Title

Closing the Translation Gap: Toolkit-based Implementation of Universal Decolonization in Adult Intensive Care Units Reduces Central Line-associated Bloodstream Infections in 95 Community Hospitals.

Permalink

Journal

ISSN

Authors

Septimus, Edward
Hickok, Jason
Moody, Julia
et al.

Publication Date

DOI

Peer reviewed

Closing the Translation Gap: Toolkit-based Implementation of Universal Decolonization in Adult Intensive Care Units Reduces Central Line–associated Bloodstream Infections in 95 Community Hospitals

Edward Septimus,[1,2] Jason Hickok,[1] Julia Moody,[1] Ken Kleinman,[3] Taliser R. Avery,[3] Susan S. Huang,[4] Richard Platt,[3] and Jonathan Perlin[1]

[1]Hospital Corporation of America, Nashville, Tennessee; [2]Texas A&M Health Science Center College of Medicine, Houston; [3]Harvard Medical School and Harvard Pilgrim Health Care Institute, Boston, Massachusetts; and [4]University of California, Irvine Health School of Medicine

Background. Challenges exist in implementing evidence-based strategies, reaching high compliance, and achieving desired out- comes. The rapid adoption of a publicly available toolkit featuring routine universal decolonization of intensive care unit (ICU) patients may affect catheter-related bloodstream infections.

Methods. Implementation of universal decolonization—treatment of all ICU patients with chlorhexidine bathing and nasal mupirocin—used a prerelease version of a publicly available toolkit. Implementation in 136 adult ICUs in 95 acute care hospitals across the United States was supported by planning and deployment tactics coordinated by a central infection prevention team using toolkit resources, along with coaching calls and engagement of key stakeholders. Operational and process measures derived from a common electronic health record system provided real-time feedback about performance. Healthcare-associated central line–associated bloodstream infections (CLABSIs), using National Healthcare Safety Network surveillance definitions and comparing the preimplementation period of January 2011 through December 2012 to the postimplementation period of July 2013 through February 2014, were assessed via a Poisson generalized linear mixed model regression for CLABSI events.

Results. Implementation of universal decolonization was completed within 6 months. The estimated rate of CLABSI decreased by 23.5% (95% confidence interval, 9.8%–35.1%; $P = .001$). There was no evidence of a trend over time in either the pre- or postimplementation period. Adjusting for seasonality and number of beds did not materially affect these results.

Conclusions. Dissemination of universal decolonization of ICU patients was accomplished quickly in a large community health system and was associated with declines in CLABSI consistent with published clinical trial findings.

Keywords. universal decolonization; decolonization; healthcare-associated central line–associated bloodstream infections (CLABSI); quality improvement; learning health system.

There has been increasing interest in improving the dissemination of best practices into routine clinical care. Despite frequent acknowledgment of the need for faster translation of evidence- based interventions into practice, it can be challenging to accomplish this. This is often the case even when the desired interventions are the product of pragmatic trials that are intended to test interventions under conditions of routine practice [1, 2]. Growing evidence suggests that universal decolonization of intensive care unit (ICU) patients reduces the risk of healthcare- associated bloodstream infections (BSIs). These include central line–associated bloodstream infections (CLABSIs), which comprise the majority of these

infections [3]. In 2009, an estimated 18 000 CLABSIs occurred among patients hospitalized in ICUs in the United States, down from 43 000 in 2001 [4]. However, despite recent reductions in the incidence of CLABSIs, they continue to result in increased length of stay and costs, as well as significant mortality. Klevens et al reported that up to 25% patients who develop a CLABSI in the ICU will die [5].

A 43-hospital pragmatic trial (the REDUCE MRSA trial) found that universal decolonization of patients in the ICU with a combination of chlorhexidine (CHG) bathing and intra- nasal mupirocin significantly reduced methicillin-resistant *Staphylococcus aureus* (MRSA)–positive clinical cultures by 37% and BSIs from any pathogen by 44% [6]. However, the broad adoption of universal decolonization into routine practice has not been demonstrated to achieve com- parable gains. This study's goal was to determine whether the clinical trial procedures could be effectively translated into routine practice and whether doing so would yield the same clinical benefit. To address this question, we tested a prerelease version of a now publicly available universal decolonization toolkit offered by the Agency for Healthcare Quality and Research [7] for its utility in implementation of routine universal decolonization of ICU patients and its impact on catheter-related BSIs. The ability to rapidly implement universal decolonization would show the advantage of a well-designed toolkit and associated resources in combination with a supportive implementation plan; accompanying decreases in CLABSIs would support the previously demonstrated benefit of universal decolonization.

METHODS

Setting
This study was conducted in 136 ICUs in 95 acute care hospitals affiliated with the Hospital Corporation of America (HCA) healthcare system. Facilities were distributed across the United States, representing urban and suburban communities in 17 states. From geographic, demographic, and socioeconomic standpoints, this population is representative of the US population as a whole [8].

Census and administrative data were obtained from corporate data warehouses, which undergo line-item validation until 99% accuracy is achieved. Primary analysis was reduction in health- care-associated CLABSIs using National Healthcare Safety Network (NHSN) surveillance definitions [9] as reported by hospital-based infection preventionists as part of routine surveillance responsibilities. ICU patient-days from NHSN data were matched with administrative data within 10% threshold to verify patient demographics.

Implementation
A recommended policy and procedure of universal decolonization for all ICU patients, based on the results of the REDUCE MRSA trial [6], was introduced in January 2013; this practice was implemented in all participating facilities by June 2013. Implementation procedures followed previously published methods outlined in the Universal ICU Decolonization Toolkit, which provides instruction for implementing universal decolonization in adult ICUs [7]. In short, all patients received twice- daily intranasal mupirocin for 5 days or the length of their ICU stay, whichever was shorter, and were bathed daily with CHG- impregnated cloths for their entire ICU stay.

Key stakeholders for implementation included leadership champions, healthcare providers, infection preventionists, pharmacists, and information technology and supply chain personnel. Planning and deployment tactics were coordinated by corporate infection prevention personnel using available toolkit resources, operational and process measures from electronic health record systems providing aggregate and standardized data, and coaching calls. The toolkit contains detailed implementation guidance and materials, including a flowchart, a guide to assessing readiness, messages for healthcare workers, a detailed decolonization protocol and training materials, a skills assessment guide, and safety information. The toolkit used in this study was identical to the publicly available toolkit [7] used in the REDUCE MRSA trial [6].

Table 1. Coaching Call Strategy

Call Number	Goals
Coaching call 1	Communicate goal/create the vision
	Define each member's roles and responsibilities
Coaching call 2	Hospital protocol
	Electronic order set
Coaching call 3	Go Live
	Supply chain requests
	Nursing education (CHG bathing, mupirocin, documentation)
Coaching call 4	Define process and outcome metrics (compliance, CLABSI)
Coaching call 5	Identify opportunities and refine the process
	Monitor process and metrics daily, then weekly, then monthly

Abbreviations: CHG, chlorhexidine; CLABSI, central line–associated bloodstream infection.

Implementation tactics included enterprise coaching calls focused on evidence rationale, preparation, implementation, and tactics to achieve highly compliant practices; Table 1 outlines the coaching call strategy and schedule. Coaching calls 1–4 occurred within the first 3 months of the implementation period, and coaching call 5 occurred later within that time period. Through these coaching calls, the enterprise team facilitated and informally verified implementation as well as gathered feedback and gauged the readiness for implementation at the local level. Related resources and audio podcasts were available through a central corporate intranet site. Questions were directed to corporate email for response and incorporated into frequently asked questions that were provided to all facilities for their reference. Physician-specific communication resources and evidence tools

to support endorsement were available as well as an enterprise physician study investigator to directly address peer concerns.

Statistical Analysis

The preimplementation period was defined as January 2011 through December 2012. The postimplementation period was defined as July 2013 through February 2014. The phase-in period, January through June 2013, was omitted from analysis. The 43 hospitals (74 ICUs) in the original trial were excluded from the analysis, as were facilities without separate critical care units. In addition, facilities missing data for an entire portion of the study period due to unit closure, opening, or entry into the HCA system were omitted. Of the 122 HCA-affiliated hospitals that were not in the original trial, 27 were excluded from the final analysis, resulting in 95 participating hospitals.

We used a Poisson generalized linear mixed-model regression analysis for CLABSI events to assess differences between the pre- and postimplementation periods while accounting for hospital- and unit-level correlation. Unadjusted and adjusted analyses were conducted with the log number of central lines per unit as the offset adjustment. The adjusted analysis included season, number of unit beds, and unit type. The possibility of trend over time was assessed. To compare the standard infection ratio (SIR) in the pre- and postimplementation periods, we repeated the Poisson analysis described above, but used the Centers for Disease Control and Prevention (CDC) expected number of CLABSIs as the offset, rather than the log line- days. Analyses were performed using SAS software, version

9.4 (SAS Institute, Cary, North Carolina).

This study was approved by the Harvard Pilgrim Health Care Institutional Review Board.

RESULTS

The final study cohort included 95 hospitals with 136 units. The ICU bed range was 4–167 (median, 37 [interquartile range, 21– 56]), and the average number of patient-days per ICU per year was 4619. Most hospitals had 1 or 2 units (67 [70.5%] and 19 [20.0%], respectively), with a small group having 3–5 units (9 [9.5%]). The majority of critical care units were classified as medical/surgical (82 [60.3%]), followed by surgical (13 [9.6%]), surgical cardiothoracic (13 [9.6%]), medical (12 [8.8%]), medical cardiac (7 [5.2%]), neurosurgical (5 [3.7%]), trauma (3 [2.2%]), and a neurologic critical care unit (1 [0.7%]) based on NHSN population reporting criteria [10]. Patient characteristics were similar between the baseline and postintervention periods (Table 2).

Table 2.   Demographic Characteristics

Characteristic	Preimplementation 24 mo[a] (N = 95 Hospitals)	Postimplementation 8 mo (N = 95 Hospitals)
Hospital admissions with ICU stay, No.	305 583	102 220
ICU days, mean (SD)	3.8 (5.3)	3.8 (4.9)
Hospital LOS, mean (SD)	8.8 (10.2)	8.6 (10.4)
Age, y, mean (SD)	63.2 (17.4)	63.0 (17.4)
Sex		
Female	145 180 (47.5)	48 125 (47.1)
Male	160 390 (52.5)	54 093 (52.9)
Unknown	13 (0)	2 (0)
Race		
White	214 083 (70.1)	70 888 (69.3)
Black/African American	41 091 (13.4)	14 134 (13.8)
Hispanic	37 787 (12.4)	12 305 (12)
Other	4534 (1.5)	2478 (2.4)
Asian	5309 (1.7)	1234 (1.2)
Unknown	2779 (0.9)	1181 (1.2)
Insurance		
Medicare	181 649 (59.4)	60 825 (59.5)
Commercial	61 380 (20.1)	19 374 (19)
Medicaid	30 669 (10)	10 414 (10.2)
Self-pay	20 515 (6.7)	7522 (7.4)
Free care	6129 (2)	2282 (2.2)
Other	4755 (1.6)	1686 (1.6)
Unknown	486 (0.2)	117 (0.1)
Comorbidities		
Diabetes	105 584 (34.6)	35 926 (35.1)
Liver	13 210 (4.3)	4512 (4.4)
Cancer	27 546 (9)	8727 (8.5)
Renal	69 185 (22.6)	22 417 (21.9)
Surgery	112 088 (36.7)	36 043 (35.3)

Data are presented as No. (%) unless otherwise specified.

Abbreviations: ICU, intensive care unit; LOS, length of stay; SD, standard deviation.

[a] One hospital is missing demographic data for the initial 9 months of preimplementation.

During implementation, uptake of the various toolkit components was informally assessed through the enterprise coaching calls (Table 1) and questions submitted to the corporate team. Challenges identified via this process included (1) concerns about mupirocin resistance and (2) questions about peer review of the original trial results, which was accepted for publication during the implementation period. These challenges were addressed via peer-to-peer conversations from physician champions and the corporate implementation team. In contrast, most facilities were able to easily implement daily CHG bathing, as this practice, when supported by education about appropriate methods, fit within the normal nursing workflow and did not require a physician order.

The raw CLABSI rate, defined as the number of CLABSI events divided by the number of central line–days in the entire cohort, dropped from 1.1 per 1000 central line–days in the preintervention period to 0.87 per 1000 central line–days in postintervention. In total, there were 672 CLABSIs per 587 891 central line–days in the 24 month preintervention period (24 495 central line–days per month), and 181 CLABSIs per 208 175 central line–days in the 8-month post-intervention period (26 022 central line–days per month). After implementation, the rate of CLABSI decreased by 23.5% (95% confidence interval [CI], 9.8%–35.1%; $P = .001$; Figure 1) in the unadjusted Poisson analysis.

There was no evidence of trend over time in either the pre- or postimplementation period. Adjusting for seasonality, number
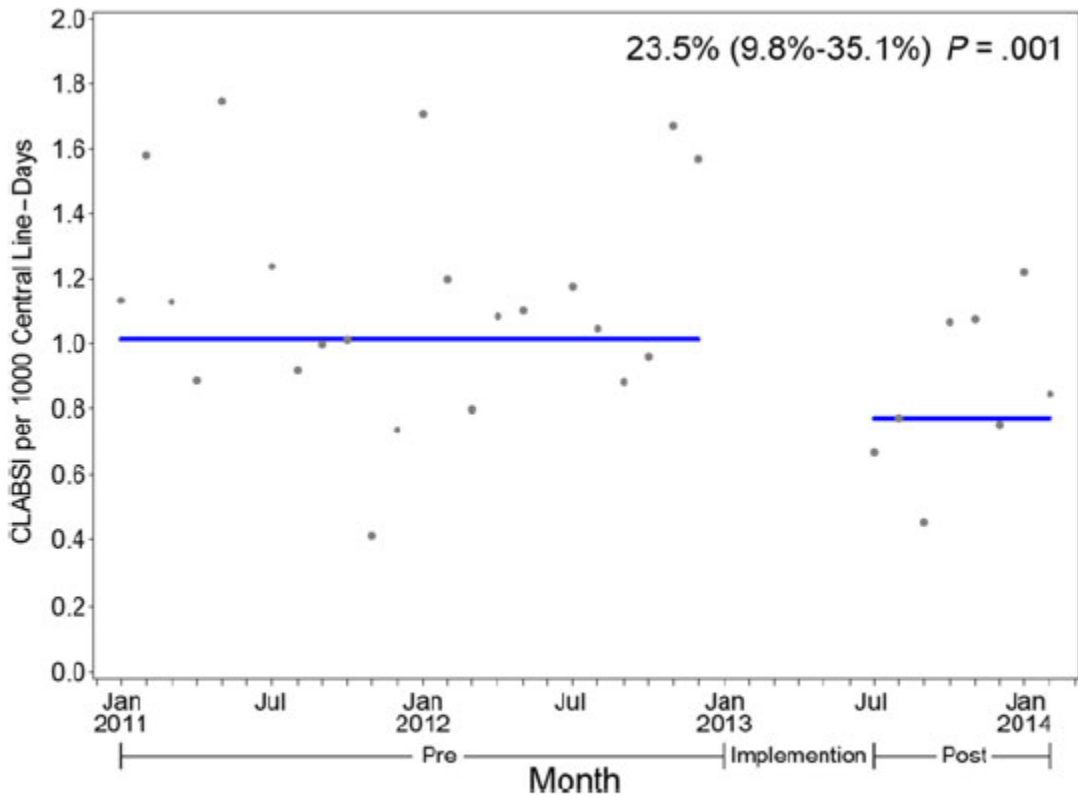
Figure 1. A comparison of the rate of central line–associated bloodstream infections (CLABSIs) per 1000 central line–days pre- and postimplementation.
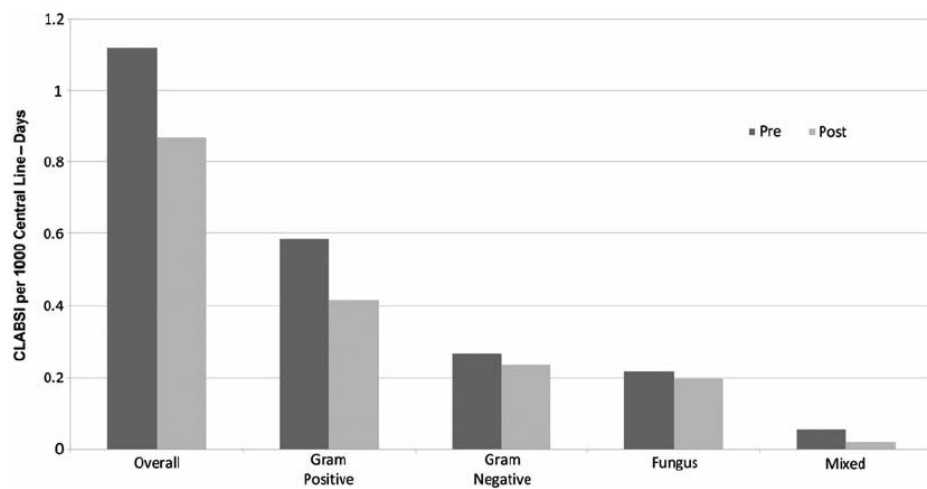
Figure 2. Rate of central line–associated bloodstream infections (CLABSIs) per 1000 central line–days pre- and postimplementation, stratified by pathogen type.

of beds, and unit type did not materially affect these results (rate decrease, 23.1% [95% CI,

8.8%–35.1%]; $P = .003$). In units classified as medical/surgical, which comprised 60.3% of all participated units, the rate of CLABSIs decreased 25.8% (95% CI, 9.6%–39.1%; $P = .003$); the number of other unit types was too small to stratify the analysis by those unit types.

We observed a reduction for all pathogen types, with the largest impact on gram-positive pathogens (Figure 2), similar to our original study [6]. The gram-positive CLABSI rate decreased 28.7% (95% CI, 9.7%–43.7%; $P = .005$). The number of CLABSI events due to other organisms was too small to stratify the analysis by other pathogen types, including *Staphylococcus aureus*. The rate of CLABSI due to *S. aureus* decreased from 0.11 per 1000 central line–days to 0.02 per 1000 central line–days, a de- crease of 31.9% (95% CI, 27.2%– 63.5%; $P = .2$); there were 66 CLABSIs due to *S. aureus* in the preintervention period and 12 in the postintervention period.

After implementation, the mean SIR decreased 21.5% (95% CI, 7.5%–33.5%; $P = .004$). The mean SIR preimplementation was 0.66 (95% CI, .61–.71); the mean SIR postimplementation was 0.51 (95% CI, .44–.59).

We examined small multiples as a way of assessing heterogeneity between units. This has revealed that some units began the baseline period with very low rates of CLABSI and others with relatively variable rates. Postintervention, rates were uniformly low (Supplementary Appendices 1 and 2).

DISCUSSION

This rapid dissemination and implementation program demonstrated the utility of a protocol- specific toolkit, coupled with a multistep translation program to implement universal decolonization in a large, complex organization. Doing so demonstrated that use of CHG bathing plus nasal mupirocin in routine practice reduced ICU CLABSIs at a level commensurate with that achieved within the framework of a clinical trial. This sup- ports the use of universal decolonization in a wide variety of acute care facilities across the United States.

The speed at which this study was accomplished highlights several possible contributing factors that may influence the success of implementations. These include (1) a well-designed tool- kit with proven success in a pragmatic clinical trial; (2) a program team, experienced in implementing evidence-based practices, that is responsive to local needs; and (3) an established infrastructure for implementing large quality improvement projects. As this study showed, when these factors are used to implement an evidence-based practice, widespread improvements can be achieved.

Investigation into which evidence-based practices are the safest, most effective, and most efficient for patients, and the subsequent implementation of these results, forms the foundation for building a learning health system. In such a system, research is integrated into routine care to generate clinical evidence. This strategy not only addresses current challenges in healthcare but also complements patient care activities, thereby maximizing the potential to improve safety, effectiveness, and value through- out the entire system [11]. By creating standardized support and encouraging local adaptation and collaboration, this study facilitated the rapid integration of new evidence into routine care.

This reduction in BSIs agrees with previously published trials using CHG with or without mupirocin. In 2007, Bleasdale and colleagues performed a 52-week, 2-arm, crossover trial to deter- mine whether patients bathed with CHG cloths had a lower incidence of primary BSIs

compared with patients bathed with soap and water in a medical ICU setting. In 2 geographically separate but similar 11-bed units, patients in the CHG intervention arm were significantly less likely to acquire a primary BSI (4.1 vs 10.4 infections per 1000 patient-days) [12]. In 2012, Montecalvo and associates published a prospective, 3-phase multiple-hospital study in which the intervention progressed from bathing with soap and water or nonmedicated cloths to bathing with 2% CHG cloths to continued CHG bathing without oversight by re- search personnel. Compared with preintervention, CHG bathing was associated with significant reductions in CLABSIs from 6.4 per 1000 catheter-days to 2.6 per 1000 catheter-days ($P < .001$) [13]. Climo et al performed a nonblinded cluster-randomized crossover study on the incidence of hospital-acquired BSIs and found a 28% reduction in the overall rate of hospital-acquired BSIs with CHG bathing vs nonmedicated cloths [14]. Using a similar study design, Milstone et al reported that CHG bathing was associated with a significant reduction in BSIs among pediatric ICU patients compared with standard bathing [15]. The study on REDUCE MRSA trial [6], found that universal decolonization of all ICU patients with CHG bathing and intranasal mupirocin was associated with a statistically significant 44% reduction in all-pathogen BSIs [6]. These studies support the recently published recommendation that ICU patients >2 months of age should be bathed with CHG on a daily basis to prevent CLABSIs [16].

These studies and the current one also underscore the fact that events like CLABSI are simultaneously common enough to rep- resent an important national cause of preventable morbidity and mortality, yet too rare for most individual hospitals to be able to measure the benefit of a practice that substantially reduces the at- tack rate. This phenomenon is illustrated by a recent single center trial by Noto et al, which did not have sufficient power to identify an effect of universal decolonization on CLABSI, as there were only 4 events in the nonintervention period [17].

Although demonstrating the benefit of this toolkit and associated implementation program in actual practice required observation in a large set of ICUs, we believe the results should be generalizable to most hospitals. The rates of CLABSIs, a nation- ally reported measure, were assessed using CDC criteria. These facilities had already implemented national, evidence-based recommendations for preventing healthcare-associated CLABSI and achieved rates at or below national rates. The toolkit used in this study had been designed to work within usual hospital processes and to be applicable to a wide range of facilities; the ability to incorporate these practices into existing workflows also contributes to the generalizability of the results.

This study also illustrates how providers across the United States can transform themselves into a learning health system by leveraging reproducible methods for introducing new evidence into routine practice [18]. The use of a toolkit containing an array of documentation and educational materials should produce replicable results in most hospitals. Coaching calls to share evidence and experience supporting the intervention as well as to engage and motivate key local stakeholders to take ownership proved highly effective, even for physically distant facilities. Our study contained the proposed 5 key components for effective knowledge translation: (1) a focus on systems rather than care of individual patients; (2) engagement of local inter- disciplinary teams to assume ownership of the improvement project; (3) creation of centralized support for the technical work; (4) encouraging local adaption of the intervention; and (5) creating a collaborative culture

within the local unit and larger system [2].

Our study has some limitations. First, the study results may not be generalizable to hospitals without strong infrastructures for quality improvement. In this study, we benefited from our system's experience with large-scale implementations as well as our familiarity with the intervention itself. Second, our study lacks the rigorous compliance assessments of the original trial; however, the intent was to reflect true life posttrial pragmatic implementation across a broad number of hospitals. Last, although the corporate team was not aware of any new interventions introduced during the implementation phase, this was not tracked as carefully as in the original trial.

The investigation of possible development of mupirocin and CHG resistance was a planned secondary analysis of the REDUCE MRSA trial [6]. While monitoring resistance is outside the scope of the current study, further research has been conducted to investigate possible resistance and identify other agents that could be used while maintaining the infrastructure that allowed for the rapid implementation of this program.

CONCLUSIONS

We used publicly available materials and standard methods for translation to effect rapid dissemination of universal decolonization of patients in adult ICUs. This resulted in rapid reduction in the rate of CLABSIs throughout a large community health- care system. This benefit was observed in the context of rates already reduced through the use of other widely used prevention methods. The implementation plan engaged healthcare system clinicians, senior management, and staff to achieve a translation of new evidence into accelerated improvement, and is broadly applicable.

Supplementary Data
Supplementary materials are available at http://cid.oxfordjournals.org. Consisting of data provided by the author to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the author, so questions or comments should be addressed to the author.

ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

References

1. Berwick DM. Disseminating innovation in health care. JAMA 2003; 289:1969–75.
2. Pronovost PJ, Berenholtz SM, Needham DM. Translating evidence into practice: a model for large scale knowledge translation. BMJ 2008; 337:a1714.
3. Magill SS, Edwards JR, Bamberg W, et al. Multistate point-prevalence survey of health care–associated infections. N Engl J Med 2014; 370:1198–208.
4. Vital signs: central line–associated blood stream infections—United States, 2001, 2008, and 2009. MMWR Morb Mortal Wkly Rep 2011; 60:243–8.
5. Klevens RM, Edwards JR, Richards CL Jr, et al. Estimating health care-associated infections and deaths in U.S. hospitals, 2002. Public Health Rep 2007; 122:160–6.
6. Huang SS, Septimus E, Kleinman K, et al. Targeted versus universal decolonization to prevent ICU infection. N Engl J Med 2013; 368:2255–68.
7. Agency for Healthcare Research and Quality. Universal ICU decolonization: and enhanced protocol. Available at: http://www.ahrq.gov/professionals/systems/ hospital/universal_icu_decolonization. Accessed 28 May 2015.
8. Clark SL, Belfort MA, Hankins GDV, Meyers JA, Houser FM. Variations in the rates of operative delivery in the United States. Am J Obstet Gynecol 2007; 196:526.e15.
9. Centers for Disease Control and Prevention. National Healthcare Safety Network Surveillance for blood stream infections: protocol for bloodstream infection event. Available at: http://www.cdc.gov/nhsn/pdfs/pscmanual/4psc_clabscurrent.pdf. Accessed 15 February 2016.
10. Centers for Disease Control and Prevention. National Healthcare Safety Network Surveillance for blood stream infections: CDC locations and descriptions and instructions for mapping patient care locations. Available at: http://www.cdc.gov/ nhsn/pdfs/pscmanual/15locationsdescriptions_current.pdf. Accessed 15 February 2016.
11. Institute of Medicine. The learning health care system in America. Available at: http://www.iom.edu/Activities/Quality/LearningHealthCare.aspx. Accessed 28 May 2015.
12. Bleasdale SC, Trick WE, Gonzalez IM, et al. Effectiveness of chlorhexidine bathing to reduce catheter-associated bloodstream infections in medical intensive care unit patients. Arch Intern Med 2007; 167:2073–209.
13. Montecalvo MA, McKenna D, Yarrish R, et al. Chlorhexidine bathing to reduce central venous catheter-associated bloodstream infection: impact and sustainabil- ity. Am J Med 2012; 125:505–11.
14. Climo MW, Yokoe DS, Warren DK, et al. Effect of daily chlorhexidine bathing on hospital-acquired infection. N Engl J Med 2013; 368:533–42.
15. Milstone AM, Elward A, Song X, et al. Daily chlorhexidine bathing to reduce bacteraemia in critically ill children: a multicentre, cluster-randomised, crossover trial. Lancet 2013; 381:1099–106.
16. Marschall J, Mermel LA, Fakih M, et al. Strategies to prevent central line-associated bloodstream infections in acute care hospitals: 2014 update. Infect Control Hosp Epidemiol 2014; 35:753–71.
17. Noto MJ, Domenico HJ, Byrne DW, et al. Chlorhexidene bathing and health care-

associated infections: a randomized clinical trial. JAMA 2015; 313:369–78.

18. Greene SM, Reid RJ, Larson EB. Implementing the learning health system: from concept to action. Ann Intern Med 2012; 157:207–10.