily against Gram-positive microorganisms.⁵⁵

- First-generation chlorhexidine/silver sulfadiazine catheters came on the market in the early 1990s.⁵⁶ They were coated on the external luminal surface only, and studies indicated that they reduced the risk for CLABSI compared to standard CVCs.
- Second-generation CVCs are now available with a chlorhexidine coating on the internal surface and with the external surface coated with chlorhexidine and silver sulfadiazine. There is three times the amount of chlorhexidine on the external luminal surface and extended release of the surface-bound antiseptics than that of the first-generation catheters.

Although prospective studies have demonstrated a significant decrease in catheter colonization with the second-generation catheters, the studies have been underpowered and unable to demonstrate a difference in CLABSI rates. On rare occasions, anaphylaxis has been reported with the use of these catheters.^{14,19} Researchers found that the chlorhexidine/silver sulfadiazine coating's anti-infective properties last for approximately a week to 10 days and that efficacy data for longer catheter dwell times are weak.^{26,56}

Historically, these catheters have been more expensive than standard catheters, but Veenstra et al. demonstrated that their use can lead to a cost savings of \$68 to \$391 per catheter in settings where the risk for CLABSI is high despite adherence to evidence-based practices (hand hygiene, use of maximal barrier precautions, and so forth).⁵⁷ Borschel et al. demonstrated a cost savings of more than \$100,000 per year when the antiseptic-coated catheters were used in one organization, with an additional observed benefit of less vancomycin use in the units in which the catheters were used compared to the units in which they were not. The authors theorized that fewer CLABSIs resulted in fewer prescriptions for the antibiotic.⁵⁸ More recently, however, one group of researchers found that improving best practices in catheter insertion was the most significant factor in reducing CLABSIs in their surgical ICU. When they discontinued the routine use of chlorhexidine/silver sulfadiazine catheters in favor of standard catheters, following the implementation of education and best-practice standardization strategies, there was no increase in their CLABSI rate.⁵⁹

- Minocycline/rifampin catheters: These two antibiotics are effective against both Gram-positive and Gram-negative microorganisms; CVCs coated with these antibiotics have surface antimicrobial activity that persists for a longer period of time than the chlorhexidine/silver sulfadiazine catheters.^{57,55} CVCs impregnated with minocycline and rifampin on both the internal and external luminal surfaces have been associated with lower rates of CLABSI when compared to the first generation of chlorhexidine/silver sulfadiazine catheters, with the beneficial effect beginning after day 6 of catheterization. No comparative studies with the second-generation chlorhexidine/silver sulfadiazine catheters have been published. The main theoretical concern with the use of these antimicrobial-impregnated CVCs is the potential for antimicrobial resistance, though the risk appears to be low.^{14,19,60,61}

Shorr et al. evaluated the potential economic implications of using either minocycline/rifampin or chlorhexidine/silver sulfadiazine CVCs and found their use to be associated with an almost \$10,000 cost savings per CVC–associated CLABSI prevented and \$168 to \$280 savings for each patient who received one of these catheters.⁶² Use of these catheters might be cost-effective with ICU patients, burn patients, neutropenic patients, and other patient populations in which the rate of infection exceeds 3.3 per 1,000 catheter-days.^{14,19} However, the dramatic reduction in CLABSI rates with the advent of catheter bundles and multimodal interventions suggests that the economic benefit of coated and impregnated CVCs based on earlier studies needs to be reexamined to be certain that such a benefit exists today.

A silver iontophoretic CVC—a combination of platinum and silver—is commercially available in the United States, but it is of unproven benefit.⁶³ The CDC does not make a recommendation for or against use of these catheters.¹⁴

Use of Catheter Kits or Carts

Having standardized supply carts or kits with all the necessary CVC insertion and care supplies and equipment in “ready to go” locations saves health care personnel time and helps ensure that the correct supplies and equipment are used for all insertion and maintenance procedures.¹⁸ It is essential that the carts or kits are always stocked and readily accessible. Procedures should be established for used carts to be switched out in a timely manner for newly cleaned and stocked carts. Kits can be kept in unit supply rooms, at

nurses' stations, or at the bedside. Carts and kits can be assembled by health care organizations, using the supplies they prefer, or ready-made kits can be purchased. Carts and kits must contain all supplies recommended by evidence-based practices—for example, a large sterile drape for insertion procedures (rather than a small drape); chlorhexidine for skin antisepsis; and cap, mask, and sterile gloves for inserters and those assisting with the procedure.

CVC Insertion

After the appropriate preparations have been made, the insertion process may begin. As described in the sections that follow, this process includes catheter site selection, insertion under ultrasound guidance, catheter site dressing regimens, securement devices, and use of a CVC insertion bundle.

Catheter Site Selection

Data derived from several observational studies of CVC insertions suggest that the greatest risk of infection in adults is associated with use of the femoral vein as the insertion site, and the lowest risk is associated with subclavian site insertions, with an intermediate level of risk associated with internal jugular vein insertions for nontunneled CVCs.^{1,14,18,19,36,64,65} This risk is believed to be associated with the density of skin flora at the CVC insertion site. Femoral catheters are also associated with a greater risk for deep venous thrombosis than are the subclavian or internal jugular veins. In pediatric patients, however, femoral catheters have a lower rate of mechanical complications and seem to have an equivalent infection rate to nonfemoral catheters.^{14,65} Further, there is a significant risk of great vein stenosis and thrombosis in catheters used for hemodialysis that are inserted into the subclavian vein, so the internal jugular vein is the preferred insertion site for CVCs in hemodialysis patients; it should be noted, however, that a fistula or graft is preferred for patients with chronic renal failure for permanent dialysis access. Other factors that should be taken into consideration regarding the placement of CVCs include operator skill (femoral insertions are easier than subclavian or internal jugular insertions), the risk for noninfectious complications (for example, bleeding or pneumothorax), and complications that limit upper body catheter placement (for example, burns, no available sites, or refractory coagulopathy).^{1,14,18,19,65} In summary:

- Avoid using the femoral site for CVC access in adult patients.
- Keep in mind that studies have shown that, unlike in adults, in pediatric patients femoral catheters have a low incidence of mechanical complications and might have an equivalent infection rate to that of nonfemoral catheters.

- Use a subclavian site rather than a jugular site to minimize infection risks in adult patients. (Note, however, that the literature reflects comparisons of insertion sites before the routine use of ultrasound-guided insertions, so this area is deserving of additional study.)
- Avoid the subclavian site in hemodialysis patients.

The risk of infection with peripherally inserted central catheters that are placed in the internal jugular or subclavian veins in hospitalized patients is similar to the risk with CVCs.⁶⁶

Insertion Under Ultrasound Guidance

If this technology is available and health care personnel are fully trained in its use, the US CDC recommends that ultrasound guidance be used to place CVCs, to reduce the number of insertion attempts and the number of mechanical complications in adults and children.¹⁴ Pittiruti et al. point out that use of ultrasound guidance was associated with a higher rate of success at first-attempt insertions compared to blind techniques in several randomized controlled trials and is associated with a decrease in CLABSIs.³⁶

Catheter Site Dressing Regimens

A clean and dry dressing at the insertion site is important to protect the site and to minimize the risk of infection. There are generally two types of dressings that can be used to cover and protect the insertion site: (1) sterile gauze and tape and (2) sterile, semipermeable “transparent” polyurethane dressings. The choice of dressing is a matter of preference, given that studies have shown no clinically substantive differences in site colonization or CLABSI rates between them. Transparent dressings permit continuous visual inspection of the insertion site, help to secure the device, and do not need to be changed as often as gauze and tape dressings. If the patient is diaphoretic or the insertion site is oozing blood, gauze dressings are recommended.^{13,14,19}

Chlorhexidine-impregnated dressings have been used to reduce the risk of CLABSI. A recently published multicenter trial showed that patients in the chlorhexidine-impregnated dressing group had significantly fewer CLABSIs than those in the group randomized to a standard dressing.⁶⁷ Other published studies have shown a reduction in CVC colonization but no statistical differences in CLABSI rates.¹⁴

The following summarizes the evidence-based recommendations concerning catheter site dressing regimens^{14,19}:

- Use a sterile gauze or sterile, transparent semipermeable dressing to cover the insertion site.
- Use a gauze dressing if the patient is diaphoretic or if the site is oozing.
- Replace the dressing if it becomes damp, loosened, or visibly soiled.
- Replace gauze dressings every two days.
- Replace semipermeable dressings every seven days, except with pediatric patients, for whom the risk of dislodgement may outweigh the benefit of changing the dressing.

If the CLABSI rate is not decreasing despite successful adherence to basic prevention measures (education and training, appropriate use of chlorhexidine for skin antisepsis, and maximum sterile barrier precautions), guidelines also recommend using a chlorhexidine-impregnated sponge dressing for temporary short-term catheters in patients older than 2 months of age.^{14,18} Marschall et al. also recommend their use in patients with limited venous access and a history of recurrent CLABSI, as well as in patients at higher risk for severe sequelae from a CLABSI (for example, patients who have recently had such vascular devices as aortic grafts or prosthetic heart valves implanted).¹⁸ Use of these dressings in infants less than 2 months of age, especially those with low birth weights, tends to be associated with more local contact dermatitis, so their use in this age group remains an unresolved issue.¹⁴

It is also important that the insertion site be visually monitored and/or palpated through an intact dressing. If there is fever without an obvious source, tenderness at the insertion site, or other symptoms suggesting either local or bloodstream infection, the dressing should be removed and the site thoroughly inspected.¹⁴

Securement Devices

The US CDC recommends using a sutureless securement device to reduce the risk of intravascular device–related infection.¹⁴ Securing the CVC to stabilize and minimize mechanical trauma at the CVC entry site is believed to reduce phlebitis, reduce movement or dislodging of the CVC, and help prevent CLABSI by decreasing the level of bacterial colonization at the site.^{13,14,36} Using a sutureless device is preferred to suturing the catheter to the skin, as the latter further disrupts the skin around the catheter site, which can lead to inflammation and increased levels of colonization. Using a sutureless securement device also eliminates the risk of sharps injury to health care personnel from inadvertent needlestick injury.¹⁴

Use of a CVC Insertion Bundle

Bundles facilitate the use of evidence-based practices, and their use is recommended in CLABSI guidelines.^{13,14,18} More than a decade ago, the use of bundles was shown to reduce rates of CVC–related infections.⁶⁸ Recent studies have shown that consistent application of evidence-based practices can lead to significant, sustained reductions in CLABSI rates.^{67,46,69–77} The Institute for Healthcare Improvement (IHI) describes a “bundle” as “groupings of best practices with respect to a disease process that individually improve care, but when applied together result in substantially greater improvement. The science supporting the bundle components is sufficiently established to be considered standard of care.”⁷⁸ As described in Chapter 2 of this monograph, Pronovost et al. implemented a multifaceted intervention that focused on the consistent application of select evidence-based practices to reduce CLABSIs in 103 Michigan adult ICUs⁷:

- Hand hygiene before catheter insertion
- Use of full barrier precautions
- Chlorhexidine skin preparation
- Avoidance of the femoral vein for inserting CVCs (except in children)
- Prompt removal of CVCs

This intervention resulted in a 66% reduction of CLABSIs across all participating ICUs at 16–18 months after implementation. In addition to creating the bundle, clinicians were educated about CLABSI prevention; CVC carts that contained all necessary supplies were created; a checklist was developed to ensure adherence to proper practices; procedures were stopped in nonemergent situations if evidence-based practices were not being followed; feedback was provided to the clinical teams regarding the number of CLABSI episodes and overall rates; and buy-in was obtained for the initiative from the chief executive officers of the participating hospitals.⁷ This bundle was adopted by IHI in its 5 Million Lives Campaign, a voluntary initiative to protect patients from 5 million incidents of medical harm.⁷⁹

Rosenthal points out that implementation of the bundle described here could be challenging in resource-limited countries, as supplies, such as chlorhexidine or large barriers for catheter insertion, may be limited. Furthermore, the bundle alone would likely be insufficient to prevent CLABSIs in such countries, due to the use of vented (open) intravenous fluid containers rather than closed systems (see Sidebar 3-1 on page 49 for a discussion of open versus closed intravenous systems), manual admixture of medications due to the lack of ready-to-use medications, and poor

infection prevention practices, such as reusing single-use vials and withdrawing fluids from a fluid source for multiple patients.⁵¹ Implementation of elementary infection prevention measures, such as health care personnel education, hand hygiene, and feedback of infection rates to health care personnel, have been found to have a major impact on CLABSI rates in resource-limited countries, though the CLABSI rates have not declined to the level of those in developed countries.^{8,9,12,80,81}

CVC Maintenance

Proper maintenance of CVCs is essential for continued

patient safety. The sections that follow discuss the use of prophylactic lock and flush solutions; disinfection of catheter hubs, connectors, and injection ports; chlorhexidine bathing; and use of a CVC maintenance bundle.

Prophylactic Antibiotic Lock Solutions, Antimicrobial Flush Solutions, and Catheter Lock Solutions

A wide variety of antibiotic and antiseptic solutions have been used to lock or flush CVC lumens. *Catheter lock* is a technique by which an antimicrobial solution is injected into the catheter lumen dead space until it is filled and then

Sidebar 3-1. Open Versus Closed Intravenous Systems

Worldwide, there are two types of IV fluid containers in use: a collapsible plastic container that requires no external venting for the bag to empty (a closed infusion container) and a noncollapsible container (glass bottle or semirigid plastic bottle or burette) that must be vented externally to allow air to enter and the fluid to egress (an open infusion container).^{*} Open infusion systems have a higher risk of contamination during initial setup and administration than closed systems. Open systems were in use worldwide for more than 75 years, until a nationwide outbreak occurred in the United States in 1971, caused by *Enterobacter cloacae*. This outbreak was ultimately traced to intrinsic contamination of the screw cap closures on the glass IV fluid bottles of one US manufacturer.[†] By the early 1980s North America and Western Europe had universally adopted the use of closed infusion systems. These closed systems have been shown to significantly reduce the incidence of CLABSIs. Open infusion systems, however, are still in use in many parts of the world, including Eastern Europe, Germany, Asia, Africa, and Latin America.^{**} A study conducted in four countries that switched from an open infusion container to a closed infusion container observed that the incidence of CLABSIs decreased from an overall rate of 10.1 infections per 1,000 central line–days (open infusion system in use) to 3.3 infections per 1,000 central line–days (closed infusion system in use), for an overall 67% reduction in CLABSI rates.^{*} Another group of researchers found the switch from an open to a closed infusion system to be a cost-saving strategy by reducing the rate of CLABSIs without increasing hospital costs.[‡] Graves et al. analyzed the impact of the introduction of a closed infusion system in the ICUs of two Latin American cities and found that the closed system not only reduced CLABSI rates but also reduced costs and deaths.[‡]

Other benefits of using closed infusion systems, in addition to those just described, include greater container durability, less breakage, reduced weight, and easier disposal than the open systems.[‡]

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allowed to dwell for a period of time, until the catheter is accessed again.¹⁴ *Catheter flush* is a technique whereby the solution is pushed through the catheter into the bloodstream (no dwell time).¹ Use of such locks and flushes is based on the concept that preventing colonization of the intraluminal surface of the CVC will prevent CLABSIs.¹ Antibiotics and antiseptics of various concentrations—including vancomycin, ciprofloxacin, and cefazolin—have been used either alone (to target a specific organism) or in combination (to achieve broad coverage) to flush or lock CVCs; antiseptics have included alcohol, methylene blue, taurolidine, and trisodium citrate. (*Note:* Taurolidine and trisodium citrate are not approved for this use in the United States.)^{82–85} These agents are usually combined with a compound acting as an anticoagulant, such as heparin or edetic acid (EDTA).¹⁴ The US CDC does not recommend the routine use of these solutions, given the wide variety of compounds used, the heterogeneity of the patient populations studied, and the limitations in various study sizes or designs (see Sidebar 3-2 at right for a discussion of anticoagulants versus normal saline intermittent flushes). There also are no US Food and Drug Administration (FDA)–approved formulations for marketing in the United States, so most formulations are prepared in hospital pharmacies. In addition, while some studies have shown promising results, concerns with these flushes or locks include the potential for side effects, toxicity, or allergic reactions, or the emergence of resistance in exposed microorganisms.¹⁴ Ideally, an anti-infective lock or flush solution would have broad-spectrum activity against multidrug-resistant Gram-positive and Gram-negative bacteria and fungi but would not select for resistance; novel agents showing promise in ongoing studies include pharmacopeia-grade ethanol, minocycline-EDTA, and gentamicin-citrate solution.⁸⁶

The US CDC currently recommends the use of antimicrobial or antiseptic flush or lock solutions only in patients with long-term catheters who have a history of multiple CLABSIs despite optimal maximal adherence to aseptic technique.¹⁴ The Society for Healthcare Epidemiology of America/Infectious Diseases Society of America (SHEA/IDSA) compendium also recommends their use in patients who have limited venous access or who are at increased risk for severe sequelae from a CLABSI (for example, those with recently implanted intravascular devices such as an aortic graft or prosthetic heart valve).¹⁸ The IDSA's clinical practice guideline recommends that these locks be used only for salvage treatment of confirmed CLABSI, and even then they should be used in conjunction with systemic

antimicrobial therapy.⁸⁷ The bottom line: These flushes and locks should not be routinely used to prevent CLABSI.

Disinfection of Catheter Hubs, Connectors, and Injection Ports

The external surface of a catheter hub, connector, or injection port is the immediate portal of entry of microorganisms to the intraluminal surface of the catheter.^{88–90} As mentioned in

Sidebar 3-2. Anticoagulants Versus Normal Saline Intermittent Flushes

Low-dose intermittent sodium heparin locks and heparinized saline flushes have been used by clinicians for many years to maintain CVCs between uses to prevent thrombus formation, prolong catheter patency, and possibly reduce CLABSIs; the efficacy of this practice, however, has not been proven.* The primary concern is the unnecessary exposure to heparin and the potential adverse effects associated with its use (such as allergic reactions, bleeding complication, or thrombocytopenia). Furthermore, because the majority of heparin solutions contain preservatives with antimicrobial activity, it is unclear whether any decrease in CLABSI rates in available studies is a result of the reduced thrombus formation, the preservative, or both. It has been demonstrated that normal saline is as effective as heparin in maintaining patency of CVCs.[†] The US CDC guideline (2011) recommends against the routine use of anticoagulant therapy to reduce the risk of catheter-related infection in general patient populations.[‡]

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Chapter 1, microorganisms entering the system attach at any point of contact along the intraluminal surface. The colonizing organisms form within the needleless connector, catheter hub, and lumen and can be dispersed into the bloodstream, resulting in CLABSI. This is a particularly important source of contamination for long-term CVCs, where the needleless connectors and catheter hubs are accessed more frequently. (For a detailed discussion of needleless connectors, see Sidebar 3-3 on page 52.) It is critical, therefore, that these surfaces be thoroughly disinfected before they are accessed. Ryder outlined the issues associated with the disinfection of the surfaces of these access sites, noting that disinfection is dependent on the following five factors⁸⁸:

1. *The microbial burden on the surface of the access sites.* Various studies have shown significant hub contamination with up to five different microorganisms.
2. *The antiseptic agent used.* Appropriate disinfectants must be used to prevent transmission of microbes. While 70% alcohol is the most frequently used agent, chlorhexidine is recommended in several guidelines.^{14,18,19} Some studies have shown that disinfection of the device surface with chlorhexidine/alcohol solutions appears to be most effective in reducing colonization.^{91,92} The addition of 70% alcohol to chlorhexidine increases both the kill rate and the drying time of the agent, while the chlorhexidine has residual activity and is effective in the presence of serum.⁹⁰ Other agents that have been recommended include povidone-iodine and iodophors.¹⁴
3. *The concentration of the antiseptic agent.* The higher the concentration of the agent, the more rapid the antimicrobial eradication.¹⁴
4. *The amount of contact time between the surface and the antiseptic agent.* Menyhay and Maki found that swiping a luer-activated device with 70% alcohol for only three to five seconds did not adequately disinfect the septal surface of a needleless connector device.⁹⁰
5. *The method of application.* Various terms have been used in the literature and in guidelines to describe the process of applying the disinfecting agent to the surface (for example, *wipe, clean, disinfect, scrub*). The recent US CDC guideline uses the term *scrub*, changed from the word *wipe* in the 2002 guideline,⁹³ but does not give a recommended length of time for the scrub.

Novel devices, including aseptic barrier caps and silver-coated needleless connectors, may be promising in reducing microbial contamination, but all need to be further evaluated in prospective, randomized clinical trials to determine their impact on the prevention of CLABSIs. Initial studies include the following:

- Menyhay and Maki conducted a prospective in vitro study of an antiseptic barrier cap containing 2% chlorhexidine and 70% alcohol that, when threaded onto a needleless connector, releases the antiseptic; the antiseptic remains in constant contact with the connector until the cap is removed. The use of such a cap eliminates the need to do any further surface disinfection. This study demonstrated that the antiseptic cap is highly effective in eradicating microorganisms from the septum of a needleless connector.⁹⁰
- Maki reported in vitro studies of a commercially available antimicrobial connector that is lined with a coating of nanoparticle silver; the silver kills microorganisms and prevents formation of biofilm, thereby reducing the risk of CLABSI. The product, which is FDA approved, showed significant and sustained suppression of microbial growth over 96 hours.⁹⁴
- A prospective, randomized, and comparative clinical study recently reported in the literature found a significant decrease in microbial transfer from the injection port to the intraluminal pathway with the use of a protective cap that did not contain any disinfectant.⁸⁹
- Another device that differs from prep pads and cap products is a small cup filled with foam that is saturated with 5% chlorhexidine and 70% alcohol that employs both effective agents for disinfection and friction to disinfect hubs, needleless connectors, and injection ports. The device is positioned over the needleless connector, catheter (or stopcock), hub, or injection port and twisted for eight 360° turns. Contact time is only 10 seconds, and use of the device has been shown to be significantly more effective than use of an alcohol prep pad in eliminating surface microorganisms.⁸⁸

Stopcocks used for injection of medications, administration of IV infusions, and collection of blood samples also bear mentioning, as they represent a potential portal of entry for microorganisms into vascular access catheters and IV fluids. Whether such contamination is a substantial entry point of microorganisms that may lead to CLABSI has not been demonstrated. Nevertheless, stopcocks should always be capped when not in use. In general, closed catheter access systems are associated with fewer infections than open systems and should be used preferentially.^{13,14}

Chlorhexidine Bathing

Recently the innovative practice of bathing patients who have CVCs with chlorhexidine as a total-body bathing solution has been studied as a strategy to lower CLABSI

Sidebar 3-3. Needleless Connectors

Needle-free devices are commonly used in some countries, including the United States, as a way to minimize sharps injuries to health care personnel and the attendant risk of transmission of blood-borne pathogens (for example, hepatitis B or C, human immunodeficiency virus).^{*†‡§} The purpose of these devices is to provide needle-free access at the catheter hub in order to administer intravenous medications or fluids, withdraw blood samples, or connect administration sets to intravascular catheters, and there has been an explosion in the manufacture and use of these devices over the past 20 years.^{||} The term *needleless connector* (NC) is intended to describe the entire group of these devices; they can be categorized based on the how they function and the complexity of their internal mechanisms.[#] Table 3-2 below provides an overview of the two categories of needleless connectors.

Unfortunately, these products have gone largely untested relative to patient safety and to device-related bloodstream infection. Several outbreaks in hospitals, long term care, and home care settings have been reported in the literature, particularly when switching from split septum to mechanical valve NCs (see Table 3-3 on page 53).^{*} A key feature common to several participants in the study was the significant decrease in CLABSI rates to levels at or below pre–mechanical valve NC rates when split septum NCs were reinstated.^{*} Two common risk factors emerged from the outbreaks that have been reported in the literature: an NC design that allows contamination to occur when not in use and poor adherence by health care personnel to disinfection practices before accessing the devices.^{**} Researchers have also identified that health

care personnel were often unaware of manufacturer-specific recommendations for use of the NCs.^{*}

Jarvis et al. published a report involving several wards and ICUs in the United States and Australia that experienced CLABSI outbreaks when they switched from split septum to mechanical valve NCs and found several factors that prompted the switch^{*}:

- Interest in being able to better visualize the internal structure of the NC
- Concern that the split septum NCs would not continue to be manufactured
- Use of infusion pumps that required the use of manufacturer-compatible mechanical valve NCs
- Desire to reduce the use of prophylactic heparin/thrombolytic agents

The researchers also learned that the decision to change from split septum to mechanical valve NCs was often made by occupational health staff, product evaluation, or other committees, without input from infection preventionists.^{*}

There are likely many factors that may have contributed to outbreaks associated with the use of NCs over the past two decades, including the following^{††}:

- Failure to adequately disinfect the surface of the connector if the surface is not smooth
- Complex fluid pathway properties that could make adequate flushing difficult and permit biofilm development
- Complex internal mechanisms, which can also permit biofilm development or fail to work as designed
- Potential dead spaces, where blood can pool
- Poor visualization of fluid flow pathway (opaque rather than clear) that can result in inadequate flushing of the device

Table 3-2.
Overview of the Two Categories of Needleless Connectors

Type of Needleless Connector (NC)	Description
Split septum NC	Prepierced connectors that have no internal mechanisms. These were the first generation of NCs. They are accessed with a blunt plastic cannula or the male luer end of an administration set or syringe, rather than a needle.
Mechanical valve NC	Connectors with a mechanical valve, which controls the flow of fluid within the system. These were the second generation of NCs. These connectors require a luer connector, and the tip of the syringe or intravenous tubing is directly inserted into the cap, obviating the need for a blunt needle. They are classified as negative, neutral, or positive displacement type, based on their internal membrane or valve function.

Sources: Btaiche IF, Kovacevich DS, Khalidi N, Papke LF. The effects of needleless connectors on catheter-related bloodstream infections. *Am J Infect Control*. 2011 May;39(4):277–283. Epub 2011 Jan 22; Hadaway L, Richardson D. Needleless connectors: A primer on terminology. *J Infus Nurs*. 2010 Jan–Feb;33(1):22–31. Accessed Mar 18, 2012. <http://www.cdc.gov/publiccomments/comments/guidelines-for-the-prevention-of-intravascular-catheter-related-infections/2034.ashx>.

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Sidebar 3-3. (Continued)

Table 3-3.
Some Examples of Increased Catheter Infections
Related to Needleless Devices

Reference	Type of Needleless Connector/Setting	Summary
Rupp ME, Sholtz LA, Jourdan DR, et al. Outbreak of bloodstream infection temporally associated with the use of an intravascular needleless valve. <i>Clin Infect Dis</i> . 2007;44:1408–1414.	Positive-pressure mechanical valve	Multiple units in a hospital. There was a temporal association between switching from a split septum NC to a positive-pressure mechanical valve NC and an almost threefold increase in the CLABSI rate. The CLABSI rate returned to baseline once the mechanical valve NC was removed from clinical use.
Salgado CD, Chinnes L, Paczesny TH, Cantey JR. Increased rate of catheter-related bloodstream infection associated with use of a needleless mechanical valve device at a long-term acute care hospital. <i>Infect Control Hosp Epidemiol</i> . 2007;28(6):684–688.	Positive-pressure mechanical valve Long-term acute care hospital	A temporal association was identified between switching from a split septum NC to a positive-pressure mechanical valve NC and a more than threefold increase in the CLABSI rate (1.79 versus 5.95 CLABSIs per 1,000 catheter-days). The CLABSI rate returned to baseline within six months of the switch back to the use of the split septum NC (1.70 CLABSIs per 1,000 catheter-days).
Field K, McFarlane C, Cheng AC, et al. Incidence of catheter-related bloodstream infection among patients with a needleless, mechanical valve-based intravenous connector in an Australian hematology-oncology unit. <i>Infect Control Hosp Epidemiol</i> . 2007;28(5):610–613	Negative-pressure mechanical valve Hospital hematology-oncology unit	The unit switched from a split septum to a mechanical valve NC and coincidentally noticed more than a doubling of its CLABSI rate (2.6 versus 5.8 CLABSIs per 1,000 catheter-days). The CLABSI rate returned to baseline within six months of the switch back to the split septum NC (2.3 CLABSIs per 1,000 catheter-days)
Maragakis LL, Bradley KL, Song X, et al. Increased catheter-related bloodstream infection rates after the introduction of a new mechanical valve intravenous access port. <i>Infect Control Hosp Epidemiol</i> . 2006;27(1):67–70.	Positive-pressure mechanical valve Adult, pediatric, and neonatal ICUs in an academic medical center	The hospital identified a temporal association between a switch from a negative-pressure mechanical valve NC to a positive-pressure mechanical valve NC and a 60% increase in the CLABSI rate (1.5 versus 2.4 CLABSIs per 1,000 catheter-days). When the previously used mechanical valve NC was reintroduced, the CLABSI rate returned to baseline.
Cookson ST, Ihrig M, O'Mara EM, et al. Increased bloodstream infection rates in surgical patients associated with variation from recommended use and care following implementation of needleless device. <i>Infect Control Hosp Epidemiol</i> . 1998;19(1):23–27.	Split septum NC Surgical ICU and the organ transplant unit of a tertiary care hospital	The CLABSI rate increased with the introduction of an NC (replaced needle-access) (9.4 versus 5.0 per 1,000 catheter-days for the SICU; 13.6 versus 2.2 per 1,000 catheter-days for the organ transplant unit). The researchers identified unfamiliarity with the newly implemented device and care practices that deviated from those recommended by the manufacturer as factors contributing to the outbreak.

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Sidebar 3-3. (Continued)

- Presence of internal corrugations that could harbor bacteria.

Mechanical valve connectors also require a specific routine clamping sequence when disconnecting the syringe or tubing from the luer cap (either disconnect and clamp or clamp and disconnect); if the proper sequence is not followed, catheter occlusion can result, leading to an increased risk for CLABSI.[†]

These reported outbreaks led to the recommendation in the 2008 SHEA/IDSA compendium against the routine use of positive-pressure mechanical NCs (also referred to as positive-displacement mechanical NCs),^{††} although the research done by Jarvis et al. identified both positive- and negative-pressure mechanical valve NCs manufactured by different companies in the CLABSI outbreaks they studied.* In 2010 the US FDA sent an alert to health care personnel regarding concerns with the positive-pressure mechanical NCs but stated that there was insufficient data to determine whether the risk was associated with some or all of the devices or the exact magnitude of the CLABSI risk with the devices. The FDA established a requirement that manufacturers of positive-displacement NCs conduct postmarket surveillance studies to help clarify the infection risk associated with the devices and to more precisely define their risks and benefits. Specifically, the FDA required manufacturers to collect data on patients who developed CLABSIs while their devices were in use, compared to other types of NCs. The FDA expects these studies to take up to three years to complete; the FDA will determine whether regulatory or other actions need to be taken at the completion of the study period.^{§§}

SHEA and IDSA stated in their joint 2008 recommendations that a thorough assessment of the risks, benefits, and education regarding proper use of positive-pressure NCs should precede their adoption for use.^{††} Close monitoring of CLABSI rates would also be advised when any change in technology occurs in health care organizations.^{||}

The US CDC recommends that needleless systems be used to access intravenous administration sets, along with the following additional recommendations^{††}:

- Use a split septum rather than mechanical valve NCs due to the increased risk of infection with the mechanical valves.
- Ensure that all components of the system are compatible to reduce the risk of leaks and breaks in the system.
- Change needleless components at least as frequently as the administration set and no more frequently than every 72 hours.
- Change the NCs no more frequently than every 72 hours, or according to the manufacturer's recommendations.

- Reduce the risk of contamination by scrubbing the access port with an appropriate disinfectant and access the port using sterile devices.

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- §§ US Food and Drug Administration. Positive Displacement Needleless Connectors and Bloodstream Infections: Initial Communication. Aug 11, 2010. Accessed Mar 18, 2012. <http://www.fda.gov/MedicalDevices/Safety/AlertsandNotices/ucm221988.htm>.
- || Chittick P, Sherertz RJ. Recognition and prevention of nosocomial vascular device and related bloodstream infections in the intensive care unit. *Crit Care Med*. 2010 Aug;38(8 Suppl):S363–372.

rates. The rationale for the use of chlorhexidine bathing in place of soap and water bathing relates to the patient's resident skin flora that can enter the bloodstream at the CVC insertion site or the extraluminal surface of the catheter. Reducing skin contaminants should further reduce the risk of CLABSI. A few researchers, including the following, have studied chlorhexidine bathing as a risk-reduction strategy:

- Dixon and Carver implemented the IHI central line bundle in 2005 in their surgical ICU. By 2007 adherence to the bundle had become sustained at 90%, but the unit's CLABSI rate was still above the National Healthcare Safety Network's (NHSN's) benchmark rate. Within three months of implementing the chlorhexidine body washes, the CLABSI rate decreased from 12.07 to 3.17 infections per 1,000 catheter-days, almost a 74% decrease.⁹⁵
- Evans et al. used a before-and-after study design to evaluate the impact of daily bathing with no-rinse disposable chlorhexidine-impregnated washcloths in a 12-bed ICU in a level 1 trauma center. More than 250 patients were bathed without the chlorhexidine washcloths before the intervention, and more than 280 were bathed with the chlorhexidine washcloths during the six-month intervention. Patients who were bathed with chlorhexidine were significantly less likely to develop CLABSIs (2.1 versus 8.4 infections per 1,000 catheter-days). Colonization with methicillin-resistant *Staphylococcus aureus* (MRSA) and *Acinetobacter* was also significantly lower in the chlorhexidine group than in the comparison group (23.3 versus 69.3 and 1.0 versus 4.6 per 1,000 patient-days, respectively).⁹⁶
- Climo et al. sought to determine whether daily chlorhexidine bathing could reduce the incidence of multidrug-resistant organisms and CLABSIs in six ICUs at four medical centers. After the introduction of the daily chlorhexidine bathing, MRSA acquisition decreased by 32% (5.04 versus 3.44 cases per 1,000 patient-days) and vancomycin-resistant enterococci (VRE) acquisition decreased by 50% (4.35 versus 2.19 cases per 1,000 patient-days). The rate of CLABSIs caused by VRE decreased during the study period, from 2.13 infections to 0.59 infections per 1,000 patient-days (72.4% decrease); MRSA rates were low initially and continued to be so during the study period.⁹⁷
- Munoz-Price et al. evaluated the effect of chlorhexidine bathing of patients on the rate of CLABSI in a 70-bed long term acute care hospital. The findings of the researchers are summarized here:

- During the preintervention period (patients received daily baths with soap and water) the CLABSI rate was 9.5 per 1,000 catheter-days.
- During the intervention period (daily baths with chlorhexidine) the CLABSI rate decreased to 3.8 per 1,000 catheter-days.
- During the postintervention period (daily nonmedicated baths and weekly chlorhexidine baths), the CLABSI rate rose to 6.4 infections per 1,000 catheter-days.

The research team concluded that chlorhexidine bathing was an easy and effective intervention that reduced the rate of CLABSI in the facility.⁹⁸

- Bleasdale et al. studied the implementation of daily chlorhexidine bathing versus soap and water bathing in a 22-bed medical ICU. They found a 61% relative decline in the CLABSI rate in the group of patients with the antiseptic bathing compared to the regular soap and water group (4.1 versus 10.4 infections per 1,000 catheter-days).⁹⁹

The US CDC and SHEA/IDSA recommendations suggest that daily bathing of ICU patients older than 2 months of age with a 2% chlorhexidine-impregnated washcloth may be a useful strategy to decrease CLABSI rates in organizations that have unacceptably high CLABSI rates, despite implementation of the basic recommended prevention strategies.^{14,18} Concern has been raised, however, regarding the potential for chlorhexidine resistance and whether widespread use of chlorhexidine gluconate bathing may create problems in the future.¹⁰⁰

Use of a CVC Maintenance Bundle

CVCs can be in place from hours to weeks or longer and are manipulated by a multitude of staff members over the life of a CVC. CVCs are accessed many times while in place, to deliver fluids and medications and to collect blood specimens. Because each entry into access points in the delivery system is an opportunity to introduce microorganisms, the post-CVC insertion period presents multiple opportunities for risk of infection. It was recently reported that almost 72% of all CLABSIs reported to the NHSN by Pennsylvania acute care hospitals in 2010 occurred more than five days after insertion, suggesting that infection prevention lapses likely occurred in the postinsertion care and maintenance of the CVCs.¹⁰¹ Shapey et al. sought to assess staff members' practice and knowledge of CVC postinsertion care in a tertiary care hospital, finding that lapses in proper infection prevention techniques occurred in 45% of

postinsertion care episodes; the most common lapses were related to keeping caps and site dressings in place.¹⁰²

Many of the evidence-based practices used for the insertion of CVCs are also important in the care and maintenance of these catheters (for example, hand hygiene, proper skin antisepsis at the insertion site, dressing changes, thorough disinfection of CVC hubs and injection ports, replacement of administration sets and fluids, daily assessment of the continued need for the CVC).^{14,19} The use of insertion bundles has resulted in more consistent application of evidence-based practices during the insertion of CVCs, but much less is known about the potential impact postinsertion bundles might have on the prevention of CLABSIs. A few recent studies that have evaluated the use of postinsertion bundles include the following:

- In 2004 researchers at a large university hospital studied the impact of a multimodal teaching intervention and CVC care procedures on CLABSI rates in five adult ICUs.²⁹ Education was directed at all nurses and physicians. CVC insertion practices were not the focus of the study, as evidence-based practices for CVC insertion were already part of the hospital's internal guidelines. Specific components of the postinsertion care education included hand hygiene and proper procedures for catheter site dressing changes, CVC manipulation, and infusate preparation. CLABSI rates decreased from 3.9 infections per 1,000 catheter-days before the intervention to 1.0 infection per 1,000 catheter-days during the intervention.
- Also in 2004, 27 National Association of Children's Hospitals and Related Institutions (NACHRI) member hospitals came together to reduce CLABSI rates among 29 pediatric ICUs across the United States.⁷⁰ They sought to identify which infection prevention practices would have an impact on CLABSI rates in children. The pediatric population has risk factors for infection that are different from adults (for example, CVCs are often used to obtain blood samples or are kept in place longer in case the line is needed in an emergency, or the presence of underlying genetic syndromes and congenital malformations could affect the functioning of CVCs in children), and little research has been done on whether multifaceted interventions that have been successful in reducing adult CLABSI rates would apply to children. Collaborative leaders developed a CVC insertion and maintenance bundle, which was implemented at each site between October 2006 and September 2007. Hospital teams used quality improvement methods to

ensure that their care practices were in line with each bundle's specifications and participated in ongoing workshops and conference calls to facilitate communication and coordinate efforts among the hospitals. CLABSI rates were monitored, and staff members' adherence to each element of the bundles was determined. CLABSI rates decreased by 43% across the 29 pediatric intensive care units (PICUs) (5.4 versus 3.1 CLABSIs per 1,000 catheter-days) over the study period. Adherence to each element of the insertion and maintenance bundles was also monitored during this time period, with insertion bundle adherence at 84% and maintenance bundle adherence at 82%; bundle adherence was assessed as "all or none," meaning all elements of each patient's insertion and maintenance procedure needed to comply with all elements of the respective bundle to be considered adherent. When the researchers assessed the relative importance of the insertion versus the maintenance bundles, they found that the only significant predictor of improvement in the CLABSI rate was maintenance bundle adherence.

Due to the limited available evidence on effective maintenance bundles, this maintenance bundle was developed by the collaborators using the US CDC's 2002 guideline with the consensus of pediatric physicians and nurses.⁹³ The maintenance bundle developed by the consensus group included the following:

- Assess the continued need for the catheter every day.
- Perform catheter site care with chlorhexidine at dressing changes.
- Change gauze dressing every 2 days, clear dressings every 7 days (and more frequently if soiled, damp, or loose).
- Replace administration sets and add-on devices no more frequently than every 72 hours, unless contamination occurs.
- Replace tubing used to administer blood, blood products, or lipids within 24 hours of start of infusion.
- Change caps no more often than 72 hours (or according to manufacturer's recommendations and whenever the administration set is changed).

While this was a successful initiative, the collaborators recognize that additional research will be necessary to determine the optimal maintenance bundle components that will facilitate the elimination of CLABSIs in pediatric patients with short- or long-term CVCs.⁷⁰

- US Department of Veterans Affairs (VA) hospitals implemented a CVC insertion bundle and surveillance system across all of its US hospitals in April 2006.¹⁰³ The Denver VA Medical Center, however, noticed that its CLABSI rate continued to be high during the first 2 years of the program (5.7 CLABSIs per 1,000 catheter-days), despite 94% adherence to all aspects of the bundle by health care personnel. A review of CLABSI cases revealed a median dwell time of 12 days before onset of infection, leading to concerns about postinsertion CVC care and resulting in the implementation of a postinsertion bundle in October 2008. The postinsertion bundle, developed by nursing staff and facilitated by each nursing unit's IV champion, included hand hygiene before manipulation of the IV system; daily inspection of the insertion site; site care if the dressing was wet or soiled or had not been changed for 7 days; application of a chlorhexidine-impregnated sponge at the insertion site; alcohol scrub of infusion hubs for 15 seconds before each use; and documentation of the ongoing need for the CVC. All nursing staff members were required to attend a 4-hour, hands-on training class in the proper techniques for caring for and accessing catheters, which was followed by a competency evaluation of CVC insertion site and hub care.

During the implementation of the postinsertion bundle (October 1, 2008, to September 30, 2009), adherence to the insertion bundle protocol remained high at 93%. The CLABSI rate, however, declined significantly to 1.1 CLABSIs per 1,000 catheter-days, from the 5.7 rate observed in the preintervention period.

This study was one of the first to focus on postinsertion care of CVCs in a setting where insertion bundles had already been successfully implemented. It demonstrated that sterile technique at the time of CVC insertion, while essential to prevent infection, is not sufficient alone.¹⁰³

Removal or Replacement of Catheters or System Components

Health care personnel must ensure that a patient's central venous catheter is removed or replaced at the appropriate time and in a safe manner. The following sections discuss daily review of line necessity, changing administration system components, and CVC exchanges over a guidewire.

Daily Review of Line Necessity

Risk of CLABSI increases with the duration of time the catheter is left in place, so daily evaluation of the continued

need for a catheter is an important aspect of CLABSI prevention; catheters that are no longer needed should be promptly removed.^{7,14,18,19,104–107} Lederle et al. found that 20% of the peripheral intravenous catheter–days in their organization were “idle,” or days when the line was not in use.¹⁰⁸ In a study conducted by Zingg et al. in a large university-affiliated hospital, 130 of 2,704 (4.8%) CVC–days were determined to be unnecessary; in several site visits, neither the nurse nor the treating physician knew why the patient had a CVC.¹⁰⁹ Trick et al. studied patients with CVCs in a 600-bed public teaching hospital and found that 43 of 945 (4.6%) catheter-days were not justified.¹⁰⁶ Both of these research groups also found differences in CVC use between ICU and non-ICU settings: unjustified CVC–days were more common in the non-ICU settings.

Daily review of the continued need for CVCs can be done during multidisciplinary patient care rounds or by using reminders, such as stickers on patient records or order sets, or via automated computer alerts.

Changing Administration System Components

The cumulative risk of contamination of an IV system increases if an infusion runs for an extended period. Therefore, it is important that the administration system, which includes the primary and any secondary sets and add-on devices, be changed on a regular basis. In 1971, in response to an outbreak in the United States associated with intrinsic fluid contamination, the US CDC recommended that all administration sets be routinely changed every 24 hours.¹¹⁰ Over the next 25 years and with additional research showing safety in extension of use for longer periods, most hospitals in the United States routinely changed the entire administration system every 24 to 48 hours.⁶⁵ Current evidence suggests that the most appropriate interval for routine replacement of IV administration sets is no more frequently than every 96 hours, and at least every 7 days, after initiation of use. This replacement interval is safe and permits considerable cost savings to health care organizations.^{13,14,18} However, if fluids that enhance microbial growth are infused (for example, fat emulsions combined with amino acids and glucose in three-in-one admixture or [infused separately]; blood products), tubing and add-on devices should be changed within 24 hours of the start of the infusion.^{13,14,18} Needleless components should be changed at least as often as the administration set and no more often than every 72 hours.¹⁴

The evidence is less clear for intravenous sets that are used intermittently, due to a lack of published research in this area.

Because intermittent infusions require manipulation at both ends of the set with each use (a new fluid container replaces the empty one, and the male luer end is connected to the intravenous catheter), there is a greater opportunity for contamination of the IV system. The Infusion Nursing Society makes a distinction between administration sets that are used intermittently and those that are used for continuous infusion, recommending that intermittent sets be changed every 24 hours.¹³ In a survey conducted by Hadaway, intermittent infusion therapy was found to be a common method used for administering medications and fluids in all clinical settings, with extreme differences in how the sets are handled between use and the length of time they are in use.¹¹¹ The US CDC regards the optimal interval for changing administration sets used infrequently as an unresolved issue.¹⁴

CVC Exchanges over a Guidewire

While guidelines recommend that central lines not be routinely replaced, they should be replaced if there is a suspected infection or a mechanical malfunction.^{14,19} There are two methods for replacing CVCs: (1) placing a new catheter over a guidewire at an existing CVC site and (2) inserting a new catheter at a different site. Guidewire insertion has been the accepted technique for replacing a malfunctioning CVC (or exchanging a pulmonary artery catheter for a CVC when invasive monitoring is no longer necessary), as it is associated with significantly fewer mechanical complications and less patient discomfort than those inserted at a new site.^{14,19} This technique also preserves limited venous access in some patients. Unfortunately, the use of an existing CVC site is also associated with an increased risk of CLABSI, as compared with the use of a new CVC site.⁶⁵ Guidewire exchange is not recommended in the presence of a CLABSI, as the colonized CVC skin tract from the insertion site to the vein is usually the source of infection.³⁸ However, in select patients with CLABSIs who have limited venous access and who have tunneled hemodialysis catheters, catheter exchange over a guidewire along with antibiotic therapy is an alternative salvage strategy.¹⁴

It is essential that the same strict aseptic technique (maximal sterile barrier precautions, including the use of a cap, mask, sterile gown, sterile gloves, a sterile full body drape, and so forth) be used during guidewire exchanges as is used during insertion of CVCs at new sites.¹⁴

Tools and Techniques

A variety of tools and techniques have been developed to help health care personnel use best practices and improve

their performance in handling CVCs. The sections that follow discuss checklists, vascular access teams, and safe practices for parenteral fluid and medication administration and vial access.

Checklists

A checklist is a list of criteria or action items that are arranged in a systematic order, the purpose of which is to improve adherence to best practice and reduce error.¹¹² Standardized CVC checklists reflect the elements included in the bundle and serve to remind health care personnel of key steps and procedures that need to be done with each CVC insertion (or maintenance episode). A checklist is a tool that can help prevent CLABSI by reminding health care personnel of the evidence-based practices all patients should receive, thereby reducing ambiguity about what should be done and promoting patient safety.¹¹³ In addition to the evidence-based practices (such as using a large sterile drape and avoiding the femoral site for CVC placement), the checklist can also contain other reminders, such as to correctly identify the patient before the procedure or not to use the subclavian site for patients needing hemodialysis. Using a checklist requires at least two staff members: the inserter, who performs the procedure, and the observer, who records the information on the checklist. In many organizations the observer, usually a registered nurse, is also empowered to stop the procedure if any lapses in technique occur.

Organizations can develop their own checklists, or they can adopt or adapt an existing checklist to meet their needs. Figure 3-2 on page 59 contains an example of a CVC insertion checklist developed by one organization.

The checklist must be used with each CVC insertion¹³; placing checklists on or near supply carts or catheter kits is important to ensure their use. Finally, organizations will need to determine whether a checklist becomes part of a patient's medical record or whether it will be used strictly as a performance improvement tool.

A word of caution is in order regarding the use of checklists. Use of a checklist, in and of itself, is not a magic bullet that automatically results in safer patient care and a reduction in CLABSI rates. Its use must be coupled with attitude and culture change within the organization, a thorough awareness and understanding of the evidence-based underpinnings of the bundle elements reflected on the checklist, and a team mind-set that each and every step is essential in order to provide the best possible care for every patient. Checklists

**CENTRAL LINE INSERTION STANDARD WORK & SAFETY (BUNDLE)
CHECKLIST for CCU & IV RNs**

Date: _____		Start Time: _____		End Time: _____	
Procedure Location: <input type="checkbox"/> Radiology <input type="checkbox"/> OR <input type="checkbox"/> CCU <input type="checkbox"/> Induction Room <input type="checkbox"/> Dialysis <input type="checkbox"/> Other _____		Person Filling Out Form:			
Procedure Operator: _____		<input type="checkbox"/> Attending <input type="checkbox"/> Resident <input type="checkbox"/> IV RN <input type="checkbox"/> PA <input type="checkbox"/> IV RN <input type="checkbox"/> CCU RN <input type="checkbox"/> Other, title _____ <input type="checkbox"/> Dialysis <input type="checkbox"/> Central Venous <input type="checkbox"/> PICC (type) <input type="checkbox"/> PA/Swan Ganz <input type="checkbox"/> Port Number of Lumens: <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 Catheter lot number: _____			
Insertion Site: <input type="checkbox"/> Jugular <input type="checkbox"/> Upper Arm <input type="checkbox"/> Subclavian <input type="checkbox"/> Femoral		Side of Body: <input type="checkbox"/> Left <input type="checkbox"/> Right <input type="checkbox"/> Bilateral			
Reason for Insertion (NO Routine Replacement) <input type="checkbox"/> Elective <input type="checkbox"/> Malfunction <input type="checkbox"/> Emergent					
BEFORE	Central Line Standard Work				YES
	Patient's Allergy Assessed (especially to Lidocaine or Heparin)				<input type="checkbox"/>
	Patient's Latex Allergy Assessed (modify supplies)				<input type="checkbox"/>
	Consent form complete & in chart Exception: Emergent Procedure				<input type="checkbox"/>
	Bundle Element = Hand Hygiene				
	Operator and Assistant cleanse hands (ASK, if not witnessed)				<input type="checkbox"/>
	Bundle Element = Optimal Catheter Site Selection				
	Subclavian is the preferred site for central lines Check / Explain why alternate site used: _____				<input type="checkbox"/>
	<input type="checkbox"/> Anatomy – distorted, prior surgery/rad. Sac <input type="checkbox"/> Anesthesiologist placed <input type="checkbox"/> Chest wall infection <input type="checkbox"/> Coagulopathy <input type="checkbox"/> COPD severe/ lung dx <input type="checkbox"/> Dialysis line placed <input type="checkbox"/> Emergency / CPR <input type="checkbox"/> Operator training <input type="checkbox"/> PICC Placed				OR Exception(s) Checked to left
	Procedural Time - Out Performed _____ Patient ID X 2 _____ Announce the procedure to be performed _____ Mark/ assess site _____ Position patient correctly for procedure (Supine or Trendelenburg) _____ Assemble equipment/ verify supplies, including venous confirmation method _____ Verify that all medication & syringes are labeled _____				<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
DURING	Bundle Element = Skin Antisepsis				
	Skin Prep Performed				
	Chlorhexidine/alcohol applicator used: Dry technique: 30 second scrub + 30 second dry time				<input type="checkbox"/> DRY
	OR				<input type="checkbox"/> OR
	Chlorhexidine/alcohol applicator used: Wet technique: 2 minute scrub + 1 minute dry time				<input type="checkbox"/> WET
	Bundle Element = MAXIMUM Sterile Barriers				
	Patient's body covered by sterile drape				<input type="checkbox"/>
	Operator and Assistant in PPE (sterile gloves, hat, mask and sterile gown)				<input type="checkbox"/>
	Others (in room, except patient) wearing Mask				<input type="checkbox"/>
	VMMC Bundle Element = Ultrasound Guidance				
Ultrasound Guidance Used for PICC, Internal Jugular & Femoral Insertions				<input type="checkbox"/> Device OR <input type="checkbox"/> Subclavian	
AFTER	VMMC Bundle Element = Venous Confirmation				
	Confirmation of Venous Placement PRIOR TO DILATION OF VEIN by:				<input type="checkbox"/> Method OR
	Approved methods: 1) TEE OR 2) Pressure Transducer OR 3) Manometry Method OR 4) Fluoroscopy				<input type="checkbox"/> PICC
	Type and Dosage (mL / units) of Flush: _____				<input type="checkbox"/>
	Catheter Caps Placed on Lumens				<input type="checkbox"/>
	Catheter Secured / Sutured in place				<input type="checkbox"/>
	Tip position confirmation via: Fluoroscopy OR Chest X-ray ordered				<input type="checkbox"/>
	Sterile Technique Maintained when applying dressing				
Dressing Dated					
Chest Xray / Fluoroscopy Findings Confirm Catheter Position					
Repositioning Required because of Xray Findings					
"Approved for use" Writing on Dressing After Confirmation					
If placed in CCU, CCU RN Notified IV RN Dept. X of Central Line Placement					
If a Femoral line placed, Elective PICC Placement Ordered (NOW).					
Central line (maintenance) Order Placed					
Procedure Note: _____					
Tip location: _____			Catheter Measurements: (Cut catheter, external length, internal length) _____		

PATIENT NAME & ID # _____

VIRGINIA MASON MEDICAL CENTER – Seattle WA
Central Line Insertion Standard Work & Safety (Bundle)
Checklist for CCU & IV RNs



DISTRIBUTION WHITE: Medical Record

YELLOW: Patient

VMMC Form 901550 (04-12)

Figure 3-2. Sample CVC Insertion Checklist

Source: Virginia Mason Medical Center, Seattle. Used with permission.

are a tool to *support* the implementation of a multifaceted intervention aimed at improving patient care.^{112,113}

Vascular Access Teams

Studies have shown that the use of specialized vascular access teams (or IV teams), consisting of trained nurses or technicians who use strict aseptic technique during catheter insertion and follow-up care, can reduce the risk of phlebitis, bloodstream infections, and costs.^{14,18,65} Marschall et al. note, however, that few studies have been performed regarding the specific impact of such teams on CLABSI rates.¹⁸

Marschall et al.¹⁸ and Pratt et al.¹⁹ categorize the use of vascular access teams as a CLABSI improvement strategy that is an unresolved issue regarding reducing CVC infection risk, due to the paucity of studies specific to CVC insertion. However, regarding peripheral venous catheter infection prevention or combined peripheral venous and CVC infection prevention, studies of IV teams have repeatedly demonstrated reduced cost and risk of infection.⁵⁴ Having a team may be difficult to achieve in settings with a low nurse-to-patient ratio. However, even if an organization does not have a vascular access team, the evidence does support formal education of physicians and nurses, as well as adherence to CVC insertion and maintenance care best practices, to reduce CLABSI rates.^{17,68}

Safe Practices for Parenteral Fluid and Medication Administration and Vial Access

Aseptic technique, which is important in the insertion and care of CVCs, also plays a broader role in an organization's overall approach to safe handling of intravenous fluids. All fluids (that is, infusates, medications, parenteral nutrition, and flushes) must be prepared and administered aseptically to avoid introducing microorganisms into the intravenous system. Outbreaks have occurred following improper preparation or administration of such fluids.^{114–116} In 2008, the United States Pharmacopeia (USP) revised General Chapter 797: Pharmaceutical Compounding—Sterile Preparations, which applies to pharmacy settings and to all individuals who prepare compounded sterile preparations (CSPs) in all settings in which they are administered.¹¹⁷ Commonly known simply as USP 797, this chapter covers standards for preparing and labeling sterile preparations, as well as time frames for discarding these preparations. To maintain the sterility of compounded sterile preparations, pharmacies compound sterile preparations in an International Organization for

Standardization (ISO) Class 5 environment. A Class 5 environment is a “clean room” that has stringent ventilation and air quality specifications, as well as laminar air-flow hoods and strict requirements for personal protective equipment worn by health care personnel and for surface sanitation. However, “immediate use” CSPs (for example, those that involve the measuring, diluting, dissolving, or mixing of nonnutrient sterile preparations using sterile devices) that are prepared outside the ISO 5 environment without these special facilities is permitted for certain sterile products; “immediate use” requires beginning the administration of these preparations within one hour. The rationale for the requirement that immediate-use CSPs be administered within that time frame takes into consideration the potential for contamination of intravenous solutions, vials, and syringes from both direct contact and airborne sources. If contamination does occur, microorganisms begin to replicate within one to four hours, with rapidly accelerating growth thereafter.¹¹⁷ It is important, therefore, that only health care personnel who are deemed competent perform these procedures and that adherence to proper procedures and aseptic technique be periodically assessed.

Although outbreaks associated with contaminated infusate are rare, as with all aseptic practices, proper hand hygiene must always be performed before handling solutions and medications.¹⁴ Other basic infection prevention practices that should also be performed include the following^{118,119}:

- Medications should be stored and prepared in a designated clean medication area away from areas where potentially contaminated items are placed (for example, locations with equipment such as syringes, needles, IV tubing, blood collection tubes, needle holders, or other soiled equipment or materials that have been used in a procedure). In general, any item that could have come in contact with blood or body fluids should not be in the medication preparation area.
- Ideally, IV solutions should be admixed in a controlled environment in a pharmacy, using a laminar airflow hood and aseptic technique.^{13,120,121}
- Syringes and needles/cannulas should be stored in their original packages until ready to use, to maintain sterility.¹²⁰
- To prevent introducing potential contaminants into the patient's CVC line, IV ports and the rubber septum on vials should be disinfected by wiping with friction, using an approved antiseptic swab prior to piercing it (for example, chlorhexidine, 70% isopropyl alcohol, ethyl/ethanol alcohol, iodophors).

- Parenteral medications should be accessed in an aseptic manner, using a new sterile syringe and sterile needle to draw up medications. Care should be taken to prevent contact between the injection materials and the nonsterile environment.
- A medication vial should be entered with a new sterile access and sterile syringe.¹²⁰ There has been at least one outbreak attributed to health care personnel using a common needle and syringe to access multiple multidose vials for the purpose of combining their contents into a single syringe.¹¹⁴ If one vial becomes contaminated, contamination can spread to the other vials, increasing the potential for infection transmission. Syringe reuse in this fashion may also have been a factor in additional outbreaks.^{122,123}
- A needle or other device should never be left inserted into a medication vial septum for multiple uses. This provides a direct route for microorganisms to enter the vial and contaminate the fluid.
- Intravenous solution containers (for example, bottles or bags) should never be used as a common source of solution for more than one patient for any reason, even if using a spiking device that has a one-way valve.¹²⁰ (*Note:* The only exception to this is in pharmacies using laminar airflow hoods and meeting associated air quality, ventilation, and sanitation requirements to maintain sterility in the preparation of solutions and medications.^{118,120})
- Single-dose vials should be used for each patient.
- The use of multidose vials should be limited; if they must be used, each should be used for one patient only (labeled with the patient's name and date).
- All opened IV solutions, vials, and prepared or opened syringes involved in a patient emergency should be discarded.¹²⁰
- Any solutions, medications, or vials should be discarded in any of the following situations:
 - Sterility is compromised or in question.
 - The expiration date has passed, even if the vial contains antimicrobial preservatives.
 - Any discoloration, particulate matter, or turbidity is present.

The tools and techniques described in the foregoing sections are examples of best practices. However, there are some practices, as shown in Sidebar 3-4 on page 62, that should be avoided because they have not been found effective or, worse, have been found to increase risk of harm to the patient.

Special Considerations

The following sections discuss the special considerations of parental nutrition and of CVC use in ICU versus non-ICU settings.

Parenteral Nutrition

Parenteral nutrition (PN) provides the minimal critical nutrients to reduce the risk of malnutrition in patients unable to obtain adequate nutrition by the oral or enteral route.^{124,125} Candidates for PN include patients with Crohn's disease, radiation enteritis, and intestinal obstruction, as well as critically ill and trauma patients.^{125,126} Due to the often acidic and hypertonic properties of the solution, most PN solutions require administration through a CVC.¹²⁷⁻¹²⁹ However, peripherally administered PN may be used for low-osmolarity mixtures.¹²⁸

The risk of administering PN is different from that of other intravascular therapy modalities due to the following¹²⁸:

- Underlying disease in the patient can increase the risks of acquiring HAIs.
- Remote infections are often present that can result in hematogenous seeding of the CVC.
- CVCs for PN are often in place longer than most CVCs.

PN is widely recognized as an independent risk factor for CLABSI,¹³⁰⁻¹³⁵ so health care personnel should replace PN with enteral feeding at the earliest opportunity to reduce CLABSI risk.¹³⁵⁻¹³⁸ Due to differences in study design, definitions of infections, and varying populations, the incidence of CLABSI has been reported to be as low as 1.3% and as high as 39% in patients receiving PN.^{125,126,132} Contamination of PN is seldom the cause of CLABSI when there is strict adherence to aseptic compounding technique. PN solutions can foster microbial growth, with *Candida* being the microorganism most frequently reported to proliferate in PN.^{125,139} The component of PN most likely to foster fungal or bacterial proliferation is the lipid emulsion component.^{125,139} One group of researchers, however, did not find lipid emulsions administered with premixed PN to be a significant factor in the development of infection, when compared to omitting lipids from PN therapy.¹⁴⁰

PN can be provided as either standardized or individualized solutions compounded in a health care facility or by an outsourced pharmacy. Commercially available premixed ready-to-use formulations in multichamber bags are also available.¹²⁸ The use of multichamber bags instead of compounded PN has been associated with lower risks of

Sidebar 3-4. Practices to Avoid

The following practices should be **avoided** because there is **no evidence to support them**:

- *Routine replacement of CVCs at specified intervals as a strategy to prevent CLABSI (including guidewire exchanges).*^{*,†‡} CVCs should be replaced only when there is suspected infection, catheter migration, or defects in the catheter; further, CVCs should be replaced if they have been replaced over a guidewire and the site is subsequently found to be colonized, or if the CVC was inserted under emergent conditions when aseptic technique was not maintained.
- *Use of antimicrobial prophylaxis before short-term or tunneled catheter insertions or while CVCs are in place.*^{*,†‡} This practice has not been found to reduce the risk of CLABSI and may increase the risk of fungal infection and antimicrobial resistance.
- *Use of organic solvents to defat skin prior to CVC insertion.*^{†§} There is no scientific evidence to support this practice, either prior to CVC insertion or as part of postinsertion maintenance care. In fact, the skin's natural lipids provide a level of intrinsic antimicrobial protection, and these solvents could contribute to skin irritation and patient discomfort.
- *Application of topical creams or ointments at the CVC insertion site as part of maintenance care.*^{*,†,§,||} This practice could promote antimicrobial resistance and fungal infections. The exception to this is a patient who has a CVC for the purpose of hemodialysis; povidone-iodine antiseptic ointment or bacitracin/gramicidin/polymyxin B ointment may be used at the hemodialysis CVC site after catheter insertion and at the end of each dialysis session, but only if the ointment does not interact with the material of the hemodialysis catheter per manufacturer's recommendation.
- *Use of inline filters to prevent CLABSI.*^{†||} Filtration to remove particulates in medications or infusates can be done more practically and in a less costly manner in the pharmacy.

- *Use of positive-pressure needleless connectors with mechanical valves before conducting a thorough assessment of benefits, risks, and staff education needs regarding their proper use.*[‡] Using the currently marketed devices has been associated with an increased risk of CLABSI.
- *Use of CVCs for blood sampling.* This practice increases the number of catheter manipulations at the catheter hub, thereby increasing the risk for contamination. It also increases the risk of catheter occlusion if not adequately flushed immediately after the sample has been withdrawn.[#]

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infection as well as lower costs.^{124,128,141} Such products require fewer additional additives and are guaranteed by the manufacturer to be sterile, minimizing the potential for touch contamination in PN preparation and administration.¹⁴²

When PN is compounded, it is important that PN compounding practices adhere to evidence-based recommen-

dations.^{117,128,129,143,144} Multiple sterile ingredients must be transferred aseptically to a single container, with each step in the process presenting an opportunity for contamination.¹²⁴ To minimize microbial contamination, the US Pharmacopeia recommends that PN preparations be compounded by trained health care personnel in an ISO Class 5 environment, such as a room with a certified laminar

airflow hood in a pharmacy clean room.¹¹⁷ In addition to a properly functioning ISO Class 5 environment, health care personnel hand hygiene and garbing practices (for example, clean gowns or coveralls, gloves, masks, hair covers, shoe covers), along with adherence to recommended surface cleaning practices and proper aseptic technique, are essential in minimizing the risk of contamination during the preparation of PN.^{117,129} PN can be obtained from a commercial PN supply company or from a hospital's aseptic compounding unit. Prepared PN must be properly stored (some solutions require refrigeration until used, and some have a short shelf life) and allowed to infuse over a period no longer than 24 hours.^{13,129} This means that if the complete volume of PN has not infused within 24 hours, the remaining solution should be discarded.

CVC Use in ICU Versus Non-ICU Settings

While most CLABSI intervention studies have been conducted in the ICU, it is clear that CVCs are used regularly in non-ICU settings, with CLABSI rates similar in these settings to those occurring in ICUs.^{145,146} Zingg et al. conducted hospitalwide CVC surveillance in a large university-affiliated hospital and found that more CVC-days occurred in non-ICU settings (67%, with a higher incidence of late infections) than occur in the ICU (33%, with a higher incidence of early infections).¹³⁶ In fact, catheter duration times were twice those of ICU CVCs. The researchers also found more CLABSIs in patients in the non-ICU settings. These findings parallel those of Climo et al., who surveyed six large urban hospitals for CVC use within and outside the ICU setting. They found that two thirds of the CVCs they identified were in non-ICU patients, and most were tunneled, totally implanted, or inserted peripherally—the types of CVCs generally associated with longer dwell times and different CLABSI risk factors than nontunneled CVCs.¹⁴⁷ Kirkland et al. found that two thirds of the CLABSIs at their medical center occurred in outpatients.¹⁴⁸ Because most CLABSI prevention studies (including the use of bundles) have been done in ICUs, prevention efforts aimed at non-ICU settings may need to be tailored to address the differences in the epidemiology of CVC use outside the ICU.^{26,136,145–147,149}

Summary of Key Points

This chapter presents CLABSI prevention strategies, techniques, and technologies. Key points to keep in mind include the following:

- Even in resource-poor areas of the world, researchers have found that basic education, and particularly education with feedback of CLABSI rates to staff, can result in lower CLABSI rates. The educational methods chosen should take into consideration the preferred methods of learning, principles of adult education, resources available, cultural norms, and languages spoken by health care personnel.
- Hand hygiene is a key component of any effective patient safety and infection prevention program.
- Aseptic technique, a method used to prevent contamination with microorganisms, is recommended by the evidence-based guidelines for all instances of insertion and care of CVCs.
- When preparing to insert a CVC, health care personnel should be attentive to maximal sterile barrier precautions, skin preparation, catheter selection, and use of catheter kits or carts.
- Using an insertion checklist can improve adherence to best practices and reduce error.
- The insertion process includes catheter site selection, insertion under ultrasound guidance, catheter site dressing regimens, securement devices, and use of a CVC insertion bundle.
- Proper maintenance of CVCs includes disinfection of catheter hubs, connectors, and injection ports and changing dressings over the site every two days for gauze dressings or every seven days for semipermeable dressings. A dressing should also be changed if it becomes damp, loose, or visibly soiled.
- Health care personnel must ensure that a patient's CVC is removed or replaced at the appropriate time and in a safe manner. Such considerations include daily review of line necessity, changing administration system components, and CVC exchanges over a guidewire.
- Administering parental nutrition presents special considerations for infection prevention.

In this chapter, we have examined the evidence-based strategies that have been shown to be associated with reducing the risk of CLABSIs, infections that we realize more than ever are largely preventable when these strategies are consistently used in the insertion of CVCs or their postinsertion care.

In the next chapter, the idea of incorporating CLABSI prevention efforts into patient safety initiatives will be explored.

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CHAPTER 4

CLABSI Patient Safety Initiatives: Factors Contributing to Improvement

In this chapter the strategies associated with implementing successful central line–associated bloodstream infection (CLABSI) prevention programs are introduced. The fundamental linkage between measurement and improvement activities and the challenges of translating best evidence into best practices are also presented.

Clinicians are faced with an ever-growing and rapidly changing body of evidence. Becher and Chassin point out that “the only surety is that today’s knowledge is obsolete tomorrow.”^{1(p. 74)} The vastness of information presents challenges in determining which published research can be relied upon to guide practice, as much published health care research lacks sufficient methodological rigor. Reviewing the literature requires careful consideration of the evidence for its validity and clinical usefulness.² To evaluate evidence-based practices, health care personnel must have both the ability and time to interpret evidence appropriately, using critical thinking skills to effectively evaluate clinical research findings.³ Compounding this challenge, research findings can have mixed or even conflicting results.⁴ Specialized training to read and interpret complex research evidence is important in order to distinguish between

high- and low-quality evidence. Many clinicians complain of information overload, lacking the time necessary to evaluate evidence.³ Clinical practice guidelines (CPGs) are developed by a group of experts who evaluate the state of the evidence and make practice recommendations for busy clinicians to review and incorporate into actual practice.

The Challenges of Translating Evidence into Practice

As valuable as CPGs are for identifying evidence-based practices, their availability alone does not necessarily result in directly changing the behavior of health care personnel.^{5–11} While the goal of CPGs is to reduce inappropriate variation in care and improve patient safety and quality of care, adherence to CPGs has been estimated to vary anywhere between 20% and 100%.¹² A national survey of more than 700 US hospitals in 2005¹³ revealed that approximately one quarter of US hospitals were not routinely using either maximal sterile barrier precautions during central line insertion or chlorhexidine gluconate for insertion site preparation, two practices widely recommended in the guidelines published in 2002.^{14,15} Approximately 15% of US hospitals reported routinely changing central venous catheters (CVCs) to prevent infection,^{13,16} findings similar to those from a study in Thailand,¹⁵ despite evidence that this practice should no longer be used. It has also been estimated that as much as two thirds of efforts to implement organizational change are not successful, with barriers present at the patient, provider team, and organizational levels.⁷

Successful dissemination and implementation of CPGs requires more than simply increasing awareness. To bring best practices to the bedside level, improvement efforts must change practice patterns.¹⁷ Implementation strategies that are multifaceted and multidisciplinary, and that include sufficient resources and explicit support from organizational leaders, are most likely to be successful.^{10,18} The challenge comes in identifying which multifaceted approaches are likely to be most effective in a given organization, as there is no “one size fits all” approach; instead, it is important that implementation strategies are customized to specific problem areas within a given organization in order to be most effective.

There is no one theoretical framework that best directs efforts to improve adherence to CPGs, although several conceptual models exist, many of which are adapted from non-medical industries and are described elsewhere.^{17–19} Many barriers have been identified in the literature as inhibiting

adherence to CPGs. These include a lack of familiarity with guidelines (or disagreement with them), the level of difficulty associated with implementing aspects of guidelines, and a lack of needed equipment or supplies.¹² In order to reduce preventable harm and improve patient safety, barriers to CPGs must be identified and eliminated.¹⁸

As a first step, Gurses et al. recommend using a systematic and multidisciplinary approach to identify, prioritize, and remove the local barriers that can diminish CPG adherence.¹² The barrier identification and mitigation (BIM) tool described by Gurses et al. contains five practical steps to guide improvement efforts to move evidence into practice¹²:

1. Assemble an interdisciplinary team, composed of front-line workers, administrators, and quality improvement staff.
2. Identify barriers by observing staff attempting to use the CPG and by talking with staff about their agreement with the guideline or about their suggestions to improve adherence to it.
3. Summarize the barriers in writing, as collected by several members of the interdisciplinary team.
4. Prioritize the barriers, based on the likelihood of actually experiencing each barrier and the probability that the barrier would lead to nonadherence.
5. Develop an action plan for each targeted barrier that includes a leader, predetermined dates to monitor progress, and the measures most appropriate for each action.

The BIM approach includes a tool to record barriers and their prioritization, as well as a template for the development of an action plan.¹²

Factors That Affect the Success of Improvement Initiatives

The following are nine of the most important internal and external factors that can affect the success of any improvement initiative that is designed to reduce or eliminate health care–associated infections (HAIs), including CLABSIs:

1. Leadership
2. Culture of safety
3. Multidisciplinary teams and teamwork
4. Accountability of health care personnel
5. Empowerment
6. Resource availability
7. Data collection and feedback of CLABSI rates
8. Policies and procedures
9. Involvement of patients and families

Each of these factors will be discussed in more detail in this chapter. Table 4-1 below provides an overview of each factor.

Leadership

Any effort to promote organizational change to improve patient safety must have leadership commitment and

Table 4-1.
Overview of Factors Affecting the Success of Improvement Initiatives

Factor	Key Points
Leadership	<p>An essential component in the success of any HAI improvement initiative, leaders should do the following:</p> <ul style="list-style-type: none"> ■ Effectively communicate their vision to staff ■ Interface with frontline staff during multidisciplinary rounds, staff meetings, or educational programs ■ Provide for the human and fiscal resources to support CLABSI improvement initiatives ■ Ensure that there is a culture of safety at the unit and organizational level ■ Work with staff to overcome barriers
Culture of safety	<p>Refers to an organization's commitment to patient safety that is found across all levels of an organization and that includes the following:</p> <ul style="list-style-type: none"> ■ Recognition of the high-risk nature of an organization's activities and the desire to maintain consistently safe operations ■ Blame-free environment that encourages staff to report errors or close calls (near misses) ■ Collaboration among staff at all levels of the organization in seeking solutions to patient safety issues ■ Willingness to provide resources necessary to address patient safety issues
Multidisciplinary teams and teamwork	<p>Multidisciplinary teams create a balanced approach to improving patient care and safety. CLABSI improvement teams should include all staff involved in CVC insertions and maintenance, clinical champions and opinion leaders, managers, infection preventionists, leaders (including those who allocate resources), and patients capable of assisting in their care. Health care personnel must not only be clinically competent, they must also be expert team members.</p>
Accountability of health care personnel	<p>Standardized protocols aimed at CLABSI prevention must be consistently carried out by all members of the health care team. Each individual is accountable for following the evidence-based practices outlined in organizational policies and procedures.</p>
Empowerment	<p>As part of the safety culture, health care personnel should have the ability to speak up when unacceptable behaviors, errors, or near misses occur, without fear of blame or intimidation. When a safety culture exists, health care personnel are encouraged to report such concerns, in the ongoing efforts to improve patient care.</p>
Resource availability	<p>Resources that should be available to support CLABSI improvement efforts include the following:</p> <ul style="list-style-type: none"> ■ Necessary supplies and equipment, conveniently located or packaged in supply carts or kits ■ Education, training, and competency assessment resources for health care personnel on evidence-based CVC insertion and maintenance practices ■ Trained epidemiologists and infection preventionists to oversee the CLABSI prevention program, conduct ongoing CLABSI surveillance, and provide feedback of CLABSI rate information ■ Achieving and maintaining appropriate staffing levels
Data collection and feedback of CLABSI rates	<p>Surveillance for CLABSI and feedback of CLABSI rates to frontline staff can have a significant impact in CLABSI prevention efforts, even in resource-limited countries.</p>
Policies and procedures	<p>Written policies and procedures that incorporate evidence-based guidelines should be available. Even when available, it is important that their implementation be monitored and that they be reviewed and updated as new information or technology becomes available.</p>
Involvement of patients and families	<p>Patients and their families should be educated on the steps they can take to reduce the risk of CLABSI.</p>

Note: HAI: health care–associated infection; CLABSI: central line–associated bloodstream infection; CVC: central venous catheter.

involvement in order to be successful. Leadership should be broadly defined to include not only the organization's executives, officers, and directors but also the clinical leaders and leaders of improvement teams or initiatives. Organizational leaders can ensure, for example, that the necessary supplies are available, that human and fiscal resources are adequate to support CLABSI improvement initiatives, that policies and procedures are in place, and that there is a culture of safety underpinning the CLABSI improvement initiative. Leaders can also demonstrate their support by being involved with frontline staff, participating in multidisciplinary rounds, or participating in staff meetings or educational programs.

Saint et al. conducted a research study to better understand why some hospitals are able to successfully engage in HAI prevention activities while others cannot.²⁰ The researchers quickly identified the important role hospital leadership played and further identified the following characteristics of successful leaders:

- They cultivate a culture of clinical excellence and effectively communicate the vision to staff.
- They are solution oriented and successful at influencing others; they overcome barriers and work directly with resistant staff, tackling issues that impede HAI prevention efforts.
- They inspire staff, cultivating leadership skills in the staff they supervise and keeping the focus on the end goal; they interact directly with staff to energize and motivate them.
- They think strategically but act locally; they plan ahead and leave little to chance. This can include “politicking” before important issues are put to committee vote or using their personal influence to move initiatives forward.

Similarly, Griffiths et al. found proactive, positive leadership, with shared visions and interaction with staff, to have a positive impact on the effectiveness and success of organizations. In contrast, inadequate communication and teamwork and the lack of clarity of responsibilities were deterrents to success.²¹

Active involvement of senior leadership from sites participating in the Michigan Keystone project discussed in Chapter 2 was found to be a critical factor in the success of the project.²² Interestingly, the Hopkins team identified early on in the Keystone project that, while chief executive officers (CEOs) were committed to improving safety and qual-

ity and reducing CLABSI rates in the organizations, they were unsure how to support improvement efforts and often were not actively involved. The Hopkins team created the Executive/Senior Leader Checklist, which contained specific tasks for leaders, to facilitate their support of CLABSI prevention efforts, such as the following²²:

- Make elimination of CLABSI an organizationwide goal that is included in the strategic plan.
- Provide approximately 10% dedicated, protected time for each CLABSI reduction team member.
- Monitor hand hygiene no less than quarterly and provide feedback on performance to employees and the board.
- Review CLABSI rates at least quarterly at board meetings.
- Empower nurses and other health care personnel to stop CVC placement if there is a breach in protocol during insertions that are not life-threatening.

A similar checklist was developed for the board and included specific tasks such as the following²³:

- Define an organizational goal of 75% CLABSI reduction over three years.
- Require the chief financial officer to provide a review of CLABSI cases subject to the US Centers for Medicare & Medicaid's (CMS's) pay-for-performance system, along with the financial impact per case, on a quarterly basis.
- Hold the CEO and executive team accountable for CLABSI reduction via performance-based compensation.

The board checklist distinguishes the strategic responsibilities for quality and patient safety improvement of trustees from the operational responsibilities of hospital leaders.

Project leaders, clinical leaders, and “champions” are also key to the success of CLABSI initiatives. These leaders are responsible for direct oversight of improvement activities and ensuring that the goals established by the improvement team and supported by senior leadership are translated into actual practices that drive improvement. These leaders are visible role models who collaborate with frontline staff and reinforce the importance of all aspects of the improvement initiative. Infection preventionists and hospital epidemiologists are also critical to improvement efforts, given the expertise they bring to bear. The Hopkins team developed the Infection Preventionist Checklist, which was adapted from the executive leader and board checklists and was aligned with the central line insertion checklist the team had previously created.²⁴ The checklist includes tasks that are

part of the Comprehensive Unit-Based Safety Program (CUSP) as well as those specific to CLABSI improvement efforts, such as the following:

- Identify and eliminate barriers to preventing CLABSI. Ask clinicians what is difficult and collaborate to resolve the issues identified.
- Collaborate with clinical and administrative leaders to develop a coordinated CLABSI reduction plan throughout the organization.
- Ensure accuracy and efficacy of staff education regarding CLABSI prevention strategies.
- Provide monthly unit-level CLABSI data to project leaders.
- Send senior hospital leaders weekly unit-specific reports of the number of patients who developed CLABSIs, weeks without a CLABSI, and quarterly CLABSI rates.

Culture of Safety

As described in Chapter 2, safety culture (or culture of safety) refers to an organization's commitment to safety that can be found at all levels across an organization. In 1999 the Institute of Medicine stated that "health care organizations must develop a culture of safety such that their workforce and processes are focused on improving the reliability and safety of care for patients."^{25(p. 4)} Organizations with consistent performance at high levels of safety over extended periods of time have been termed "high-reliability organizations." The study of such organizations initially began with those that undertake extreme hazards with outstanding safety records, such as the nuclear power industry and the commercial air travel system.⁵ The Agency for Healthcare Research and Quality (AHRQ) notes that "high-reliability organizations consistently minimize adverse events despite carrying out intrinsically hazardous work. Such organizations establish a culture of safety by maintaining a commitment to safety at all levels, from frontline providers to managers and executives."²⁶ Krein et al. define safety culture as "a unifying theme within an organization that is manifested through common attitudes, values and practices."¹³ Listed below are some key features of a culture of safety²⁷:

- Acknowledgment of the high-risk nature of an organization's activities and a collective mind-set to achieve consistently safe operations
- A blame-free environment in which individuals are able to report errors or near misses without fear of reprimand or punishment
- An expectation of collaboration across staff at all levels of the organization to seek solutions to vulnerabilities
- The organization's willingness to direct resources to address safety concerns

Safety culture is generally measured by surveying providers at all levels of an organization. It is important to recognize that there can be significant variations in safety culture within an organization, either from unit to unit or from organizational leaders to frontline staff. Safety culture surveys provide a measure of an organization's culture and the opportunity to identify any areas of the culture that need improvement.²⁸ Validated surveys include AHRQ's Patient Safety Culture Surveys and the Safety Attitudes Questionnaire. These surveys ask providers to rate the safety culture in their work area and in the organization as a whole, specifically with regard to the four key features in the foregoing list. Versions of the AHRQ Patient Safety Culture survey are available for hospitals and nursing homes, and AHRQ provides yearly updated benchmarking data from the hospital survey.²⁷

Pronovost and Sexton point out that understanding the sources of variation in an organization's culture is a necessary first step in identifying where efforts need to be focused to improve the culture of safety.²⁹ In the Michigan Keystone intensive care unit (ICU) project, teams utilized the six-step CUSP process to assess and improve the safety culture in the study ICUs before improvement teams could redesign care to improve CLABSI and ventilator-associated pneumonia rates. Pronovost and Sexton further note that it is important to provide feedback to staff as well as senior leaders on the results of the safety culture questionnaire, followed by a focused intervention to improve the culture.²⁹

There are many resources available to help organizations build a safety culture, two of which are listed here:

- *Improving Patient Safety in Hospitals: A Resource List for Users of the AHRQ Hospital Survey on Patient Safety Culture*. AHRQ Publication No. 11-0012-2-EF, August 2010. Agency for Healthcare Research and Quality, Rockville, MD, available at <http://www.ahrq.gov/qual/patientsafetyculture/hospimpptsaf.htm>.³⁰ This document outlines the 12 dimensions of safety, with references for each, such as "teamwork within units" (dimension 1) and "nonpunitive response to error" (dimension 12). It also contains references to additional websites that provide practical resources for implementing change to improve patient safety culture and patient safety, such as "becoming a high reliability organization" and "partnering with patients to create safe care." This resource list is not exhaustive but does provide initial guidance to hospitals looking for information about patient safety initiatives.

- *Develop a Culture of Safety* is available on the Institute for Healthcare Improvement website (<http://www.ihl.org/knowledge/Pages/Changes/DevelopaCultureofSafety.aspx>).³¹ This site includes 10 “changes for improvement,” with links to additional resources for each, such as “involve patients in safety initiatives” and “conduct safety briefings.”

Multidisciplinary Teams and Teamwork

The Institute for Healthcare Improvement (IHI) recommends that improvement teams be multidisciplinary, to include all stakeholders in the process, in order to gain buy-in and cooperation.³² The US Centers for Disease Control and Prevention (CDC) recommends that CLABSI improvement efforts “should be multidisciplinary, involving health-care professionals who order the insertion and removal of CVCs, those personnel who insert and maintain intravascular catheters, infection control personnel, healthcare managers including the CEO and those who allocate resources, and patients who are capable of assisting in the care of their catheters.”^{33(p. 163)} Each member of the care team should have a stake in the outcome, and all the members should have clear roles and responsibilities, a shared vision, and a common purpose to achieve the valued goal. The team should also include clinical champions and opinion leaders, to enhance the credibility of the improvement effort.³⁴ A multidisciplinary team can help create a balanced approach to improving patient care and safety.³⁵

Teamwork and an underlying safety culture are essential components of safe, effective, and efficient patient care.^{28,36,37} Effective teamwork, however, does not automatically happen just by putting a group of people together. Many staff members may feel rushed, be overworked, and have limited training regarding teamwork and conflict resolution that can result in patient harm.^{36,38} Physicians, in particular, often receive their training in an environment in which very little attention is paid to the importance of collaborating with other health care personnel. This fosters a belief that they are the primary source of all important health care decisions, and errors are seen as personal failures.¹ Health care personnel must be clinically competent *and* expert team members in order to ensure the best possible outcomes for the patients they care for. Shared accountability and teamwork have been viewed as key facilitators in implementing effective infection prevention strategies.³⁶ In today’s complex health care delivery system, high-quality patient care can be provided only by truly interdisciplinary teams.¹

Planning, training, and practice are necessary in order for teams to function optimally. As such, team training strategies, such as TeamSTEPPS (which stands for Team Strategies and Tools to Enhance Performance and Patient Safety), have been developed to train health care personnel in better teamwork practices.³⁹ Developed jointly by the US Department of Defense and AHRQ, a multimedia TeamSTEPPS toolkit is now available in the public domain for civilian health care facilities and medical practices (available at <http://teamstepps.ahrq.gov/abouttools/materials.htm>).⁴⁰ TeamSTEPPS can be tailored to any health care setting.

Accountability of Health Care Personnel

Preventing CLABSIs requires that all health care personnel responsible for inserting and maintaining CVCs consistently follow all standardized protocols. Each individual is accountable for complying with the evidence-based practices that are defined in organizational policies, procedures, and protocols. Further, all clinical and administrative leaders must be accountable for CLABSI rates and supporting CLABSI prevention activities.³⁸ Marschall et al. summarized the accountability of health care personnel, from frontline staff to senior leaders, in the prevention of CLABSIs⁴¹:

- CEOs and senior management:
 - Ensure that there is an adequate number of trained infection preventionists and an effective infection prevention and control program that supports CLABSIs prevention efforts.
 - Ensure that all licensed and nonlicensed health care personnel are competent to perform their job responsibilities.
- Hospital and unit leaders must hold health care personnel accountable for their actions.
- Direct caregivers and ancillary personnel:
 - Must practice proper infection prevention and control at all times (for example, proper hand hygiene, cleaning and disinfection of instruments and the patient care environment, aseptic technique when inserting and maintaining CVCs).
- The individual(s) responsible for the infection prevention and control program is accountable for the following:
 - Ensuring that an active program is in place to identify CLABSIs
 - Analyzing data on the occurrence of CLABSIs, with regular feedback of the data to all who can use the information to improve care (frontline staff, clinical staff, administrators)

- Ensuring that evidence-based practices for CLABSI prevention are incorporated into the program
- Ensuring that appropriate education and training on CLABSI prevention is developed and provided to staff, patients, and families
- The individual(s) responsible for the infection prevention and control program (along with the laboratory and information technology departments) must ensure that systems are in place to adequately support the CLABSI surveillance program.

Although this list was developed with hospitals in mind, it is readily adaptable to nonhospital settings.

The safety culture in any health care setting should hold that everyone is accountable for following evidence-based CLABSI prevention practices, and organization leaders must clearly communicate that department or unit leaders are accountable for the CLABSIs that occur in their patients.⁴² Staff who are chronically nonadherent to following such prevention practices may need oversight to motivate the necessary changes in behavior. It should be noted that holding health care personnel accountable is not in conflict with a blameless safety culture.

Empowerment

All health care personnel should have the ability to speak up, without fear of blame or intimidation, when a problem or deviation from protocol occurs that impacts any patient safety–related issue, including CLABSI prevention. Teamwork lapses or failures are common contributors to errors in health care.²⁸ Pronovost points out that often health care personnel know something is wrong but do not speak up, or they are ignored if they try to do so.³⁸ Physicians, in particular, may feel embarrassed or ashamed if questioned by a nurse and may respond in a negative manner.³⁸ The Society for Healthcare Epidemiology of America (SHEA), the Infectious Diseases Society of America (IDSA), and the IHI recommend that health care personnel should be empowered to stop a CVC insertion if any lapses in aseptic technique are observed or deviations from the insertion checklist are noted.^{41,43} The source of that empowerment must be leadership because, as previously mentioned, it is their responsibility to establish and support the organization's culture of safety. When a safety culture exists, health care personnel are encouraged to report unacceptable behavior and errors, and they actually follow through and do so.²⁸ The goal is to create a reporting culture in which health care personnel work together to improve patient safety.⁴⁴

Resource Availability

There are a number of resources that should be available to support health care personnel in their efforts to prevent CLABSIs:

- Health care personnel must have ready access to the supplies and equipment necessary for the proper insertion and care of CVCs. Using kits or carts that contain all the necessary supplies in one convenient package or location eliminates needless searching that not only wastes time but also jeopardizes patient safety, as staff may be tempted to “cut corners” and not follow evidence-based practices.
- Appropriate education, training, and competency assessment resources are needed for all staff responsible for the insertion and maintenance of CVCs. Several studies have demonstrated that intensified training and educational programs reduce the risk of CLABSIs.^{16,45–48} Even in resource-limited countries, promoting and reinforcing infection prevention measures (such as proper hand hygiene) through education and training can help improve practices.^{49,50}
- Trained infection preventionists and epidemiologists are also essential in ensuring that infection prevention and control programs are in place and that CLABSI surveillance is performed appropriately. Epidemiologists and infection preventionists are important resources to all staff, providing education, motivation, and support in implementing best practices or troubleshooting barriers. This key human resource, however, is often inadequately staffed and may be entirely lacking in developing countries.^{49,51–53}
- Appropriate staffing levels are also a key resource. Researchers have reported a significant link between nurse staffing levels and CLABSIs.^{54,55} A vicious circle can develop when nurses are unable to cope with the burden of work, as subsequent absences from work add to the burden of the remaining nurses.⁵⁶ Achieving and maintaining appropriate staffing ratios can be particularly challenging in developing countries.⁵⁷

Another infrastructure resource that researchers are suggesting likely plays a key role in creating a successful culture of safety and the implementation of evidence-based practices is automated systems for HAI surveillance.^{58,59} Such systems allow infection preventionists to collect more data more efficiently, including details on adherence to CVC insertion bundles and collection of central line–days.⁵⁹ Better and more timely data on process and outcome measures can then be used to develop

performance improvement initiatives. Additional information on automated surveillance systems can be found in Chapter 5.

Data Collection and Feedback of CLABSI Rates

Data collection followed by comparative feedback on performance can be effective in stimulating improvement at both the provider and organizational levels, particularly when baseline levels of performance are low,^{60–63} and has been recommended as part of a comprehensive program to improve CLABSI rates.^{10,41,64} Several researchers have witnessed the positive impact of feedback of CLABSI rates to health care personnel when it is part of a program aimed at reducing these rates.^{65–68} Underscoring the impact of feedback even in resource-limited countries, Rosenthal et al. demonstrated a 54% reduction in CLABSI rates overall in a two-year period by providing outcome and process performance feedback to staff, coupled with education, in 15 developing countries.⁵²

Policies and Procedures

Health care organizations should have written policies and procedures that incorporate evidence-based practices. These policies should describe how recommended practices are translated into actual practices and processes at the bedside. Evidence-based guidelines use various ranking systems to identify the level of evidence associated with recommendations within guidelines. The level of evidence can be taken into consideration when writing policies and procedures because confidence in the recommendations decreases as the level of evidence declines. For example, in guidelines issued by the US CDC and HICPAC, each recommendation is categorized on the basis of existing scientific data, theoretical rationale, applicability, and economic impact. The system for categorizing recommendations within the US CDC and HICPAC guidelines is found in Table 4-2 below, with examples of each level taken from the HICPAC’s *Guidelines for the Prevention of Intravascular Catheter-related Infections*.³³

Table 4-2.
US Centers for Disease Control and Prevention Ranking System for Levels of Evidence

Category	Description	Example from the Guideline
Category IA	Strongly recommended for implementation and strongly supported by well-designed experimental, clinical, or epidemiologic studies	Avoid using the femoral vein for central venous access in adult patients (page 11).
Category IB	Strongly recommended for implementation and supported by some experimental, clinical, or epidemiologic studies and a strong theoretical rationale; or an accepted practice (for example, aseptic technique) supported by limited evidence	Use ultrasound guidance to place central venous catheters (if this technology is available) to reduce the number of cannulation attempts and mechanical complications. Ultrasound guidance should be used only by those fully trained in its technique (page 11).
Category IC	Required by state or federal regulations, rules, or standards	Use a needleless system to access IV tubing. Category IC (page 20).
Category II	Suggested for implementation and supported by suggestive clinical or epidemiologic studies or a theoretical rationale	Do not remove CVCs or PICCs on the basis of fever alone. Use clinical judgment regarding the appropriateness of removing the catheter if infection is evidenced elsewhere or if a noninfectious cause of fever is suspected (page 16).
Unresolved issue	Represents an unresolved issue for which evidence is insufficient or no consensus regarding efficacy exists	No recommendation can be made regarding the frequency for replacing intermittently used administration sets (page 19).

Note: CVC: central venous catheter; PICC: peripherally inserted central catheter.

Source: O’Grady NP, Alexander M, Burns LA, Dellinger EP, Garland J, Heard SO, Lipsett PA, Masur H, Mermel LA, Pearson ML, Raad II, Randolph AG, Rupp ME, Saint S; Healthcare Infection Control Practices Advisory Committee (HICPAC). Guidelines for the prevention of intravascular catheter–related infections. *Clin Infect Dis*. 2011 May;52(9):e162–193. Epub 2011 Apr 1.

Several researchers have identified the gap that can exist between policy awareness and actual implementation or documentation.^{8,13,16,69,70} This gap can be present even when staff are knowledgeable about the best practices. As an initial step in efforts to reduce CLABSIs, organizations should review their policies and procedures, as well as actual practice, against recommended best practices. On an ongoing basis, policies should be reviewed and updated as new information or technology becomes available.

Monitoring adherence to evidence-based practices can provide essential information about the level of implementation of policies and procedures. Such monitoring has also been found useful by health care organizations as a method for identifying quality improvement opportunities and strategically targeting interventions to reduce CLABSIs.⁷¹ Feedback of adherence data has been a component of multifaceted interventions that have successfully reduced CLABSI rates.^{45,52,60,61,67} Quality improvement efforts begin by identifying specific gaps in adherence to recommended prevention practices, thereby helping to target intervention strategies for reducing CLABSI rates. One of the ways to assess adherence to best practices is by observing the actual practices of health care personnel. Observation permits the observer to identify who performed (or did not perform) various aspects of insertion or maintenance procedures and how well those aspects of care were performed. Limitations to observing care practices include the following⁷²:

- It can be labor intensive and costly.
- It requires consistency in the selection and training of observers and in recording the information.
- It can compromise patient privacy.
- It can change behavior of health care personnel if they are aware they are being observed.

Various aspects of CVC insertion and maintenance procedures can be observed, such as the following^{41,71}:

- Hand hygiene
- Use of maximal sterile barriers during CVC insertions
- Use of a CVC insertion checklist
- Proper use of skin antiseptic prior to CVC insertion or during CVC maintenance care
- Proper disinfection of catheter hubs or injection ports prior to access
- Documentation of daily assessment of the need for continued CVC necessity
- Avoidance of the femoral vein for CVC insertion in adult patients

Decisions will need to be made regarding the frequency of observations, which can vary from observing all episodes of care (for example, all CVC insertions observed and documented by a registered nurse) to daily or weekly observations of various aspects of care (such as hand hygiene or proper disinfection of CVC injection ports or hubs prior to accessing). Feedback of adherence data has been a component of multifaceted interventions and is key to successfully reducing CLABSI rates.

Involvement of Patients and Families

Patients and their families can and should be active participants in the prevention of CLABSI. They should receive education regarding the insertion and care of the CVC and steps they can take to help prevent CLABSIs while in the health care organization and after they leave (if they will be discharged with the CVC in place). Such education should include the following⁷³:

- The steps that health care personnel will take during the insertion of the CVC to prevent infection (perform hand hygiene prior to inserting the CVC; wear sterile gown and gloves, mask, and cap; clean the patient's skin with an antiseptic soap; place a sterile sheet over the patient)
- The reason health care personnel will make a daily determination of the ongoing need for the CVC; patients and family members should be encouraged to ask why the catheter is needed and for how long.
- The importance of speaking up if they do not see health care personnel clean their hands or if they observe breaches in aseptic technique (for example, not disinfecting a catheter connector before accessing)
- Why it is important to notify health care personnel if the CVC dressing becomes wet or dirty or comes off, or if the area around the CVC is red, sore, or draining
- What they need to know about taking care of the CVC if they go home with it in place, as well as the signs and symptoms of infection they should watch for

The Role of Collaboratives

In recent years a collaborative approach to improving CLABSI rates has emerged as a means to facilitate the use of infection prevention practices, even in resource-limited settings.^{13,74} Collaboratives create partnerships outside single facilities that focus on using the same evidence-based practices, jointly reviewing successes and strategies to overcome barriers to effective implementation of those practices, and openly sharing results in a nonthreatening manner.⁶⁴ Successful collaboratives can be created at the local, regional,^{68,75-77} national,^{65,78-81} or international level.^{52,64,82,83}

Such initiatives have also included health departments, hospital associations, and others.⁶⁴

Summary of Key Points

This chapter introduces strategies associated with implementing successful CLABSI prevention programs. Key points to keep in mind include the following:

- Clinical practice guidelines (CPGs)—guidelines developed by experts who evaluate the state of the evidence and make practice recommendations for busy clinicians to review and incorporate into actual practice—are valuable resources only if they result in an actual improvement in practice patterns.
- As a first step, consider using a systematic and multidisciplinary approach to identify, prioritize, and remove the local barriers that can diminish CPG adherence.
- Among the most important internal and external factors that can affect the success of any improvement initiative designed to reduce or eliminate health care–associated infections, including CLABSIs, are leadership, culture of safety, multidisciplinary teams and teamwork, accountability of health care personnel, empowerment, resource availability, data collection and feedback of CLABSI rates, policies and procedures, and involvement of patients and families.
- A collaborative approach to improving CLABSI rates has emerged as a means to facilitate the use of infection prevention practices, even in resource-limited settings.

In this chapter, we have reviewed the challenges of translating evidence into practice and the factors that affect the success of improvement initiatives. In the next chapter, techniques for monitoring CLABSIs and the measurement approaches for assessing CVC insertion and maintenance practices will be presented. Regulatory and public policy–related topics will be explored.

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CHAPTER 5

CLABSI Surveillance, Benchmarking, and Public Reporting

This chapter provides information on the practices organizations can use to monitor central line–associated bloodstream infections (CLABSIs) as well as the measurement approaches that can be employed to assess central venous catheter (CVC) insertion and maintenance practices. Contemporary issues such as public reporting of infection rates and pay-for-performance programs are also explored.

Overview of Surveillance and Surveillance Systems

Surveillance in public health is defined as “the ongoing, systematic collection, analysis, interpretation, and dissemination of data regarding a health-related event for use in public health action to reduce morbidity and mortality and to improve health.”^{1(p. 2)} Surveillance for health care–associated infections (HAIs), including CLABSIs, is an essential component in any infection prevention and control program, a necessary first step in defining the nature and magnitude of the problem.^{2–4} Typically, surveillance involves measuring both outcomes and related processes of care, as well as data analysis and feedback of information to members of the health care team, as a means

to facilitate improvement in those outcomes.^{5–9} There is growing evidence that 50% or more of HAIs can be prevented.^{10–15} Surveillance is the first step in identifying problems and establishing priorities, raising awareness of HAIs, and, ultimately, decreasing infection rates.^{15–17}

A brief overview of HAI surveillance as it has evolved in the United States, from the American Hospital Association's first recommendation of hospital surveillance for HAIs in 1958 up to state-mandated public reporting of hospital CLABSI rates in mid-2011, is provided in Appendix A at the end of the book.

Surveillance data can provide information needed to improve patient outcomes and the quality of patient care.¹⁸ The usefulness of that information, however, is highly dependent on the methods used to collect and analyze the data.¹⁹ For example, the thoroughness or intensity of data collection should be maintained at the same level over time to detect true fluctuations in infection rates. Sound epidemiologic principles and practices, outlined in a written surveillance plan, must be at the foundation of any effective surveillance program.⁶ Methods for identifying infection cases should be clearly delineated, and staff responsible for surveillance should be trained in the techniques used to identify cases.^{20,21} Furthermore, elements of surveillance, such as definitions and rate calculation methods, should be used in a consistent manner over time.^{6,22} Reliable data can establish baseline infection rates, identify risk factors for infection, point to steps that can be taken to eliminate or minimize those risks, and measure the effectiveness of risk-reduction interventions.^{6,18}

Organizations participating in national or international surveillance systems conduct HAI surveillance using case definitions and surveillance methodologies that are applied consistently by all participants, in order to permit comparisons of rates and trends within and between organizations. Data submitted to the surveillance system are aggregated and sent back to participants for use in local quality improvement efforts. Surveillance is underdeveloped in many parts of the world. In the past 10 to 15 years a number of developed countries have created HAI surveillance systems, though some have yet to develop such surveillance capabilities.²¹ Few countries of low or middle income have national HAI surveillance systems,²³ although this picture is changing through the work of the International Nosocomial Infection Control Consortium (INICC).²⁴ Table 5-1 on pages 87–89 provides a brief overview of a few examples of national and international surveillance systems.

CLABSI Surveillance Methods

There have been several articles published on the development and evaluation of surveillance programs.^{1,6,25–29} The scope of surveillance may vary, as CLABSI surveillance can be done across an entire organization (whole/total house surveillance) or on a more focused basis based on high-risk, high-volume procedures.¹⁸ Surveillance activities for HAIs, including CLABSI, should be based on the results of an organizational risk assessment, as each organization serves different types of patients at varying levels of risk.⁶ External influences by regulatory, accreditation, or public sectors may also determine the scope of surveillance.³⁰

Traditionally surveillance has focused primarily on infections acquired in hospital intensive care units (ICUs).³¹ However, most HAIs likely occur outside ICUs, in non-ICU inpatient and nonhospital settings.^{20,31} Marschall et al. found that CVC device utilization rates were lower in non-ICU medical wards in the study hospital than in the medical ICU, but CLABSI rates were similar in both ICU and non-ICU medical wards.³² Other researchers have similarly found CLABSI rates to be comparable or higher in non-ICU settings than in ICU wards.^{33,34} In a one-day prevalence study Climo et al. found that two thirds of the CVCs in six medical centers were in patients outside the ICU.³⁵ A recent report by the US CDC noted that a substantial number of CLABSIs continue to occur in non-ICU settings, particularly in dialysis centers.³⁶ In the United States an estimated 18,000 CLABSIs occurred in ICUs in 2009, down from the estimated 43,000 in 2001. However, there were estimated to be 23,000 non-ICU CLABSIs in 2009 and 37,000 dialysis center CLABSIs in 2008.³⁶ While surveillance for CLABSIs in non-ICU settings provides a more complete understanding of the incidence of CLABSIs, it does require additional resources.²⁰

Surveillance has historically been a manual process, with a review of microbiology reports along with other diagnostic and patient care information extracted from various sources—an approach that can be labor intensive, limited in scope, and prone to error.^{5,19,30,37–39} Manual surveillance for HAIs has been identified as one of the most time-consuming activities for infection preventionists (IPs), consuming nearly half of an IP's time.⁴⁰ Accurate surveillance data are essential to identify areas for improvement and to assess the impact of infection prevention initiatives.⁵ There are ever-increasing demands on IPs' time and limited resource availability, and some countries also have additional requirements for reporting to the government. To that end,

Table 5-1.
Examples of National and International HAI Surveillance Systems

System Name	Country or Countries Served	Year Established	Comment
National Healthcare Safety Network (NHSN)	United States	1970 (as National Nosocomial Infection Surveillance System [NNIS])	NNIS was restructured in 2005 to become the National Healthcare Safety Network (NHSN), the oldest and most well-developed national HAI surveillance system. ¹ The NHSN is a voluntary, secure, Internet-based surveillance system that integrates and expands the patient and health care personnel safety surveillance systems managed by the Division of Healthcare Quality Promotion (DHQP) at the US Centers for Disease Control and Prevention (CDC). Beginning in 2008, all types of health care facilities in the United States could enroll in the NHSN, including acute care hospitals, long-term acute care hospitals, psychiatric hospitals, rehabilitation hospitals, outpatient dialysis centers, ambulatory surgery centers, and long term care facilities. ² There are three components to NHSN data collection, reporting, and analysis: patient safety (which includes the CLABSI module), health care personnel safety, and biovigilance. ²
Canadian Nosocomial Infection Surveillance Program (CNISP)	Canada	1994	CNISP is a collaborative effort of the Centre for Infectious Disease Prevention and Control (CIDPC) of the Public Health Agency of Canada (PHAC), the Canadian Hospital Epidemiology Committee (CHEC), and a subcommittee of the Association of Medical Microbiology and Infectious Disease (AMMI) Canada. CNISP uses NHSN definitions of HAIs. ^{2,3} About 50 sentinel hospitals from nine provinces participate in the CNISP network. ³ Active prospective surveillance for CLABSIs began in 2006 and included all ICU patients who had at least one CVC. ⁴
Nosocomial Infection National Surveillance Scheme (NINSS)	England	1996	The NINSS was established by the Public Health Laboratory Service (PHLS) in the United Kingdom to provide information to help in the identification of, and reduction in, HAIs (including CLABSIs). Methods and definitions are based on the NNIS/NHSN system. Organizations participate on a voluntary and confidential basis, and information is collected using standard surveillance methods to provide national data to be used as a benchmark of performance. ⁵
Krankenhaus Infektions Surveillance System (KISS)	Germany	1997	This voluntary, confidential national surveillance system consists of two modules: the ICU component and the surgical site infections component. NNIS/NHSN surveillance definitions and methodologies are used. The ICU component includes nosocomial bloodstream infections. ⁶
Japanese Nosocomial Infection Surveillance System (JANIS)	Japan	2000	The JANIS system has become the only source of national information regarding HAIs in Japanese hospitals. ⁷ Modified from the NNIS/NHSN system, JANIS has three components (ICU, hospitalwide, and laboratory surveillance). The ICU component has more than 30 ICUs collecting and submitting data, including data on CLABSIs. ⁸ Hospitals receive a quarterly report that includes comparative data from all participating hospitals. ⁷

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Table 5-1. (Continued)

System Name	Country or Countries Served	Year Established	Comment
The Healthcare-Associated Infections Surveillance Network (HAI-Net)	European countries	2000 (as HELICS, then IPSE)	<p>HAI-Net is a European network for the surveillance of HAIs that has been coordinated by the European Centre for Disease Prevention and Control (ECDC) since July 2008. HAI-Net had its beginnings in Hospitals in Europe for Infection Control through Surveillance (HELICS) network from 2000 to 2005, then Improving Patient Safety in Europe (IPSE) network from 2005 to 2008. The ICU component includes surveillance for CLABSIs (ECDC website).⁹</p> <p>European results on surveillance of ICU–acquired infections have been published since 2008 in the chapter on HAIs as part of ECDC’s Annual Epidemiological Report, available at http://www.ecdc.europa.eu/en/activities/surveillance/HAI/about_HAI-Net/Pages/ICU.aspx.</p>
Victorian Hospital Acquired Surveillance System (VICNISS)	Victoria, Australia	2002	<p>VICNISS was previously an acronym for Victorian Nosocomial Infection Surveillance System but is now used to mean Victorian Hospital Acquired Infection Surveillance System. NNIS/NHSN surveillance definitions and methodologies are used. For the adult ICU surveillance module, VICNISS hospitals report rates of CLABSI.¹⁰ The system produces annual reports of HAIs, available at http://www.vicniss.org.au/AnnualReport.aspx.</p>
International Nosocomial Infection Control Consortium (INICC)	More than 40 countries	2002	<p>Founded in Argentina in 1998 by a physician who implemented measurement of HAI processes and outcomes, the INICC is now an international nonprofit, multicenter, collaborative HAI infection control program with a surveillance system based on the US NHSN. It is the first multinational research network established to control HAIs in hospitals by analyzing data that is collected voluntarily by member hospitals. It is the only source of aggregate standardized international data on HAIs in developing countries.^{11–14} There are now more than 400 ICUs in approximately 40 countries on 4 continents that participate in the INICC.</p>
Surveillance Provinciale des Infections Nosocomiales (SPIN)	Province of Quebec, Canada	2003	<p>SPIN was launched to gather surveillance data on CLABSIs in ICUs in Quebec. This surveillance system sought to estimate the incidence and mortality rates of CLABSIs, the pathogens associated with them, and risk factors for the development of CLABSIs. NNIS/NHSN surveillance definitions and methodologies are used. The database permits ongoing evaluation of rates, with results published annually since 2005. Participation in the system was voluntary until 2007, at which point all ICUs with 10 or more beds were mandated to report their data.¹⁵</p>

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Table 5-1. (Continued)

References	
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Note: Websites listed in table accessed Mar 20, 2012. HAI: health care–associated infection; CLABSI: central line–associated bloodstream infection; ICU: intensive care unit; CVC: central venous catheter.

other approaches to surveillance have been sought that both save time and facilitate efficient review of relevant data.

Prevalence Surveys

Prevalence surveys assess the number of cases or events that occur in a population at a specified point in time (point prevalence) or over a specified period (period prevalence).¹⁸ Prevalence surveys may offer an alternative to traditional surveillance methods as a way to identify the most common HAIs, including CLABSI, particularly in resource-limited countries.^{41,42} Such surveys have been found to be a relatively inexpensive and quick means to estimate the incidence of

HAIs.⁴¹ They can be useful in providing baseline data regarding HAIs and help to prioritize infection prevention and control efforts.⁴³ As with traditional surveillance, however, it is important that prevalence surveys be carried out in a standardized manner, with clear definitions of infection and case finding methodologies.⁴⁴

Electronic Surveillance Systems

Electronic surveillance systems (ESSs) appear to be another approach to surveillance, eliminating or minimizing the manual collection of data. ESS technologies have been proposed as a means of improving HAI surveillance capabilities and

accuracy, and they have evolved rapidly over the past 15 years.^{5,19,20,39,45–48} ESSs, also referred to as automated systems, obtain information to identify infections from interrelated electronic databases. Analytic software in the system detects and tracks infections in real time.⁴⁹ This relatively new technology allows IPs to more efficiently collect, aggregate, and derive meaning from data.⁴⁸ More and more organizations in the United States are implementing electronic health records (EHRs), a prerequisite for ESS implementation. Now there are a multitude of independent consultants, commercial vendors, and stand-alone or in-house-developed ESSs,^{48,49} all of which integrate portions of the EHR along with admission, discharge, transfer, treatment, and diagnostic information.³⁰ ESSs may even have application in developing countries, especially for identifying device-associated infections.⁵⁰ It is likely that, as information technology grows and evolves throughout the world, more and more countries will design ESSs for use in health care organizations. Sidebar 5-1 at right provides additional information about the implementation of ESSs in the United States.

While ESSs may be efficient and effective in identifying infections, the data must still be reviewed and interpreted, which still requires the critical thinking abilities of an infection preventionist.⁴⁵ Additionally, the process of initiating and maintaining ESSs has been reported as being a challenge, and the lack of standardized ESSs across hospitals has been identified as a barrier to their effective use.⁵¹ Fortunately, however, there likely is a shift from time spent collecting data to time spent analyzing data and implementing corrective actions.⁴⁵

ESSs include two types of systems: data mining systems, which can detect new and unexpected patterns and relationships in data with the use of mathematical and statistical techniques (the system independently identifies potentially significant events), and query-based data management systems, which require user input but do not seek patterns independently (the system must be told where to look).⁴⁸ Many systems also include report-generating capabilities that produce graphs or charts for the end user.⁴⁸

The Association for Professionals in Infection Control and Epidemiology (APIC) supports the use of automated surveillance technologies as an essential component of infection prevention and control activities.³⁰ The benefits, essential components, and limitations of ESSs have been described in the literature, a key feature being the potential to ease the burden of data management for IPs,^{30,48} as summarized in Table 5-2 on page 91.

Sidebar 5-1. Status of Electronic Surveillance System Use in the United States

Electronic surveillance systems (ESSs) are presently not used extensively in infection prevention and control programs in the United States. A 2008 survey in California by Grota et al. found that only 23% (44/192) of the responding infection prevention and control programs had an ESS.* The researchers also found that organizations that had strong leadership support frequently had ESSs, which is not surprising given the costly nature of purchasing and maintaining the systems. Several US states provide incentives to hospitals to adopt ESSs†:

- New Jersey law mandates the provision of incentives for hospitals to increase the implementation of ESSs in the support of HAI prevention programs.
- Pennsylvania law requires ESSs for hospitals across the state, unless they can demonstrate that they lack the resources or technology to do so.
- California law requires the state's Department of Public Health to evaluate the use of automated databases for infection prevention data reporting, with a report of their findings to go to the legislature.

Although a minority of US hospitals currently use ESSs, the evolving environment of mandatory HAI reporting regulations, coupled with the Centers for Medicare & Medicaid Services policy that no longer reimburses hospitals to treat certain HAIs, including CLABSIs, may provide further impetus in the more widespread adoption of ESS in US hospitals.†

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- † Halpin H, Shortell SM, Milstein A, Vanneman M. Hospital adoption of automated surveillance technology and the implementation of infection prevention and control programs. *Am J Infect Control*. 2011 May;39(4):270–276.

A great deal of information needs to be considered when evaluating the various ESS products that are available. Greene et al. suggest the following steps in evaluating ESSs for potential incorporation into a facility³⁰:

- Involve all key stakeholders in the evaluation process.
- Develop a list of requirements a system must have and a list of requirements that would be nice to have.
- Interview vendors who develop facility-specific systems.
- Ask the different vendors to demonstrate a standard scenario, such as retrieving all positive cultures for a specific organism for a specific unit within a designated time frame.
- Ask other users of the systems under evaluation whether they are satisfied with the system.
- Create side-by-side vendor comparisons of the specific functions of the systems (for example, event alerts, rate and trending analyses, messaging/data collection transfer to the NHSN).
- Determine the resources and time that would be needed to implement and maintain each system.

- Evaluate the flexibility of the system and its ability to adapt to changing needs.
- Evaluate the systems' abilities to keep data secure and confidential.
- Assess the business case.
- Decide which system will be selected and work through the ordering and installation process.

APIC has developed a tool that is designed to help those evaluating ESSs determine which system would be the most appropriate and effective for their needs. The tool allows the user to capture standardized information to make the decision-making process easier. The tool is available on the APIC website, under "Practice Guidance," at <http://www.apic.org/Practice-Guidance/Practice-Resources/Surveillance-Technology>.⁵²

Additional research is still needed in the development, standardization, and implementation of ESSs. Most ESSs focus solely on monitoring HAIs.⁵ Few ESSs have been rigorously

Table 5-2.
Benefits, Essential Components, and Limitations of Electronic Surveillance Systems

Benefits	Essential Components	Limitations
<ul style="list-style-type: none"> ■ Facilitate and streamline efficient review of relevant data, thereby promoting rapid identification of outbreaks and sentinel events ■ Reduce error ■ Facilitate less "desk time," more time for engaging health care personnel in patient care areas ■ Better define and expand the scope of infection prevention activities ■ Reduce the amount of time spent on surveillance and clerical tasks ■ Improve identification of, and response to, public health issues ■ Demonstrate regulatory compliance ■ Support cost savings associated with reductions in health care–associated infections via enhanced surveillance ■ Enhance antimicrobial stewardship 	<p>The ability to:</p> <ul style="list-style-type: none"> ■ Obtain essential patient-specific clinical information from data sources throughout the organization ■ Retrieve data in real time ■ Take data from various diagnostic and/or clinical systems and translate the data into useful information or alerts ■ Send standard electronic messages and/or clinical documents to public health authorities 	<ul style="list-style-type: none"> ■ Success or failure is dependent on: <ul style="list-style-type: none"> ● User involvement ● Effective communication between users and developers ● Learning curves ● Administrative support ■ Data still require further analysis to meet surveillance definitions, such as those of the National Healthcare Safety Network ■ The threshold for detection of clusters and patterns can be low, so all data need to be evaluated to determine whether they are significant ■ Implementation usually requires extensive time and resource allocation ■ Changes and upgrades to system require ongoing financial support

Sources: Adapted from Greene LR, Cain TA, Khoury R, Krystofiak SP, Patrick M, Streed S. APIC position paper. The importance of surveillance technologies in the prevention of health care–associated infections (HAIs). *Am J Infect Control*. 2009 Aug;37(6):510–513. Accessed Mar 20, 2012. http://www.apic.org/Resource_/TinyMceFileManager/Position_Statements/Surveillance-Technologies-position-paper-2009.pdf; Wright MO. Automated surveillance and infection control: Toward a better tomorrow. *Am J Infect Control*. 2008 Apr;36(3 Suppl 1):S1–6.

evaluated in the peer-reviewed literature.⁵³ It would appear that this technology has the potential to fundamentally change the way in which surveillance is done.⁴⁸

Measurement Approaches: Outcome and Process Performance Measures

Specific outcome measures (for tracking rates) and process measures (to determine adherence to recommended practices) should be identified in individual organizations, based on areas that have been identified for performance improvement.⁵⁴ Feedback of process and outcome measure data has been a key component of multifaceted interventions that have been successful in reducing CLABSI rates.^{10,11} The measures chosen will depend on a number of variables, such as the services the organization provides, the procedures performed, the type of health care setting, identified risk factors, available surveillance resources, and regulatory or accrediting requirements.¹⁸ In some parts of the world where resources are very limited, lack of financial support for trained personnel to conduct surveillance or lack of adequate microbiologic testing capabilities will impact surveillance activities and the measures chosen, including those for CLABSI.¹⁶

It is important that appropriate calculations of both process and outcome measures be performed and reported, using a consistent methodology over time, in order that variation in rates can be adequately assessed.⁶ The measures should be reported to senior hospital and nursing leadership and clinicians who care for patients at risk for CLABSI.²⁰ Each type of measure and its calculation is discussed in more detail here:

- Outcome measure data are collected to measure the rate of CLABSI in a patient population. NHSN definitions are frequently used in CLABSI surveillance, even in countries outside the United States^{10,55} (see Sidebar 5-2 on page 93 for NHSN definitions related to CLABSI events). According to the NHSN protocol,⁵⁶ the CLABSI rate per 1,000 central line–days is calculated by dividing the number of CLABSIs by the number of central line–days and multiplying the result by 1,000:

$$\frac{\text{number of CLABSI cases in each unit assessed}}{\text{total number of central line–days in each unit assessed}} \times 1,000$$

CLABSI rates should be stratified by type of patient care unit and compared to NHSN data, if available.²⁰ Note that central line–days, not patient–days, are used as the denominator, as only patients with a central line are at

risk of developing a CLABSI.⁵⁷ The NHSN methodology also stipulates that no matter how many central lines or lumens each patient has, each patient is counted as one catheter–day.⁵⁶ It should be noted that other researchers have found that the NHSN method of collecting central line–days can result in undercounting of line–days in patients with multiple CVCs, which can inflate the CLABSI rate in settings that have high CVC use.⁵⁸ This may be especially important in countries such as the United States, where all hospitals are now required to report their ICU CLABSI rates to the Centers for Medicare & Medicaid Services (CMS) via the US CDC’s NHSN.⁵⁹ CLABSI rates, which were required to be submitted beginning in 2011, will be used to determine the level of reimbursement from CMS to US hospitals, starting in 2013.⁵⁹

Collecting central line–days can be burdensome, particularly when electronic health records are not in use and the data are collected manually each day.^{60,61} To address this burden, Klevens et al. devised a method of sampling to simplify the counting of central line–days. The approach involves collecting the number of central line–days one day a week, an approach that was tested in more than 250 US hospitals.⁶² The researchers found that the estimate of the number of central line–days, based on the sample, produced an infection rate that was not meaningfully different from the traditional method of collecting central line–days. Building on the research of Klevens et al., the US CDC began collaborating with 10 state health departments to evaluate the validity and feasibility of estimating central line–days for use in CLABSI surveillance in the NHSN.⁶³ Phase 1 of the US CDC project included retrospective evaluation of denominator data collected during 2009 and 2010; in Phase 2, which started in January 2011, volunteer hospitals began collecting denominator data using the simplified method. The US CDC will determine how well the once-weekly sampling approximates the monthly reporting of daily denominator reporting. If this methodology is determined to be valid and is adopted by the NHSN, it is estimated it could save 85% of staff time spent collecting the daily CLABSI denominator data.⁶³

Another group of researchers studied the usefulness of prospectively estimating central line–days using device utilization ratios.⁶⁴ Six New York hospitals with a total of

38 hospital units outside the ICU counted and recorded the number of patients with central lines on at least one day each week. Hospital registration systems provided the total number of patient-days per unit each month. The

device utilization ratio was calculated by dividing the number of central line–days by the number of patient–days; the researchers concluded that this ratio provided a reasonable estimate to use in calculating CLABSI rates.

Sidebar 5-2. National Healthcare Safety Network Definitions for CLABSI Event

Central venous catheter (CVC)

An intravascular catheter that terminates at or close to the heart or in one of the *great vessels* which is used for infusion, withdrawal of blood, or hemodynamic monitoring. The following are considered great vessels for the purpose of reporting central line bloodstream infections and counting central line–days in the National Healthcare Safety Network (NHSN) system: aorta, pulmonary artery, superior vena cava, inferior vena cava, brachiocephalic veins, internal jugular veins, subclavian veins, external iliac veins, common iliac veins, femoral veins, and, in neonates, the umbilical artery/vein.

Notes:

- Neither the insertion site nor the type of device may be used to determine if a line qualifies as a central line. The device must terminate in one of these vessels or in or near the heart to qualify as a central line.
- An introducer is considered an intravascular catheter, and, depending on the location of its tip, may be a central line.
- Pacemaker wires and other nonlumened devices inserted into central blood vessels or the heart are *not* considered central lines because fluids are not infused, pushed, or withdrawn through such devices.
- The following devices are not considered central lines: extracorporeal membrane oxygenation (ECMO), femoral arterial catheters, and intra-aortic balloon pump (IABP) devices.

Laboratory-confirmed bloodstream infection (LCBI)

An infection that meets one of the following criteria:

Criterion 1: Patient has a recognized pathogen cultured from one or more blood cultures *and* organism cultured from blood is not related to an infection at another site.

Criterion 2: Patient has at least one of the following signs or symptoms: fever (greater than 38°C [100.4°F]), chills, or hypotension *and* signs and symptoms and pos-

itive laboratory results are *not* related to an infection at another site *and* common commensal (i.e., diphtheroids [*Corynebacterium* spp. not *C. diphtheriae*], *Bacillus* spp. [not *B. anthracis*], *Propionibacterium* spp., coagulase-negative staphylococci [including *S. epidermidis*], viridans group streptococci, *Aerococcus* spp., *Micrococcus* spp.) is cultured from two or more blood cultures drawn on separate occasions.

Criterion 3: Patient less than 1 year of age has at least one of the following signs or symptoms: fever (greater than 38°C [100.4°F] core), hypothermia (36°C [86°F] core), apnea, or bradycardia *and* signs and symptoms and positive laboratory results are *not* related to an infection at another site *and* common skin commensal (i.e., diphtheroids [*Corynebacterium* spp. not *C. diphtheriae*], *Bacillus* spp. [not *B. anthracis*], *Propionibacterium* spp., coagulase-negative staphylococci [including *S. epidermidis*], viridans group streptococci, *Aerococcus* spp., *Micrococcus* spp.) is cultured from two or more blood cultures drawn on separate occasions. (*Note:* Further details associated with this definition appear in the NHSN module from which it is adapted; see footnote for full source listing, including web link.)

Primary bloodstream infection (BSI)

Laboratory-confirmed bloodstream infections that are not secondary to a community-acquired infection or a health care-associated infection meeting NHSN criteria for an infection at another body site. Report bloodstream infections that are *central line associated* (i.e., a central line or umbilical catheter was in place at the time of, or within 48 hours before, onset of the event). *Note:* There is no minimum period of time that the central line must be in place in order for the bloodstream infection to be considered central line associated.

Source: Adapted from US Centers for Disease Control and Prevention. National Healthcare Safety Network. Device-Associated (DA) Module. Protocol and Instructions: Central Line-Associated Bloodstream Infections (CLABSI) Event. Jan 2012. Accessed Mar 20, 2012. http://www.cdc.gov/nhsn/PDFs/pscManual/4PSC_CLABScurrent.pdf.

- Process measures assess adherence to recommended practices to prevent CLABSIs. The US CDC’s Healthcare Infection Control Practices Advisory Committee (HICPAC) has recommended incorporating evidence-based practices into the insertion and care of CVCs.⁵⁴ Process measures are all multiplied by 100 so that they are expressed as percentages. The target adherence rate is 100%.⁶⁵ Process measures to consider, ranked in order of priority from highest to lowest, include the following²⁰:

- Adherence to all elements of the CVC insertion checklist (appropriate hand hygiene performed, maximal sterile barrier precautions used, chlorhexidine skin antiseptics used), which is assessed by reviewing the documentation on the insertion checklist. This measure is calculated as follows:

$$\frac{\text{number of CVC insertions in which all 3 interventions are performed at CVC insertion}}{\text{number of CVC insertions}} \times 100$$

(Note that, in parts of the world where chlorhexidine may not be available for use, the same methodology would apply to measuring the use of other skin antiseptics.)

- Adherence to documentation of daily assessment of the need for continuing CVC access, which is assessed by reviewing the documentation in the patient’s medical record. This measure is calculated as follows:

$$\frac{\text{number of patients with a CVC for whom there is documentation of a daily assessment}}{\text{number of patients with a CVC}} \times 100$$

- Adherence to cleaning of catheter hubs and injection ports before they are accessed, which will need to be assessed through actual observation of practice. This measure is calculated as follows:

$$\frac{\text{number of times that a catheter hub or port is observed to be cleaned before it is accessed}}{\text{number of times a catheter hub or port is accessed}} \times 100$$

- Adherence to avoiding the femoral vein site for CVC insertion in adult patients that are not used for temporary hemodialysis, which can be assessed through observation on point prevalence surveys or by review of documentation on insertion checklists. This measure is calculated as follows:

$$\frac{\text{number of patients with a CVC in the femoral vein}}{\text{number of patients with a CVC}} \times 100$$

The NHSN has a Central Line Insertion Practices (CLIP) option, which can be used in any type of patient care loca-

tion where CVCs are inserted.⁶⁶ This option enables participating organizations to do the following:

- Monitor CVC insertion practices in individual units and facilities and provide aggregate adherence data for all participating organizations (an optional component of CLIP is recording inserter-specific adherence data)
- Identify gaps in recommended practices, which aids organizations in targeting intervention strategies to reduce CLABSI rates

Proposed future enhancements would link gaps in adherence to recommended practices with CLABSI rates, both in individual organizations and for all those participating.⁶⁶ Training for CLIP is available at http://www.cdc.gov/nhsn/wc_CLIP.html.⁶⁷

Benchmarking and Public Reporting

The standard perception of HAIs is changing from their being inevitable consequences of health care to their being preventable and even unacceptable events and a “zero tolerance” mind-set—with organizations setting the goal at eliminating HAIs rather than being comfortable with meeting national or local averages.^{31,68–70} However, benchmarking of HAI surveillance data has been done for many years to inform infection prevention strategies.⁷¹ In benchmarking, organizations compare their performance against that of others, with the goal of improving their performance through the implementation of best practices.⁷¹ More recently, public reporting of outcome measures has been advocated as a means to promote transparency, allow consumers to seek health care in safer organizations, and provide an incentive to improve care.^{72–75} Mandatory public reporting of HAI data has been in place in several countries, including France, England, Germany, and the United States.⁷¹ However, the approach to public reporting has varied across countries. England, Germany, and the United States have focused primarily on reporting HAI rates, while France has focused on process and structure measures.⁷¹

Many states in the United States have enacted mandates and legislation requiring health care organizations to report HAI rates (see Figure 5-1 on page 95), though such enactments vary in specific requirements.^{72,76}

Variation also exists in the complexity of each state’s measurement system, the level of data quality control, how and to whom the data are reported, and the period of time over which the programs have been phased in.⁷² In many instances the decisions regarding public reporting of HAIs

has been more political than scientific, with little attention to the accuracy of the measures, their preventability, or the burden of data collection.⁷²

US CMS passed regulations in 2008 that deny payment for the incremental costs associated with select hospital-acquired conditions (HACs), including CLABSIs, that occur during a hospital stay (that is, conditions that were not present when the patient was admitted to the hospital).^{77,78} CMS also prohibits the hospital from billing patients for additional costs incurred as a result of any HACs. This is a significant change in government policy, aligning payment with patient outcomes.⁷⁹ The HACs include those that are high volume, high cost, or both, result in the assignment of a case to a diagnosis-related group (DRG) that has a higher payment when present as a secondary diagnosis and could reasonably have been prevented through the application of evidence-based guidelines.⁸⁰ Sidebar 5-3 on page 96 contains an overview of the 10 HACs. For discharges occurring on or

after October 1, 2008, hospitals do not receive additional payment for cases in which one of the selected HACs was not present on admission (POA). That is, the case would be paid as though the secondary diagnosis were not present.

In the United States a group of researchers has begun to assess the impact of CMS's policy to deny payment for certain HACs, including CLABSIs, on health outcomes and costs in hospitals that report data to CMS and the NHSN. The Preventing Avoidable Infectious Complications by Adjusting Payment (PAICAP) project, funded by the Agency for Healthcare Research and Quality (AHRQ), is being conducted by researchers at Harvard Pilgrim Health Care Institute, Harvard Medical School, and Harvard School of Public Health. Project collaborators include leadership at the NHSN, the CDC, APIC, the Institute for Healthcare Improvement, the Society for Healthcare Epidemiology of America, and CMS.⁸¹ The aims of the project are as follows:

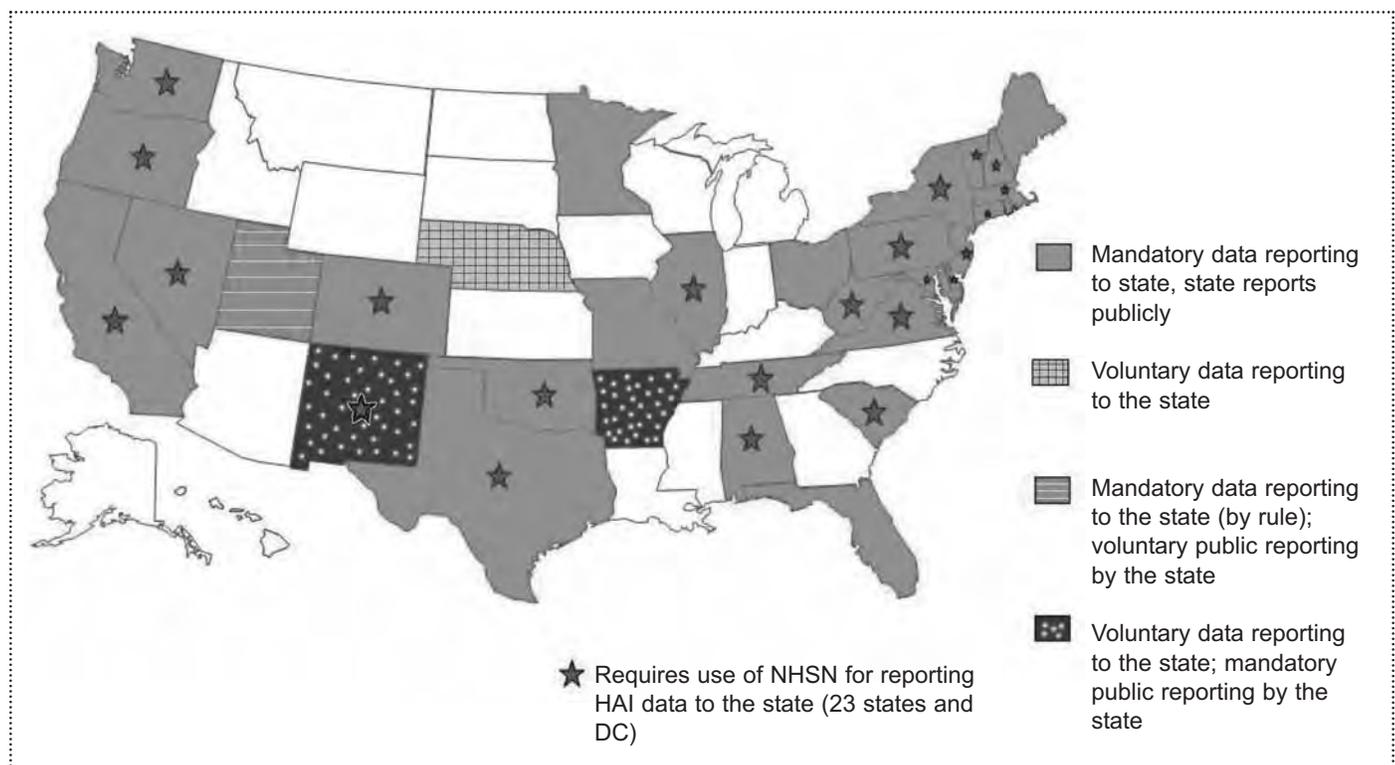


Figure 5-1. Health Care–Associated Infection Reporting Laws (as of January 2011)

Source: US Centers for Disease Control and Prevention and Association of State and Territorial Health Officials. Eliminating Healthcare Associated Infections: State Policy Options. Mar 2011. Accessed Mar 20, 2012. http://www.cdc.gov/HAI/pdfs/toolkits/toolkit-HAI-POLICY-FINAL_03-2011.pdf. Used with permission.

- To evaluate the impact of the CMS policy on HAI billing rates reported by Medicare
- To evaluate the impact of the CMS policy on true infection rates reported through the NHSN
- To explore whether the CMS policy reduces both billing and true infection rates in hospitals
- To assess whether reduced reimbursement for HAIs as a result of the CMS policy disproportionately affects hospitals that care for a high proportion of poor and minority patients

This is a four-year project that began in 2010, with voluntary reporting of data by hospitals that report data to the NHSN.

Starting in January 2011, CMS expanded public reporting beyond the state level. Medicare-eligible hospitals throughout the United States were required to begin tracking and reporting CLABSIs in ICUs to CMS to get an annual 2% Medicare payment increase. Hospitals report their infection rates to the CDC’s NHSN, which then shares the data with CMS.⁷⁸ In April 2011 CMS began publicly reporting the first eight HACs (see Sidebar 5-3 below) on the Hospital Compare website, at <http://www.hospitalcompare.hhs.gov>.⁸² (Also see the CMS website, at <http://www.cms.gov/apps/media/press/factsheet.asp?Counter=3923&intNumP>.⁸³) More information about hospital reports and the specifica-

tions for the eight HACs (numerators, denominators, inclusions, exclusions, and more) are available at <http://www.qualitynet.org/dcs/ContentServer?cid=1228759488899&pagename=QnetPublic%2FPage%2FQnetTier4&c=Page>.⁸⁴

Public reporting may be either voluntary or mandatory. Voluntary participation likely will attract organizations more interested in quality improvement than those forced to report HAI data.⁷¹ These organizations may also be more amenable to participating in validation or training exercises and may produce higher-quality data.⁷¹ In their review of public reporting in four high-income hospitals, Haustein et al. note that the proportion of hospitals participating in voluntary reporting of data was consistently at 50% or less over time.⁷¹ Another issue in voluntary reporting programs is that hospitals regularly join and leave the program, which impacts the representativeness and completeness of the reported data.⁷¹

There has been much controversy surrounding the issue of public reporting. With increasing interest in public reporting and its potential impact on health care delivery, it is essential that the mechanisms for reporting be standardized and their accuracy be assessed and confirmed.^{85,86} When validated, mandatory reporting provides confidence in a more accurate picture of HAI rates across all participating organizations.⁸⁷ Mandatory reporting does, however, require additional resources to analyze and validate data and achieve buy-in from health care organizations and other key stakeholders.⁸⁷

Surveillance for HAIs, however, is far from perfect. Interpretation and application of surveillance definitions, including those for CLABSI, can vary within and between organizations, and there is no gold standard for data validation.^{19,88,89} There are challenges in assuring that consistent, well-defined, and ongoing mechanisms are in place to determine the reliability (measuring something consistently or precisely) and validity (measuring what is intended to be measured) in the identification of HAIs.⁹⁰ European attempts at intercountry comparisons revealed differences in the sensitivity of case finding and interpretation of case definitions.^{55,91} Researchers in the United States and Australia found significant institutional variability in the application of standard CLABSI surveillance definitions by IPs across several hospitals.^{19,92} Another group of researchers compared two different methods used by state health departments in the United States to identify BSIs related to CVCs.⁸⁵ They

Sidebar 5-3. US CMS 10 Categories of Hospital- Acquired Conditions

1. Foreign object retained after surgery
2. Air embolism
3. Blood incompatibility
4. Stage III and IV pressure ulcers
5. Falls and trauma
6. Manifestations of poor glycemic control
7. Catheter-associated urinary tract infection (UTI)
8. Vascular catheter–associated infection
9. Surgical site infection following certain procedures
10. Deep vein thrombosis (DVT)/pulmonary embolism (PE)

Source: US Centers for Medicare & Medicaid Services. Hospital-Acquired Conditions. (Updated Mar 15, 2012.) Accessed Mar 21, 2012. https://www.cms.gov/HospitalAcqCond/06_Hospital-Acquired_Conditions.asp#TopOfPage.

found that the different measures identified different cases. Braun et al. similarly found that the use of various BSI indicator specifications resulted in different rates of infection.⁹³ Assuring simplicity of the reporting specifications and their use in HAI surveillance and assessing and minimizing variability in the surveillance process are essential in making valid comparisons of rates between institutions.^{19,22} While recommendations for public reporting of HAIs that provide general guidance have been developed by HICPAC, the HAI Working Group of the Joint Public Policy Committee, and the National Quality Forum, further guidance is needed regarding the many issues surrounding the actual implementation of public reporting.⁷²

The efficacy of public reporting in bringing about positive change and improving patient care is uncertain at this time.⁷⁴ Ideally, public reporting would motivate hospitals to implement evidence-based recommendations and improve processes to reduce rates of HAIs.⁷⁹ Unfortunately other, less desirable outcomes are possible, such as modifying billing practices to circumvent and limit the impact of reporting requirements or limiting exposure to potential revenue loss by shunning patients who are likely to develop HAIs.⁷⁹ Stone et al. recently studied the impact of mandatory reporting of HAI rates in California, finding increased presence of, and adherence to, evidence-based practices.⁹⁴ However, the researchers also found a change in the role of the infection preventionist, with less time spent on educational activities and more time spent on surveillance.⁹⁴ Clinicians who provide care must be aware of and confident in the data regarding HAI rates and must be motivated to change behaviors (that is, implement evidence-based recommendations), which requires the use of valid process and outcome measures and effective feedback mechanisms at all levels.⁷² Long-term research is needed in order to fully understand and appreciate the impact, both positive and negative, of public reporting policies.⁵¹

In summary, the use of surveillance data has shifted from simply measuring clinical outcomes, such as CLABSIs, to guiding performance improvement initiatives and tracking improvements in outcomes and patient care practices over time. Infection preventionists must ensure that their surveillance programs are based on sound principles of epidemiology and current recommended practices.¹⁸ The increasing emphasis on reducing CLABSI rates, by both funding agencies and the public, underscores the importance of assuring comparability in rates by minimizing variability and enhancing standardization in surveillance practices.

Summary of Key Points

This chapter provides information on practices organizations can follow to monitor CLABSIs, measurement approaches to take in assessing central venous catheter insertion and maintenance practices, and public reporting of infection rates and pay-for-performance programs. Key points to keep in mind include the following:

- Surveillance for health care–associated infections (HAIs), including CLABSIs, is a necessary first step in defining the nature and magnitude of the problem in any infection prevention and control program. Surveillance involves systematically collecting, analyzing, interpreting, and disseminating data to members of the health care team as a means to facilitate improvement in patient outcomes.
- Surveillance activities for HAIs, including CLABSI, should be based on the results of an organizational risk assessment, as each organization serves different types of patients at varying levels of risk.
- Approaches to surveillance that both save time and facilitate efficient review of relevant data include prevalence surveys and electronic surveillance systems.
- Specific outcome measures (for tracking rates) and process measures (to determine adherence to recommended practices) should be identified in individual organizations, based on areas that have been identified for performance improvement.
- Public reporting of outcome measures can promote transparency, allow consumers to seek health care in safer organizations, and provide an incentive to improve care. In many US states, reporting of HAI rates is now required by law.

In this chapter, we have examined CLABSI surveillance, benchmarking, and public reporting. The next chapter will examine the economic aspects of CLABSIs and their prevention.

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CHAPTER 6

Economic Aspects of CLABSIs and Their Prevention

There are significant financial costs associated with central line–associated bloodstream infections (CLABSIs), in addition to the morbidity and mortality that result from these infections. CLABSI costs include those related to diagnosis and treatment, prolonged hospital stays, and, more recently in some countries, lack of reimbursement by third-party payers for expenses incurred. The economic consequences of CLABSIs, as well as costs attributable to interventions aimed at reducing them, can be complex to quantify, as many factors come into play. Adding to the complexity is the lack of consistency in the methods used by various researchers to estimate these costs¹⁻⁵ and differences in financial systems across different parts of the world.⁶ This complexity has significant implications, as having an adequate understanding of the burden of health care–associated infections (HAIs), including costs, is an essential step toward identifying interventions and improving care.

This chapter includes economic terminology that has not been used in previous chapters. A few key terms are included in Table 6-1 on page 104.

An essential component of understanding the attributable costs is having reliable and valid surveillance data on the incidence of infection. Data are becoming more readily available in developing countries as a result of the work done by groups such as the International Nosocomial Infection Control Consortium (INICC), the first organization to study the burden of HAIs in developing countries.^{7,8} The INICC has been publishing annual reports containing increasing amounts of data on HAIs since 2002, using a standardized methodology and definitions.^{8–12} Many resource-limited countries, however, remain without the means to conduct HAI surveillance at the local, regional, or national levels. Scarce resources in such countries are allocated to other health priorities over patient safety considerations.^{7,13}

The unfortunate reality is that no one knows the number of patients around the globe who experience HAIs each year. Based on available data, the World Health Organization (WHO) estimates that the annual number could be in the hundreds of millions.¹³ WHO has stated, “In many settings, from hospitals to ambulatory and long-term care, [health care–associated infection] appears to be a hidden, cross-cutting problem that no institution or country can claim to have resolved yet.”^{13(p. 3)} The burden of HAIs is even greater among high-risk populations, such as patients in intensive

care units (ICUs) and newborns. HAI rates are estimated to be several times higher among high-risk populations in low- and middle-income countries than in high-income countries.¹³ This is especially true for device-associated infections, including CLABSIs. Table 6-2 on page 105 provides examples of pooled incidence densities for CLABSIs in adult ICU patients, based on WHO data from national or international surveillance networks or literature reviews.

The INICC has done additional research that demonstrates significant variation in rates between countries, which is associated with differences in economies (low income versus lower middle versus upper middle) and type of hospital (public versus private versus academic), an observation that is lost in pooled cumulative incidence rates.^{5,9,14} This variation is further noted in a yet-unpublished systematic review of the literature for CLABSI rates in several developing countries in all regions of the developing world (see Appendix B at the end of the book).

The elimination of these preventable infections presents an opportunity to both improve patient outcomes and reduce costs.¹⁵ In this chapter, cost issues encountered in estimating costs associated with HAIs and the business case for CLABSI prevention are presented.

Table 6-1.
Terminology Used in Economic Evaluations

Term	Definition
Attributable costs	Costs that would not have occurred in the absence of the infection or complication of interest.* Examples include costs associated with additional days as an inpatient (for example, antibiotics, laboratory tests, supplies) to diagnose and treat the infection.
Business case analysis	A type of cost analysis performed from the perspective of a business.*
Direct costs	Costs associated with a particular product, procedure, or service that can be traced directly to that product, procedure, or service.† Examples include nursing staff salaries to care for a patient with a CLABSI or salaries for infection prevention staff to identify and analyze the data associated with the infection.
Fixed costs	Daily operating costs, such as buildings, equipment, and staff salaries. These costs do not vary based on patient volume. It is estimated that more than 80% of hospital costs are fixed.*
Variable costs	Expenses that vary with volume. These costs may be dependent on the number of patients admitted or their length of stay. Variable costs include drugs, tests, supplies, and procedures.*

* Adapted from Perencevich EN, Stone PW, Wright SB, Carmeli Y, Fisman DN, Cosgrove SE; Society for Healthcare Epidemiology of America. Raising standards while watching the bottom line: Making a business case for infection control. *Infect Control Hosp Epidemiol.* 2007 Oct;28(10):1121–1133.

† Adapted from Dunagan WC, Murphy DM, Hollenbeak CS, Miller SB. Making the business case for infection control: Pitfalls and opportunities. *Am J Infect Control.* 2002 Apr;30(2):86–92.

First Do No Harm

The single most important reason for having an infection prevention and control program in place is to prevent the morbidity and mortality associated with HAIs, many of which are now recognized as preventable complications of health care. Health care organizations in some parts of the world, where human and financial resources are limited, may not have access to some of the most basic infection prevention knowledge, supplies, or equipment; and the necessary infrastructure for infection prevention is often lacking.¹³ But even in high-income countries with sophisticated care techniques and access to modern medical treatments, knowledge and awareness of HAI are often poor, and evidence-based infection prevention and control strategies may not be uniformly in place within or across organizations to prevent HAIs.

Conducting a business case analysis is helpful in determining whether the financial benefits of a new or increased investment in activities to prevent HAIs will outweigh their additional cost.¹⁶ Lack of financial resources is easily cited as a reason (or excuse) for not establishing an infection prevention and control program, so it is important that the economic costs of doing nothing be well communicated to leaders and key decision makers. This can be accomplished by illustrating the economic impact of infection prevention and control pro-

grams on HAI prevention.^{17,18} Infection can be identified as an avoidable cost to the organization and infection prevention and control programs as an investment rather than an expense.^{17,18} It is possible to demonstrate the business case for these programs in any country—including those in resource-constrained areas of the world. As described by Yokoe and Classen, “the safest care is often the most cost-effective care.”^{19(p. 58)}

Estimating CLABSI Costs

The types of HAIs and their associated costs vary from organization to organization, region to region, and even country to country. Facility-specific data on costs associated with CLABSI data are usually not readily available, so those responsible for infection prevention and control programs often need to rely on the literature in order to provide estimates of costs associated with CLABSIs and their prevention.^{20,21} If the literature or actual data from prior years are used to obtain cost estimates for CLABSI, inflation calculators available on the Internet can be used to align previous-year costs (for example, estimated cost of CLABSI per patient in 2002) to reflect the cost equivalent in more recent years (for example, the cost of CLABSI in 2011). One such calculator, available at <http://inflationdata.com>,²² contains current US inflation rates plus monthly inflation rate data back to January 2000; there is also a link to international inflation data on this website.

Table 6-2.
Pooled Cumulative Incidence Densities for CLABSI in Adult ICU Patients, WHO Data 1995–2010

Source of Surveillance Network or Reviews	Country/Countries	Study Period	CLABSIs per 1,000 Central Line-Days
National Healthcare Safety Network (NHSN)	USA	2006–2008	2.1
Krankenhaus Infektions Surveillance System (KISS)	Germany	2004–2009	1.3
Systematic review of the literature	High-income countries	1995–2010	3.5
International Nosocomial Infection Control Consortium (INICC)	25 developing countries	2003–2008	7.4
Systematic review of the literature	Low- and middle-income countries	1995–2010	12.2

Source: Adapted from World Health Organization. Report on the Burden of Endemic Health Care-Associated Infection Worldwide. 2011. Accessed Mar 20, 2012. http://whqlibdoc.who.int/publications/2011/9789241501507_eng.pdf.

Recently, Web-based “cost estimators” have become available to aid in assigning costs to HAIs, including CLABSIs. A few examples are listed here:

- “*Cost of Hospital-Associated Infections*” Model from the *Association for Professionals in Infection Control and Epidemiology (APIC)*. This calculator uses graphs and tables to capture and describe data on the impact of HAIs. It can be customized with organization-specific data or, if not available, data are provided from national studies to estimate economic ranges. This cost estimating tool can be accessed at <http://www.apic.org/Resources/Cost-calculators>.²³
- *Texas Medical Institute of Technology (TMIT) and APIC Healthcare Associated Infections Cost Calculator*. This cost calculator, which is the result of a collaboration between APIC and TMIT, is an alternative method from the above APIC cost calculator to determine costs associated with HAIs. This tool is also available at <http://www.apic.org/Resources/Cost-calculators>.²⁴
- *Stop BSI – CLABSI Opportunity Estimator*. Developed by the Johns Hopkins Quality and Safety Research group, this tool permits organizations to estimate the financial impact of CLABSI at the unit, hospital, or health-system level in US dollars. It also provides estimates of the number of infections, deaths, US dollars, and ICU days that could be prevented if CLABSI rates could be reduced. This calculator is available at http://www.safercare.net/OTCSBSI/CLABSI_Opportunity_Estimator_Jump.html.²⁵

Economic Analyses in Health Care

Three types of economic analyses are frequently used in health care decision making: cost-effectiveness analysis, cost–utility analysis, and cost–benefit analysis.^{1,26,27} Although the distinctions among these analyses may not be readily apparent, it is helpful to understand what is included and excluded from each.²⁷ They are described as follows:

- *Cost-effectiveness analysis* compares interventions or products that have different costs and different levels of effectiveness, in terms of cost per unit. A new intervention that costs less and is more effective than the existing intervention is more attractive economically than one that costs more but is less effective. The decision becomes more difficult, however, if the new intervention costs more but is more effective than the existing intervention—a scenario that is common with the rapidly changing technologies in health care. The benefits are measured using the most natural unit of comparison, such as the number of infections prevented (cases avoided) or lives saved.²⁷

- *Cost–utility analysis* is similar to cost-effectiveness analysis, except that the benefits of an intervention are weighted or adjusted by health preference scores. Quality adjusted life year (QALY) is a common unit of measure, the use of which has been proposed by many international organizations to facilitate comparisons among different studies.²⁸ QALY is a measure of the quantity of life weighted by the quality of life, thereby allowing the measure to take morbidity or disability into account.²⁷ In developing countries, disability adjusted life year (DALY) is a common measure used to estimate the burden of disease.²⁹
- *Cost–benefit analysis* measures all aspects, including consequences, according to a monetary unit, such as the dollar. If the benefits exceed costs, the intervention is considered worthwhile.²⁷ This analysis requires putting a monetary value on a human life or health benefits.²⁷

In recent years, cost-effectiveness analysis and cost–utility analysis have become the preferred methods for the evaluation of health care economics. Using a standardized unit of measure, such as QALY or DALY, makes it easier to compare different approaches or programs and make an informed decision.²⁷ A business case analysis is most closely related to a cost–benefit analysis.

Current Approaches to Creating a Compelling Business Case for HAI Prevention Resources

There is ever-increasing pressure to demonstrate that infection prevention and control programs are cost-effective. It is important that the business case for prevention of HAIs, including CLABSIs, be presented in a clear and concise manner to the leaders in an organization or the government who make the major financial decisions.³⁰ While many of those leaders may not have a clinical background, they are all interested in containing health care costs. All organizations are faced with deciding whether the benefits associated with increasing investments in infection prevention and control activities will outweigh the additional associated costs.²¹ The information presented in a business case analysis must be both comprehensive and accurate.²⁰ As anyone who has prepared a business case for an infection prevention and control intervention or program will likely tell you, it is much easier to quantify the costs of the intervention or program than their benefits or cost savings as a result of HAIs avoided. While making the business case for infection prevention and control may not be an easy process, it is an essential one that infection preventionists (IPs) need to understand and be capable of developing.²¹

A business case analysis is a type of cost analysis that is performed from the perspective of a business, in this case a health care organization.^{26,27} In preparing the business case, it is important not to underestimate staff time and costs or to overstate benefits. An organization's finance administrators should be consulted when considering a business case analysis, for assistance in capturing available local and organization-specific cost data.^{26,27}

The process of developing a business case analysis consists of several steps. Once broken down into separate components, and with the input from involved stakeholders, it provides an effective method to analyze a problem and present a solution.²⁶ The steps in developing a business case analysis are summarized in Table 6-3 on page 108.^{26,27}

Additional suggestions when promoting the value of infection prevention and control activities include the following:

- Understand the perspective of the health care executive, who must deal with competing priorities when making economic decisions about scarce resources. Demands on organization resources arise internally from activities associated with running the business of health care, as well as externally (such as from regulatory requirements, consumer demands, and governing bodies).²¹
- Think strategically—try to present your business case before budget time, so you will not be competing against all the other departments vying for the same limited resources.²⁰
- Bring a physician champion with you when you present your business case. Administrators know that physicians control the number of patients that come to their organization, so they are important influencers when decisions are being made.²⁰
- Be prepared to provide options, but think big. For example, first present your case for the new full-time IP, but if a full-time IP is deemed to be out of the question, be prepared to demonstrate the return on investment with a .8 FTE or a .5 FTE—sort of the gold–bronze–silver model.
- Do not base the business case for infection prevention and control solely on reducing direct operating costs that result from HAIs. As noted above, it is difficult to quantify the reductions in cost associated with the prevention of HAIs at a local level. The less tangible economic return for many organizations may come from activities

that help eliminate waste, keep staff healthy, and support an organizational culture of excellence.²¹

- Keep the ethical case for infection prevention and control programs in the forefront. “First do no harm” is not an economic argument but can be a compelling non-economic (that is, mission-based) point in justifying resource allocation to such programs.²¹

In summary, there are many factors that come into play when considering the economic consequences of CLABSIs. A business case analysis can provide information to help determine whether the financial benefits of a new or increased investment in infection prevention and control activities will outweigh their additional cost. A well-thought-out business case can go a long way toward demonstrating that infection prevention is an investment rather than an expense.

Summary of Key Points

This chapter discusses the significant economic aspects of CLABSIs in addition to the morbidity and mortality that result from these infections. Key points to keep in mind include the following:

- CLABSI costs include those related to diagnosis and treatment, prolonged hospital stays, and, more recently in some countries, lack of reimbursement by third-party payers for expenses incurred. Lack of consistency in the methods used by various researchers to estimate CLABSI costs and differences in financial systems in various parts of the world add to the complexity of quantifying these costs.
- An essential component in understanding the costs attributable to CLABSI is having reliable and valid surveillance data on the incidence of infection.
- Three types of economic analyses are frequently used in health care decision making: cost-effectiveness analysis, cost–utility analysis, and cost–benefit analysis. A business case analysis is most closely related to a cost–benefit analysis.
- Conducting a business case analysis is helpful in determining whether the financial benefits of a new or increased investment in activities to prevent health care–associated infections will outweigh their additional cost. In preparing the business case, it is important not to underestimate staff time and costs or to overstate benefits. A well-thought-out business case can help show that infection prevention is an investment rather than an expense.

Table 6-3.
Steps in Developing a Business Case Analysis

Step	Activity	Description	Example
1	Clearly articulate the issue/concern and present a hypothesis on potential solutions.	It is important that you clearly state the problem and the possible solution. You will need to convince hospital administration that any additional costs of the intervention you are proposing will be offset by the cost savings created by the intervention.	You want to implement an intervention to reduce the rate of central line–associated bloodstream infections (CLABSIs) in your organization. The additional surveillance, data analysis and feedback, and education of staff that will be required to support your intervention will require adding another infection preventionist (IP) to your department.
2	Meet with key administrators.	There are three important reasons to meet with key administrators (for example, chief operating officer, chief nursing officer, vice president of quality, chief medical officer) and other key individuals who oversee the infection prevention and control function: 1. To ensure that there is agreement that the issue you are addressing is a concern for your organization and would be supported by leadership 2. To gain their insights in identifying other key individuals (such as financial staff) or departments that may be affected by your proposal and whose needs should be incorporated into the business case analysis 3. To obtain help in identifying critical costs and factors that should be part of the analysis	Establish meetings with the chief operating or nursing officer, vice president of quality, chief medical officer, and other key individuals who oversee the infection prevention and control function.
3	Determine the annual cost.	Highlight the costs associated with your recommendation. This information may be available in budgets at your own organization, or you may be able to obtain information from the literature or surveys online. Note that infection-associated mortality is not considered.	In the current example, the cost is the salary of a full-time equivalent (FTE) plus the cost of benefits for that individual. You may have that cost information in budgets at your own organization, or you may be able to obtain similar information from the literature or surveys available online. If a baseline salary for a full-time IP is \$70,000, and benefits would cost 32% of that total, the annual cost for that FTE is \$92,400. Ideally, the costs of hiring the additional IP would be recouped over a reasonable period of time.
4	Determine what costs can be avoided through a reduced CLABSI rate.	Review the literature and determine the costs that could be avoided if the CLABSI rate could be reduced.	Based on a review of the literature, you may project that you could reduce your CLABSI rate by 20% in the first year that you have a new IP, which would be about three CLABSIs, based on historical data in your organization.

Continued on next page

Table 6-3. (Continued)

Step	Activity	Description	Example
5	Determine the costs associated with CLABSI at your organization.	In a business case analysis, the emphasis should be on attributable cost, which is the difference in costs between two identical hospital stays except for the occurrence of the complication under study. This data may be readily available in your organization, or, if not, can be found by reviewing the literature on CLABSI costs.	<p>Using a national estimate of the excess health care cost of a CLABSI at \$16,550,* it is tempting to multiply the number of CLABSIs expected to be prevented (3) by that dollar figure, which would be \$49,650. In the CLABSI example, this would be the difference in profits between a patient with CLABSI and one without. Three other aspects of attributable costs to consider:</p> <ol style="list-style-type: none"> 1. Because it is estimated that only 16% of costs are variable costs (such as supplies, medications, diagnostic procedures),† the estimate of variable costs for the three CLABSIs prevented would be \$7,944 rather than \$49,650. In this case, the annual cost of the new IP would be \$84,456 (\$92,400 minus \$7,944). 2. Another important component is the attributable cost of decreased length of stay (LOS). To calculate this cost, the mean daily cost of a hospital day is multiplied by the attributable cost of a CLABSI (figures that can be obtained from your organization's cost figures or estimates in the literature). Your review of the literature identified an average excess LOS for a CLABSI patient to be 12 days. Preventing three CLABSIs reduces the overall LOS by 36 days, and assuming a mean cost of about \$1,200 per day, the cost savings would be \$43,200. If about half of that is reimbursed (\$21,600), the total cost of the new IP considered with the cost savings would be \$84,456 minus \$21,600, or \$62,856. 3. Another way to estimate costs is to demonstrate how excess LOS can be reduced, as reducing LOS represents the greatest opportunity to improve profits. Because patients who do not develop infections leave the facility more quickly than those who do, the question becomes how many new patients could be admitted without additional investment in new equipment and buildings. If you had 15 CLABSIs last year, and you expect to reduce that by 20% (or three CLABSIs), 36 days (3 x 12 days) could be saved in the first year the new IP was in place. If your mean LOS for your organization is 3.5 days, 10 patients could be admitted, with the associated profits offsetting the investment in the new IP.

Continued on next page

Table 6-3. (Continued)

Step	Activity	Description	Example
6	Calculate the financial impact.	From the estimated cost savings or additional profits subtract the costs of the up-front outlay.	The estimated costs of the up-front outlay (salary and benefits of the new IP, or \$92,400) are subtracted from the cost savings (or additional profits) of reducing CLABSIs. In this example, the total economic impact on CLABSIs as a result of hiring an additional IP is estimated to range from an annual cost of \$62,856 to \$84,456 (see step 5). It is unlikely, however, that the new IP would be solely working on CLABSI–related activities, as this estimates assumes.
7	Include the additional financial or health benefits.	Because many infection prevention interventions have multiple benefits, one should also include any additional benefits for key administrators and stakeholders to consider.	<p>In this example, the following should also be considered:</p> <ul style="list-style-type: none"> ■ Because hand hygiene is a component of CLABSI prevention, one could anticipate a reduction not only in CLABSIs when health care personnel improve their adherence to hand hygiene but in other health care–associated infections (HAIs) as well. Other related costs would also decline with the additional infection prevention and control activities of the new IP. ■ Fewer infections in one group of patients may indirectly benefit other patients. For example, if a methicillin-resistant <i>Staphylococcus aureus</i> (MRSA) CLABSI is prevented in one patient, it also reduces the risk of MRSA transmission to other patients in the same unit. ■ HAIs, including CLABSIs, can be life-threatening, so reducing the incidence of infections will also impact the number of deaths associated with the infections. Reducing HAIs might be associated with reducing the organization’s risk management and legal costs. ■ Fewer HAIs may result in fewer dissatisfied patients and families and enhance the reputation of the organization.
8	Make the case for your business case.	Effective communication of the findings and recommendations from the analytical aspect of the business case to all critical stakeholders in the organization is essential. Communicating this information individually will provide an opportunity for each stakeholder to ask questions and discuss implementation plans and for you to evaluate the level of support for the initiative. When your findings are presented formally at a committee meeting, stakeholders are more likely to provide the support needed in the discussions prior to approval of the proposal. Enlist the help of medical and nursing administration to present your business case both in writing and verbally to the appropriate individuals, groups, or committees.	In the CLABSI example, begin by presenting your findings to the key administrators with whom you met in step 2, such as the chief operating officer, vice president of quality, chief medical officer, and other key individuals who oversee the infection prevention and control function. Next, you can present your findings to the committees deemed most appropriate, such as the infection prevention committee, patient safety committee, or quality committee.

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Table 6-3. (Continued)

Step	Activity	Description	Example
9	Prospectively collect cost and outcome data when the new program or process is in place.	To maintain consensus support and the momentum generated by the new efforts to reduce CLABSI rates, it is important to show continued improvement through the collection of outcome data and costs. Work with financial administrators to establish a way to track costs and outcomes.	Monitor CLABSI rates over time to determine whether the rates are rising, staying the same, or declining. Evaluate any associated benefits as well. Has there been a reduction in other HAI rates? What about staff and patient satisfaction?

* US Centers for Disease Control and Prevention. Vital signs: Central line–associated blood stream infections—United States, 2001, 2008, and 2009. *MMWR Morb Mortal Wkly Rep*. 2011 Mar 4;60(8):243–248.

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Source: Adapted from Perencevich EN, Stone PW, Wright SB, Carmeli Y, Fisman DN, Cosgrove SE; Society for Healthcare Epidemiology of America. Raising standards while watching the bottom line: Making a business case for infection control. *Infect Control Hosp Epidemiol*. 2007 Oct;28(10):1121–1133; Stone PW, Smith JA, Frick K. Finance for nurse managers: Return on investment. *American Nurse Today*. 2010 Mar;5(3):30–32.

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APPENDIX A

Evolution of Health Care– Associated Infection (HAI) Surveillance in the United States, 1958–2011

Evolution of Health Care–Associated Infection (HAI) Surveillance in the United States, 1958–2011

Year	Event	Summary
1958	Hospital surveillance for HAIs was first recommended by the American Hospital Association.	Recommendation was in response to nationwide outbreaks of <i>Staphylococcus aureus</i> that were occurring primarily in infants and postsurgical patients. ¹
1960s	CDC also recommended surveillance of HAIs to obtain evidence for control measures.	US hospitals began to organize infection prevention programs to conduct surveillance, develop control measures, and develop and implement infection control policies. ²
1970	CDC established the National Nosocomial Infections Study (later renamed the National Nosocomial Infections Surveillance system).	Selected hospitals began voluntarily reporting their nosocomial infection surveillance data for aggregation into a national database, the only source of national data on the epidemiology of HAIs in the United States. NNIS restructured into the NHSN in 2005. ³
1976	The Joint Commission on Accreditation of Hospitals (now The Joint Commission) established infection control standards.	For the first time, standards identified the surveillance, reporting, evaluation, and other infection prevention activities necessary for accreditation. ³

Evolution of Health Care–Associated Infection (HAI) Surveillance in the United States, 1958–2011 (Continued)

Year	Event	Summary
1985	SENIC Project results published.	The study, conducted between 1974 and 1983, demonstrated that up to one third of the major categories of HAIs (bloodstream, urinary tract, surgical wound, and respiratory) could be prevented when trained infection preventionists and epidemiologists conduct ongoing surveillance for HAIs and incorporate infection prevention activities in their programs. ³
1998	SHEA position paper <i>Requirements for Infrastructure and Essential Activities of Infection Control and Epidemiology in Hospitals: A Consensus Panel Report</i> published.	The position paper outlines the key components necessary for an effective infection prevention program, which includes the development and implementation of a surveillance system to monitor HAIs; analysis and dissemination of surveillance data are recognized as a significant factor in HAI prevention efforts. ¹
2003	Illinois was the first state to enact mandatory HAI reporting.	Hospitals must report process and outcome measures for CLABSIs, SSIs, and VAP. ³
2005	Deficit Reduction Act passed.	Requires hospitals to submit data to CMS on 10 quality measures, including CLABSIs, in order to receive the full annual update payment. Failure to do so results in a 2% reduction in payment. ³
End of 2005	By the end of 2005, six states had laws requiring public reporting of certain HAIs.	Illinois, Florida, Missouri, New York, Pennsylvania, and Virginia enacted reporting requirements for health care facilities. ³
As of January 2011	All US hospitals participating in CMS's Hospital Inpatient Quality Reporting Program are using the NHSN to report CLABSI rates among adult, pediatric, and neonatal ICU patients.	Prior to the January 1, 2011, CLABSI reporting requirement, 22 states and the District of Columbia used the NHSN for reporting requirements; CLABSI reporting was required by all 23 jurisdictions. ⁴
2011	As of mid-2011, 30 states had laws requiring public reporting.	Several other states have nonmandatory public reporting of HAI rates. ⁵

Note: CDC: US Centers for Disease Control (now US Centers for Disease Control and Prevention); NHSN: National Healthcare Safety Network; SENIC: Study on the Efficacy of Nosocomial Infection Control; SHEA: Society for Healthcare Epidemiology of America; CLABSIs: central line–associated bloodstream infections; SSIs: surgical site infections; VAP: ventilator-associated pneumonia; CMS: Centers for Medicare & Medicaid Services; ICU: intensive care unit.

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APPENDIX B

CLABSI Rates per 1,000 Central Line–Days in Limited-Resource Countries (2002–2011)

**CLABSI Rates per 1,000 Central Line–Days in
Limited-Resource Countries (2002–2011)**

Country	ICU Type	Number of Patients	CLABSIs per 1,000 Central Line–Days	Year
Albania ¹	Adult, PICU, NICU	968	—	2008
Argentina (INICC) ²	Adult	3,319	30.3	2004
Argentina ³	Adult	2,525	2.7	2004
Argentina ⁴	Adult	—	11.4	2002
Brazil (INICC) ⁵	Adult	1,031	9.1	2008
Brazil ⁶	Adult, PICU	320	34.0	2003
Brazil ⁷	PICU	515	10.2	2003
Brazil ⁸	NICU	225	60.0	2002
Brazil ⁹	NICU	6,243	3.1	2007
Brazil ¹⁰	NICU	1,443	17.3	2010
China (INICC) ¹¹	Adult	391,527	3.1	2011
Colombia (INICC) ¹²	Adult	2,172	11.3	2006

CLABSI Rates per 1,000 Central Line–Days in Limited-Resource Countries (2002–2011) *Continued*

Country	ICU Type	Number of Patients	CLABSIs per 1,000 Central Line–Days	Year
Cuba (INICC) ¹³	Adult	1,982	2.0	2011
El Salvador (INICC) ¹⁴	PICU	1,145	10.1	2011
El Salvador (INICC) ¹⁴	NICU	1,270	16.1	2011
India (INICC) ¹⁵	Adult	10,835	7.9	2007
India ¹⁶	Adult, PICU, NICU	—	0.48	2010
India ¹⁷	NICU	—	27.0	2011
Iran ¹⁸	Adult	106	147.3	2004
Lebanon (INICC) ¹⁹	Adult	666	5.2	2011
Mexico (INICC) ²⁰	Adult	1,055	23.1	2006
Morocco (INICC) ²¹	Adult	1,731	15.7	2009
Peru (INICC) ²²	Adult	1,920	7.7	2008
Peru ²³	PICU	414	18.1	2010
Philippines (INICC) ²⁴	Adult	2,887	4.6	2011
Philippines (INICC) ²⁴	PICU	252	8.23	2011
Philippines (INICC) ²⁴	NICU	1,813	20.8	2011
Poland (INICC) ²⁵	Adult	847	4.01	2011
Saudi Arabia ²⁶	NICU	—	8.2	2009
Tunisia ²⁷	Adult	340	15.3	2006
Tunisia ²⁸	Adult	647	14.8	2007
Turkey (INICC) ²⁹	Adult	3,288	17.6	2007
Turkey ³⁰	Adult	509	11.8	2010
Turkey ³¹	Adult	6,005	2.8	2011
INICC 8 countries ³² : Argentina, Brazil, Colombia, India, Mexico, Morocco, Peru, Turkey	Adult, PICU, NICU	21,069	18.5	2006
INICC 18 countries ³³ : Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, El Salvador, India, Kosovo, Lebanon, Macedonia, Mexico, Morocco, Nigeria, Peru, Philippines, Turkey, Uruguay	Adult, PICU	43,114	9.2	2008
INICC 18 countries ³³ : Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, El Salvador, India, Kosovo, Lebanon, Macedonia, Mexico, Morocco, Nigeria, Peru, Philippines, Turkey, Uruguay	NICU	1,323	14.8	2008
INICC 25 countries ³⁴ : Argentina, Brazil, China, Colombia, Costa Rica, Cuba, El Salvador, Greece, India, Jordan, Kosovo, Lebanon, Lithuania, Macedonia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Thailand, Tunisia, Turkey, Venezuela, Vietnam	Adult, PICU	144,323	7.6	2010
INICC 25 countries ³⁴ : Argentina, Brazil, China, Colombia, Costa Rica, Cuba, El Salvador, Greece, India, Jordan, Kosovo, Lebanon, Lithuania, Macedonia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Thailand, Tunisia, Turkey, Venezuela, Vietnam	NICU	9,156	13.9	2010

CLABSI Rates per 1,000 Central Line–Days in Limited-Resource Countries (2002–2011) Continued

Country	ICU Type	Number of Patients	CLABSIs per 1,000 Central Line–Days	Year
INICC 36 countries ³⁵ : Argentina, Brazil, Bulgaria, China, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Egypt, El Salvador, Greece, India, Jordan, Kosovo, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Puerto Rico, Saudi Arabia, Singapore, Sri Lanka, Sudan, Thailand, Tunisia, Turkey, Uruguay, Venezuela, Vietnam	Adult, PICU	295,264	6.8	2011
INICC 36 countries ³⁵ : Argentina, Brazil, Bulgaria, China, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Egypt, El Salvador, Greece, India, Jordan, Kosovo, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Puerto Rico, Saudi Arabia, Singapore, Sri Lanka, Sudan, Thailand, Tunisia, Turkey, Uruguay, Venezuela, Vietnam	NICU	15,420	12.2	2011
INICC 15 countries ³⁶ : Argentina, Brazil, Colombia, Dominican Republic, El Salvador, India, Jordan, Malaysia, Mexico, Morocco, Peru, Philippines, Thailand, Tunisia, Turkey	NICU	13,251	13.7	2011

Note: CLABSI: central line–associated bloodstream infection; ICU: intensive care unit; PICU: pediatric intensive care unit; NICU: neonatal intensive care unit; INICC: International Nosocomial Infection Control Consortium.

Source: Personal communication, Victor Rosenthal, Mar 29, 2012. Used with permission.

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GLOSSARY

aseptic technique A type of technique used to keep objects and areas free of microorganisms and thereby minimize infection risk to the patient; accomplished through practices that maintain the microbe count at an irreducible minimum.^{1*} Also called *sterile technique*.

attributable costs Costs that would not have occurred in the absence of the infection or complication of interest.² Examples include costs associated with additional days as an inpatient (for example, antibiotics, laboratory tests, supplies) to diagnose and treat the infection.

biofilm Microorganisms living in a self-organized, cooperative community attached to surfaces, interfaces, or each other, embedded in a matrix of extracellular polymeric substances of microbial origin. Biofilms may be composed of bacteria, fungi, algae, protozoa, viruses, or infinite combinations of these microorganisms. The qualitative characteristics of a biofilm (such as population density, thickness, chemical composition, consistency, and other materials in the matrix that are not produced by the biofilm microorganisms) are controlled by the physicochemical environment in which it exists.³ Biofilm formation is a precursor to the development of vascular-access-related bloodstream infections.⁴

bundles Groupings of evidence-based practices with respect to a disease process, device, or procedure that individually improve care but when applied together result in substantially greater improvement. The science supporting the bundle components is sufficiently established to be considered standard of care.^{5*}

business case analysis A type of cost analysis performed from the perspective of a business.²

catheter-related bloodstream infection (CRBSI) A rigorous clinical definition that is used in diagnosing and treating patients; it requires specific laboratory testing to identify the catheter as the source of the bloodstream infection, such as culturing the catheter tip or using more elaborate methods such as time-to-positivity.^{6*}

central venous catheter (CVC) An intravascular venous catheter that terminates at or close to the right side of the heart or in one of the great vessels which is used for infusion, withdrawal of blood, or hemodynamic monitoring. The following are considered great vessels for the purpose of reporting central-line bloodstream infections and counting central line–days in the National Healthcare Safety Network system: aorta, pulmonary artery, superior vena cava, inferior vena cava, brachiocephalic veins, internal jugular veins, subclavian veins, external iliac veins, common iliac veins, femoral veins, and in neonates, the umbilical artery/vein.^{7*} (*Note:* Further details associated with this definition appear in the US CDC module from which it is adapted; see end-note for full source listing, including web link.) Also called *central line*.

central line–associated bloodstream infection (CLABSI) Primary bloodstream infection in the presence of a central line or umbilical catheter at the time of, or within 48 hours before, onset of the infection, with no other source of infection evident other than the catheter. There is no minimum period of time that the central line must be in place in order for the bloodstream infection to be considered central line associated.^{7*} (This is a definition used in surveillance for CVC-related bloodstream infections, not a clinical definition.)

clean technique A set of practices to *reduce* the overall number of microorganisms present and to minimize the risk of transmission from the environment or health care personnel to the patient. In clean technique, hand hygiene is performed, and clean (rather than sterile) gloves are used. Efforts are made to prevent direct contamination of supplies and materials. Routine cleaning of the patient's environment is done.^{1*} Clean technique does not eliminate all microorganism or spores.

colonization The presence of microorganisms on skin, on mucous membranes, in open wounds, or in excretions or secretions that are not causing clinical signs or symptoms.^{8*}

* Adapted from original source.

direct costs Costs associated with a particular product, procedure, or service that can be traced directly to that product, procedure, or service.⁹ Examples include salaries of nursing staff caring for the patient with a CLABSI or salaries for infection prevention staff who identify and analyze the data associated with the infection.

endogenous sources of HAIs Body sites, such as skin, mouth, nose, gastrointestinal tract, or vagina that are normally inhabited by microorganisms.^{8*}

exogenous sources of HAIs Sites external to the patient, such as health care personnel, visitors, patient care equipment, medical devices, or the health care environment.^{8*}

fixed costs Daily operating costs, such as buildings, equipment, and staff salaries. These costs do not vary based on patient volume. It is estimated that more than 80% of hospital costs are fixed.²

hand hygiene A general term that applies to any one of the following: hand washing with (1) plain (non-antimicrobial) soap and water; (2) antiseptic hand wash (soap containing antiseptic agents and water); or (3) antiseptic hand rub antiseptic product, most often alcohol-based, rubbed on all surfaces of hands.^{10*}

health care–associated infection (HAI) An infection that develops in a patient who is cared for in any setting where health care is delivered (for example, acute care hospital, chronic care facility, ambulatory clinic, dialysis center, surgical center, home) and is related to receiving health care (that is, was not incubating or present at the time health care was initially provided). In ambulatory and home settings, HAI would apply to any infection that is associated with a medical or surgical intervention.^{10*}

health care personnel Defined broadly for the purposes of this monograph, all paid and unpaid persons working in health care settings who have the potential for exposure to patients and/or infectious materials. The full range of health care personnel work in a variety of settings, including acute care hospitals, long term care facilities, skilled nursing facilities, rehabilitation centers, physicians' offices, urgent care centers, outpatient clinics, home health care agencies, and emergency medical services. Some health care personnel provide direct patient care. Others, such as housekeepers, maintenance staff, vendors, volunteers, and

outside contractors, have jobs that may put them into close contact with patients or the patient environment.^{11*} (This definition of health care personnel is not applicable to The Joint Commission's standards and National Patient Safety Goals [NPSGs]. For the terms *staff* and *licensed independent practitioners*, which are used in the standards and NPSGs, see the glossary in The Joint Commission's *Comprehensive Accreditation Manuals*.)

infection preventionist (IP) A person whose primary training is in nursing, medical technology, microbiology, or epidemiology and who has acquired special training in infection prevention and control. Responsibilities may include collection, analysis, and feedback of infection data and trends to health care providers; consultation on infection risk assessment, prevention, and control strategies; performance of education and training activities; implementation of evidence-based infection control practices or practices mandated by regulatory and licensing agencies; application of epidemiologic principles to improve patient outcomes; evaluation of new products or procedures on patient outcomes; oversight of employee health services related to infection prevention; implementation of preparedness plans; communication within the health care setting, with local and state health departments, and with the community at large concerning infection control issues; and participation in research. Certification in infection control (CIC) is available through the Certification Board of Infection Control and Epidemiology (known as Infection Control Professionals prior to July 10, 2008).¹²

infusion The introduction of a solution through a blood vessel by way of a catheter lumen. This definition may include continuous infusions such as nutritional fluids or medications, or it may include intermittent infusions such as flushes or intravenous antimicrobial administration, or blood, in the case of transfusion or hemodialysis.^{7*}

laboratory-confirmed bloodstream infection (LCBI) An infection that must meet one of the following criteria:

Criterion 1: Patient has a recognized pathogen cultured from one or more blood cultures and organism cultured from blood is not related to an infection at another site.

Criterion 2: Patient has at least one of the following signs or symptoms: fever (greater than 38°C [100.4°F]), chills, or hypotension and signs and symptoms and positive laboratory results are not related to an infection at another

* Adapted from original source.

site and common commensal (that is, diphtheroids [*Corynebacterium* spp. not *C. diphtheriae*], *Bacillus* spp. [not *B. anthracis*], *Propionibacterium* spp., coagulase-negative staphylococci [including *S. epidermidis*], viridans group streptococci, *Aerococcus* spp., *Micrococcus* spp.) is cultured from two or more blood cultures drawn on separate occasions.

Criterion 3: Patient less than 1 year of age has at least one of the following signs or symptoms: fever (greater than 38°C [100.4°F] core) hypothermia (less than 36°C [86°F] core), apnea, or bradycardia and signs and symptoms and positive laboratory results are not related to an infection at another site and common skin commensal (i.e., diphtheroids [*Corynebacterium* spp. not *C. diphtheriae*], *Bacillus* spp. [not *B. anthracis*], *Propionibacterium* spp., coagulase-negative staphylococci [including *S. epidermidis*], viridans group streptococci, *Aerococcus* spp., *Micrococcus* spp.) is cultured from two or more blood cultures drawn on separate occasions.^{7*} (*Note:* Further details associated with this definition appear in the US CDC module from which it is adapted; see endnote for full source listing, including web link.)

maximal sterile barrier (MSB) precautions

Precautions that require the inserter to wear a cap, mask, sterile gown, and sterile gloves and use a sterile full body drape over the patient for the insertion of CVCs or guidewire exchanges.^{6*}

permanent central line A category of catheter that includes tunneled catheters, including certain dialysis catheters, and implanted catheters, including ports.^{7*}

primary bloodstream infections Laboratory-confirmed bloodstream infections that are not secondary to an HAI that meet criteria of the US Centers for Disease Control and Prevention or the National Healthcare Safety Network at another body site.^{7*}

sterile technique See aseptic technique.

surveillance A public health term that refers to the ongoing, systematic collection, analysis, interpretation, and dissemination of data regarding a health-related event for use in public health action to reduce morbidity and mortality and to improve health.¹³

temporary central line A nontunneled catheter.^{7*}

umbilical catheter A central vascular device inserted through the umbilical artery or vein in a neonate.^{7*}

variable costs Expenses that vary with volume. These costs may be dependent on the number of patients admitted or their length of stay. Variable costs include drugs, tests, supplies, and procedures.²

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