EDITOR'S CHOICE

Reduction of central line infections in Veterans Administration intensive care units: an observational cohort using a central infrastructure to support learning and improvement

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ABSTRACT

Background: Elimination of hospital-acquired infections is an important patient safety goal.

Setting: All 174 medical, cardiac, surgical and mixed Veterans Administration (VA) intensive care units (ICUs).

Intervention: A centralised infrastructure (Inpatient Evaluation Center (IPEC)) supported the practice bundle implementation (handwashing, maximal barriers, chlorhexidinegluconate site disinfection, avoidance of femoral catheterisation and timely removal) to reduce central line-associated bloodstream infections (CLABSI). Support included recruiting leadership, benchmarked feedback, learning tools and selective mentoring.

Data collection: Sites recorded the number of CLABSI, line days and audit results of bundle compliance on a secure website.

Analysis: CLABSI rates between years were compared with incidence rate ratios (IRRs) from a Poisson regression and with National Healthcare Safety Network referent rates (standardised infection ratio (SIR)). Pearson's correlation coefficient compared bundle adherence with CLABSI rates. Semi-structured interviews with teams struggling to reduce CLABSI identified common themes.

Results: From 2006 to 2009, CLABSI rates fell (3.8−1.8/1000 line days; p<0.01); as did IRR (2007; 0.83 (95% CI 0.73 to 0.94), 2008; 0.65 (95% CI 0.56 to 0.76), 2009; 0.47 (95% CI 0.40 to 0.55)). Bundle adherence and CLABSI rates showed strong correlation (r=0.81). VA CLABSI SIR, January to June 2009, was 0.76 (95% CI 0.69 to 0.90), and for all FY2009 0.88 (95% CI 0.80 to 0.97). Struggling sites lacked a functional team, forcing functions and feedback systems.

Conclusion: Capitalising on a large healthcare system, VA IPEC used strategies applicable to non-federal healthcare systems and communities. Such tactics included measurement through information technology, leadership, learning tools and mentoring.

INTRODUCTION

The landmark Institute of Medicine report characterised preventable injury as an important and largely ignored problem in healthcare delivery, contributing to mortality and costs.[1] The *Saving 100,000 Lives Campaign* of the Institute for Healthcare Improvement (IHI) galvanised efforts to reduce preventable injury.[2−5] The campaign aimed to reduce two hospital-acquired infections—central line-associated bloodstream infections (CLABSI) and ventilator-associated pneumonia—by implementing bundles of evidence-based practices. Bundle practices to reduce CLABSI included use of maximal sterile barriers (bed-sized sterile drapes, sterile gown and gloves, cap and mask), chlorhexidine gluconate skin prep, avoidance of femoral sites during insertion and removal of the line once no longer needed.[6][7] Several single and multicentre studies reported reduction in CLABSI after bundle implementation in intensive care units (ICUs).[8−12] To engage leaders, US payors eliminated a perverse incentive, additional payment for CLABSI.[13] Recently, the Center for Disease Control (CDC) reported a 17% reduction in standardised CLABSI rates from January to June 2009 in 17 states with mandatory reporting.[14]

Senior leaders in the Veterans Administration (VA), the largest US healthcare system, agreed to participate in IHI's campaign in 2006. Responsibility for national coordination and measurement of CLABSI was assigned to the director of the VA Inpatient Evaluation Center (IPEC), a new quality infrastructure.

This paper, following the SQUIRE (Standards for Quality Improvement Reporting Excellence) guidelines,[15] describes the implementation of a practice bundle to reduce CLABSI using infrastructure elements focused on building leadership support, measurement, shared learning, mentoring and teams to move practices.

METHODS

Project review

The CLABSI initiative is part of an operational VA ICU quality improvement programme. The proposal to conduct and publish an evaluation of the CLABSI initiative was reviewed and approved by the institutional review board at the University of Cincinnati and the VA ICU clinical advisory group composed of a nurse manager and ICU director from each of the VA's 21 regions.

Setting

The 174 VA ICUs in 123 hospitals admit 103 689±1156 patients annually to 1774 beds. The VA has five types of ICUs (cardiac care units, medical intensive care units, medical intensive/cardiac care units, surgical ICUs (caring for predominantly postoperative patients) and mixed units (caring for cardiac, medical and surgical patients)) with four levels of complexity. Level 1 ICUs offer the most complex services and level 4 ICUs have more limited testing and evaluation available.[16] From electronic data, IPEC reports risk-adjusted mortality and length of stay and process adherence quarterly for all VA ICUs.[17 18] The characteristics of VA ICUs are described in online supplementary table A.

Intervention

The national project plan (1) recruited leadership interest, (2) identified strong practices within the VA early and spread their use, (3) created a system for learning, (4) developed a measurement system for CLABSI rates and practice bundle adherence, (5) reported benchmarked CLABSI rates and (6) mentored struggling sites. Local ICUs structured their implementation based on local conditions.

Recruiting leadership and identifying strong practices

National, regional and hospital leaders agreed to implement the bundle of practices to reduce central line infection rates as part of IHI's *Saving 100,000 Lives Campaign* in 2006. To recruit mid-level leadership, IPEC programme managers interviewed the ICU nurse managers and infection control practitioners in every VA

VISN 97 FY2009 through Q1 ICU Process Measures

| | IPEC ICU | | | | | | | | | | OQP | RSMR (FY2008) | |
| | % Gluc days with hypo episodes | | %Patients w Mean Glucose >180 | DVT-prophylaxis | | | Throughput | | Infection | | | AMI | |
	≤45 mg dl	< 60 mg dl		Mech vent	Non Op	Op	OME LOS	LOS	CLABSI Rate	VAP Rate	AMI	IPEC acute care	Hospital referred region
National aggregates													
Facility level 15th %tile	0.5	1.8	10.2	61.4	59.3	57.1	-0.72	2.18	0.00	0.00		14.68	15.76
Facility level mean	1.4	3.6	16.8	76.0	70.9	81.7	-0.06	2.87	1.84	2.83		14.91	16.09
Facility level 85th %tile	2.3	5.3	23.0	96.0	83.3	100.0	0.63	3.58	4.72	7.04		15.13	16.46
National aggregates													
Site 1	1.6	5.3	23.0	78.9	83.3	100.0	-0.99	2.15	1.31	12.12		14.68	16.55
Site 2	0.5	1.0	10.2	80.0	60.6	100.0	0.50	3.18	0.00	3.18	✓	15.52	16.23
Site 3	1.0	4.7	21.5	79.4	59.3	45.5	-0.01	2.91	6.61	0.00	★	15.08	16.19
Site 4	3.1	5.0	11.9	59.0	63.2	75.0	0.14	3.36	0.00	7.19	✓	15.23	16.72
Site 5	1.0	3.1	22.0	89.5	61.4	50.0	-0.53	2.27	0.00	0.00	✓	14.77	16.2
Site 6	0.5	3.0	13.8	74.1	70.6	86.7	-0.85	2.59	0.00	0.00	✓	14.83	15.94
Site 7	2.0	4.4	13.5	61.4	75.0	100.0	0.36	3.47	1.98	2.49	✓	14.73	16.18
Site 8	0.8	1.3	13.3	80.0	50.7	41.2	-0.72	2.20	2.49	5.95		14.86	16.1
Site 9	0.6	2.6	23.8	91.7	86.4		0.98	4.22	0.00	0.00	✓	14.62	16.18

Figure 1 Intensive care unit (ICU) process page in quarterly dashboard, where aggregated national results are presented (mean, 15th and 85th percentile). Process page tracks CLABSI and ventilator associated pneumonia rates, it also tracks hypoglycaemia and hyperglycaemia, pharmacologic prophylaxis to prevent deep venous thrombosis and throughput.

ICU, reviewing existing practices to reduce CLABSI and CLABSI rates. These interviews identified early successful sites.

An ICU dashboard updates the leadership regarding progress of their ICUs in reducing CLABSI rates compared with national rates (figure 1). The IPEC director identified progress or problems in reducing CLABSI and strategies to jumpstart success in biannual regional conference calls attended by regional and hospital directors and chief medical officers and ICU managers. The annual executive leadership contract and performance contracts of some ICU managers included reduction in CLABSI rates in 2008.

Creating learning

The national project began with a 2-hour web-based conference call (agenda - online supplementary table B). Senior VA leadership confirmed the initiative's importance; experts reviewed CLABSI and the evidence for prevention of CLABSI. ICU teams that had already successfully reduced their CLABSI infection rates presented their experience, emphasising five facilitators: (1) a physician champion, (2) use of central line cart and (3) checklist during line insertion as a forcing function, (4) addition of a daily ICU goal sheet during physician rounds as a memory aid for central line removal, (5) and feedback to frontline nurses and doctors about their CLABSI rates and bundle adherence. Finally, the conference call highlighted an improvement in approach that used multiple small tests of change asking always 'what can we do by next Tuesday'.

A web-based toolbox shared tools from ICUs that had reduced their CLABSI rates. These tools included CDC definitions, case scenarios to test understanding of the definitions, measurement tools, an annotated bibliography, powerpoint slides adaptable for local presentations, learning modules with continuing education units (CEUs), depiction of contents and organisation of a line cart, examples of daily goal sheets and policies and procedures. Some ICUs mandated learning module completion, others made it available with free CEU as an incentive.

Mentoring

Twelve months after the kick-off, IPEC programme managers invited five to six ICUs with either the highest CLABSI rates or absolute numbers of infections to be mentored. Initial semi-structured interviews with each site focused on use of facilitators (team members, established goal for initiative, physician champion, feedback system to front line staff and to local leadership, use of forcing functions, availability of supplies needed for implementation) identified in the literature and improvement method (online supplementary table C). From the interview, programme managers and the sites projected a series of Plan-Do-Study-Act (PDSA) cycles. The progress towards implementation of next step was assessed with monthly calls. In a qualitative analysis, two investigators (MLR, RH) reviewed data from the initial structured interviews and notes from the calls for common themes.

Planning the study of the intervention

This was an observational quality improvement project where adherence to the CLABSI bundle elements and CLABSI rates were tracked monthly across all ICUs in the VA.

Measures/definitions

CDC definitions were used (table 1).[19]

Data collection

Although central line infection rates and adherence to the evidence-based practice bundle was not recorded electronically when the national CLABSI project began, local VA ICUs did collect central line days and bloodstream infections. IPEC created a data management website, operational in March/April 2006 (online supplementary figure A), where ICUs entered monthly (1) line days, (2) number of CLABSI and (3) the number of audits or checklists completed during central line insertion and

Table 1 Definitions of central line-associated bloodstream infections (CLABSI)

Data element	Definition
Central line	Terminates at or near the heart or in a great vessel.
CLABSI infection rate	Number of CLABSI divided by the number of device days multiplied by 1000. For hospitals with <750 line days, the number of months since the last infection is reported.
Laboratory confirmed CLABSI infection	When a patient has or had a central line within the past 48 h *and* either a recognised pathogen is grown in one or more blood cultures in the absence of another source for that pathogen *or* the patient has clinical signs of infection (hypotension, fever, chills) not related to another site of infection and grows a skin pathogen from at least two blood cultures.
Central line day	Counted for each patient who has one or more central lines in place.
Central line utilisation rate	Number of line days divided by the number of patient days.

Table 2 Central line-associated bloodstream infections and rates and practice adherence stratified by year and ICU characteristics

All VA ICUs	FY2006	FY2007	FY2008	FY2009
CLABSI infection rate	3.85	3.18	2.50	1.80
Line days	177 058	214 604	216 818	224 693
CLABSI infections	681	683	543	404
CLABSI audits	7822	13 315	13 554	16 130
Central line utilisation	31.8	42.2	42.9	39.2
Practice adherence (began April 2006)				
Hand hygiene	95.4	97	98.2	98.2
Cap worn	91.6	95.4	97	97.8
Bed-sized drape	88.1	93.7	95.8	97.1
Chlorhexidinegluconate skin prep	93.5	97.5	98.5	98.4
Femoral site	18.4	17.1	16.2	12.2
Sterile gloves worn	96.9	98.2	99.1	98.6
Sterile gown worn	95.8	97	98.2	98.3
By level of complexity of ICU				
CLABSI infection rate (year)				
Level 1	3.79	3.14	2.61	1.80
Level 2	4.37	3.78	2.42	2.11
Level 3	3.82	2.89	2.07	1.40
Level 4	1.96	1.63	0.64	1.55
Number of line days				
Level 1	132 790	159 351	164 321	165 221
Level 2	24 952	29 373	28 120	32 758
Level 3	16 767	22 821	21 247	23 489
Level 4	2549	3059	3130	3225
Number of CLABSI infections				
Level 1	503	501	429	297
Level 2	109	111	68	69
Level 3	64	66	44	33
Level 4	5	5	2	5
Number of audits				
Level 1	4919	8498	8887	10 826
Level 2	1349	2499	2222	2575
Level 3	1348	1903	2054	2290
Level 4	206	415	391	439
By type of ICU				
CLABSI infection rate (year)				
Mixed ICU	3.65	2.82	2.42	1.68
CCU	4.53	2.37	1.89	1.68
MICU	4.24	3.85	2.71	2.01
SICU	3.40	2.91	2.37	1.87
MICU/CCU	4.58	4.04	2.85	1.82
Number of line days				
Mixed ICU	53 393	70 302	67 781	77 251
CCU	5519	8447	8975	8911
MICU	18 397	20 764	21 062	18 403
SICU	62 870	70 548	71 010	68 931
MICU/CCU	36 879	44 543	47 990	51 197
Number of CLABSI infections				
Mixed ICU	195	198	164	130
CCU	25	20	17	15
MICU	78	80	57	37
SICU	214	205	168	129
MICU/CCU	169	180	137	93
Number of audits				
Mixed ICU	2999	5128	4874	5387
CCU	296	591	642	895

Table 2 Continued				
All VA ICUs	FY2006	FY2007	FY2008	FY2009
MICU	882	1269	1424	1894
SICU	1876	2904	2987	3987
MICU/CCU	1769	3423	3627	3967

CCU, cardiac care unit; CLABSI, central line-associated bloodstream infections; ICU, intensive care unit; level, the complexity of ICU services available; MICU, medical intensive care unit; MICU/CCU, medical intensive/cardiac care unit; SICU, surgical intensive care unit; VA, Veterans Administration.

from those checklists (4) the number of times individual bundle practices were used including femoral location. Data entry into the website required completion of a learning session and a test—correctly identifying CLABSI infections in case scenarios based on CDC definitions.[19] The programme included audits because the audit tool teaches critical bundle elements and facilitates communication about bundle adherence between team members.

Statistical analysis

Analysis of variance (p value<0.05 significant) compared annual counts of central line infections, line days, CLABSI rates (infections/1000 line days) and adherence with the central line bundle. Pearson's correlation coefficient assessed the relationship of CLABSI rates to bundle adherence. Incidence rate ratios (IRR, an estimate of the rate of disease development) compared CLABSI infections rates between each fiscal year and the reference year 2006 using a Poisson regression (repeated measures generalised estimating equation (GEE)). A standardised infection ratio (SIR) compared observed to predicted infections (calculated by multiplying the line days for each type of unit by the CLABSI rates of a referent ICU specific population in the National Healthcare Safety Network (NHSN) from 2006 to 2008).[20]

RESULTS

Intensive care unit central line data

This report covers 833 172 central line days (208 294/year) reported from 2006 through the fourth quarter of 2009 representing 8352 ICU months (2076 ICU months annually). ICUs averaged 1068±844 central line days annually (range 74—3682; table 2). Central lines utilisation was 40.5% in 2007, 41.5% in 2008 and 43.3% in 2009, somewhat less than the 52 line days/patient days reported by the NHSN in medical surgical units.[21]

Adherence to evidence-based practices

VA ICUs audited insertion of 7822 central lines in the last two quarters of 2006, increasing to 16 130 in 2009 as the improvement efforts spread. Central lines placed outside of the ICU (operating room, emergency room,

acute care wards) were not audited, though CLABSI in the ICU from those lines were included. The increase in composite adherence to practice bundle from 85% to 98% (second quarter of 2006, when the data management website first became available; 4 months following the kick-off call, to 2009) had a strong inverse correlation (R=−0.81) with CLABSI rates (figure 2).

Infection rates and infections

The number of CLABSI decreased by 140 cases (from 683 to 543, p≤0.01) in 2008 compared with 2007, and by 139 cases (from 543 to 404, p<0.01) in 2009 compared with 2008. The national CLABSI rate/1000 line days decreased from 3.85/1000 line days in 2006 to 1.8/1000 line days in 2009. CLABSI rates fell in all types and levels of ICUs (table 2). Fifty of 174 ICUs (28.7%) reported a CLABSI rate of 0 for 2009; 74 ICUs (40.8%) reported a rate of 0 in the final 6 months of 2009. ICUs with CLABSI rates at 0 for 2 years were more often small delivering less complicated care (level 3 or 4, 21/29; 72.4%). IRR from the Poisson regression (repeated measures GEE) found years 2007—2009 compared to
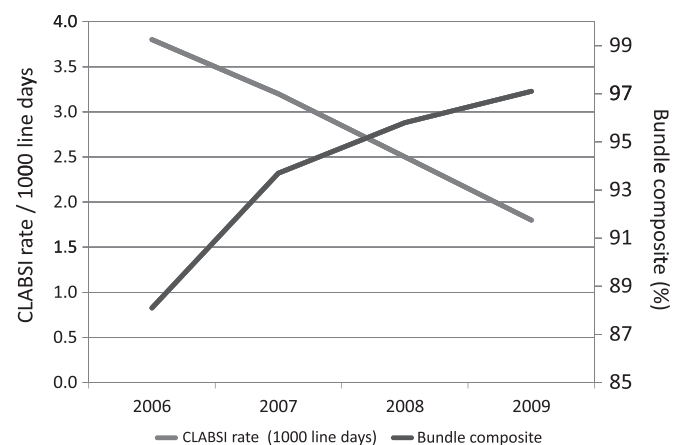

Figure 2 Reduction in CLABSI rate and improvement in adherence to bundle practices. The elements in the bundle practice included handwashing, use of maximal sterile barriers (bed-sized sterile drapes, sterile gown and gloves, cap and mask), chlorhexidinegluconate skin prep, avoidance of femoral site during insertion and removal of the line once no longer needed.

Table 3 Incidence rate ratios from Poisson regression

| Fiscal year | Summary statistics—CLABSI rate | | | | Time | |
	Mean	Median	25%	75%	IRR (95% CI)	p Value
2006	3.84	3.20	0.70	5.70	Reference	
2007	3.19	2.65	1.20	4.50	0.83 (0.73 to 0.94)	0.0033
2008	2.44	2.10	0.50	3.50	0.65 (0.56 to 0.76)	<0.0001
2009	1.85	1.20	0.00	2.50	0.47 (0.40 to 0.55)	<0.0001

IRR, incidence rate ratio.

2006 significantly associated with CLABSI rates (p<0.001, table 3).

The VA SIR for fiscal year 2009 and for the first 6 months of calendar year 2009 was significantly lower than the NHSN 2006–2008 referent rates (0.88 (95% CI 0.80 to 0.97); table 4 and 0.76 (95% CI 0.69 to 0.90), respectively; online supplementary table D).

Effectiveness of intervention strategies

Participation by local ICUs in the web-based national conferences, measured by number of telephone lines in use during the call was high for the kick-off call (215 lines), and the follow-up call in 4 months (185 lines). During the project, 2016/40 503 (48%) of Full Time Employee Equivalent nurses completed the CLABSI learning modules.

Four out of six hospitals with the highest numbers and rates of infections volunteered to participate in mentoring. Over a year, infection rates of mentored sites decreased 53%, from 7.7/1000 line days in 2007 to 3.6/1000 line days in 2008; and 1.1/1000 line days in 2009. Common themes from qualitative analysis of initial semi-structured interviews included a poorly organised team, lack of a physician champion, failure to set a goal, limited or no feedback to clinicians regarding the unit's infection rates and lack of forcing functions (line carts, checklists, etc.).

DISCUSSION

This paper reports a reduction in CLABSI in the largest healthcare system in the USA. The infrastructure and systematic approach used in this effort can be translated to improvement projects in other large healthcare systems, states and communities as well as VA ICUs. The qualitative analysis of struggling sites supports the value of using a variety of strategies in improvement efforts.

The SIR for the VA CLABSI in 2009 is similar to referent rates reported by the NHSN[21] and those reported by Missouri,[22] Pennsylvannia,[23] New York[24] and Colorado.[25] The VA SIR (0.77) for the first 6 months of 2009 is lower than the NHSN SIR of 0.83 in 17 states with mandatory CLABSI reporting. Since the NSHN rate for the 17 states is drawn from an incomplete sample of hospitals (range 32–100% by state), selection bias may overestimate improvement in these states. In contrast, the VA SIR represents a 100% sample. VA ICUs, like others nationally, will be challenged to meet the 5-year goal of US Health Human Services to reduce CLABSI by 75% (SIR of 0.25), translating to CLABSI rates by type of ICU between 0.37 and 0.56/1000 line days. We found the goal of zero infections/line days achievable in ICUs with limited missions, but sustaining zero in large complex ICUs may be associated with patient factors

Table 4 Standardised infection rate ratio comparing CLABSI in VA ICUs with referent rates from National Healthcare Safety Network fiscal year 2009

| ICU | NHSN group | Observed CLABSI rates in FY2009 | | | | | NHSN CLABSI rates 2006–2008 | | |
		CLABSI	Line days	CLABSI rate	Pred CLABSI	SIR	No. of CLABSI	No. of line days	CLABSI rate
Mixed LVL 1	Medical surgical teaching	59	33 568	1.76	70.76	0.83	1474	699 300	2.11
Mixed LVL 2, 3, 4	Medical surgical <15	71	43 683	1.63	65.34	1.09	1130	755 437	1.50
Medical	Medical ICU	37	184 03	2.01	42.34	0.87	2097	911 476	2.30
Surgical	Surgical ICU	127	68 953	1.84	158.97	0.80	1683	729 989	2.31
Medical CCU	Med/CCU	94	51 175	1.84	102.72	0.92	876	436 409	2.01
VA overall		388	215 782	1.80	440.13	0.88			

LVL, level; NHSN, National Healthcare Safety Network; CLABSI, central line-associated bloodstream infections; CLABSI rate, CLABSI divided by line days multiplied by 1000; Pred CLABSI, predicted VA CLABSI rates; NHSN CLABSI rate divided by 1000 times VA line days; SIR, standardised infection rate (observed number of CLABSI divided by the predicted CLABSI).

such as the duration of line placement, rather than bundle adherence on insertion.

Three multicentre projects in the USA have reported reduction in CLABSI.[11] [12] [26] The largest report to date, the Keystone project, includes 103 ICUs in 67 Michigan hospitals.[12] Like the Keystone project, the VA IPEC programme includes multiple targets for ICU implementation (ventilator-associated pneumonia bundle, use of daily goal sheet, increased use of prophylaxis for deep venous thrombosis, glycaemic control). The VA project differed from Keystone project in scope, implementation pathway and data collection. First, the VA project involved ICUs geographically distributed across the USA compared with a single state in the Keystone project. Second, the Keystone project used a collaborative pathway (face to face biannual meetings, conference calls with each site twice a month). In contrast, the VA project used a more streamlined model, taking advantage of its size, to provide benchmarks by type of ICU, building a toolbox that shared tools from successful sites and mentoring a minority of ICUs. This approach was likely facilitated by a longstanding culture of performance measurement and quality improvement and clear lines of authority within the VA. Third, the VA project reports both process and outcomes and includes a brief qualitative analysis of common facilitators to reducing CLABSI.

The study is limited in that all the data are self-reported. Safeguards that improved the data accuracy included test cases to assure understanding of the CDC definitions, conference calls with infection control practitioners and an open help desk for questions. The spikes observed monthly in ICU infection rates as the processes for sustaining low infection rates degraded suggest that the self-report is representative. A 2005 survey which found VA hospitals' reported use of CLABSI bundle elements more often than non-VA hospitals supports adherence results.[27] Several factors argue against a temporal trend in infection rates accounting for the reduction in CLABSI, unrelated to the intervention. First, the economic incentive, elimination of additional payment for CLABSI didn't affect VA hospitals. Second, the rate of change mirrors the stepwise implementation of interventions—the national kick-off call, feedback, mentoring and addition of the CLABSI rates to executive performance contracts. Third, the timeframe matches that of the Keystone project adjusting for the differences in size. Healthcare systems or communities with different organisational cultures might need to adapt these tactics.

The VA quality infrastructure in the ICU capitalises on the electronic medical record to build quality indicators for ICU report cards.[28] [29] The VA CLABSI initiative applied principles from high performing microsystems

and organisations[30]: (1) engaging multiple levels of leadership, (2) support of the microsystem (measurement, benchmarking, tools, policies/procedure samples), (3) education/training (learning modules with CEU), (4) interdependence (daily goal sheets), (5) process improvement (CLABSI project), (6) performance results (report cards and review by regional and local leadership) and (7) information technology (roll-up of local data, dissemination of results). VA ICUs reduced the CLABSI across all types and levels of ICUs. This model can likely be used to support improvement goals in the private sector within large healthcare systems, states or community improvement projects.

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