AHRQ Safety Program for Intensive Care Units: Preventing CLABSI and CAUTI

Final Report

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A Project of the:
American Hospital Association (AHA)
American Organization for Nursing Leadership (AONL)
Association for Professionals in Infection Control and Epidemiology (APIC)
Society of Critical Care Medicine (SCCM)
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*Expansion of the Comprehensive Unit-based Safety Program (CUSP) to reduce Central Line-Associated Bloodstream Infections (CLABSI) and Catheter-Associated Urinary Tract Infections (CAUTI) in Intensive Care Units (ICU) with persistently elevated infection rates

Contents

Glossary of Terms and Abbreviations

AA: Allied Association (state, district, or territorial hospital association)

AHA: American Hospital Association

AHRQ: Agency for Healthcare Research and Quality

ANA: American Nurses Association

AONL: American Organization for Nursing Leadership

APIC: Association for Professionals in Infection Control and Epidemiology

CAD: Cumulative Attributable Difference

CAUTI: Catheter-Associated Urinary Tract Infection

CDC: Centers for Disease Control and Prevention

CDS: AHA's Comprehensive Data System

CI: Confidence Interval

CLABSI: Central Line-Associated Bloodstream Infection

CMS: Centers for Medicare & Medicaid Services

CUSP: Comprehensive Unit-based Safety Program

CVC: Central Venous Catheter

EMR: Electronic Medical Record

HAIs: Healthcare-Associated Infections

HC: Hospital Compare

HHS: United States Department of Health and Human Services

HIIN: Hospital Improvement Innovation Network

ICU: Intensive Care Unit

IRR: Incidence Rate Ratio

ITS: Interrupted Time Series (Analysis)

IUC: Indwelling Urinary Catheter

NHSN: National Healthcare Safety Network

NPT: National Program Team

PEIR: Persistently Elevated Infection Rate

PIC: Performance Improvement Coach

QI: Quality Improvement

QIN/QIO: Quality Innovation Network/Quality Improvement Organization

SCCM: Society of Critical Care Medicine

SHM: Society of Hospital Medicine

SIR: Standardized Infection Ratio

SLAC: State Lead Action Council

SLQR: State Lead Quarterly Report

SME: Subject Matter Expert

SUR: Standardized Utilization Ratio

TEP: Technical Expert Panel

U of M: University of Michigan

VLG: Virtual Learning Group

A. Executive Summary

Introduction

This is the final report on the implementation and impact evaluation of the Agency for Healthcare Research and Quality (AHRQ) Safety Program for Intensive Care Units (ICUs): Preventing central line-associated bloodstream infections (CLABSIs) and catheter-associated urinary tract infections (CAUTIs). Hereafter referred to as the AHRQ ICU Safety Program, or simply the program, this initiative was designed to reduce healthcare-associated infection (HAI) rates in adult ICUs with persistently elevated CLABSI and/or CAUTI infection rates. Based on the experiences of six cohorts of ICUs that implemented the 12-month program between February 2016 and April 2021, the report describes program components and implementation, impact evaluation findings and limitations, information about program spread, lessons learned, and conclusions. The report also provides recommendations to the critical care community and quality improvement field on how to enhance future infection prevention programs.

Program Rationale and Goals

HAIs affect one in every 31 hospitalized patients (Centers for Disease Control and Prevention [CDC], 2019) and are largely preventable. When the AHRQ ICU Safety Program was initiated in 2015, CLABSIs were associated with a significantly increased risk of death (Ziegler et al., 2014). CLABSI-related mortality is assumed to range from 12 to 25 percent. (Liang et al., 2011[1]). Although rarely lethal, CAUTIs accounted for 75 percent of all hospital-associated urinary tract infections (CDC, 2019). It is estimated that 65–70 percent of CLABSIs and CAUTIs are preventable (Septimus et al., 2016). The cost of both HAIs is substantial in terms of morbidity, mortality, and financial resources expended (Liu et al., 2020).

Two previous national programs funded by AHRQ used the Comprehensive Unit-based Safety Program (CUSP) method to reduce CLABSI (called On the CUSP: Stop BSI[2] implemented 2008 through 2012) and CAUTI (called On the CUSP: Stop CAUTI, implemented 2009 through 2015) in hospitals. These two programs, respectively, were associated with a 43 percent overall reduction in CLABSI among more than 1,000 ICUs and a 32 percent overall reduction in CAUTI among 533 non-ICUs (Berenholtz et al., 2014, Saint et al., 2016). However, ICUs did not achieve a statistically significant reduction in CAUTI (Saint et

[1] Most recent available CLABSI mortality statistic for U.S. acute care hospitals.
[2] BSI refers to bloodstream infection; however, the On the CUSP: Stop BSI program was focused only on CLABSI reduction.

al., 2016), and despite an overall CLABSI reduction, results varied among ICUs, with some ICUs continuing to have elevated CLABSI rates (Berenholtz et al., 2014).

As a result, AHRQ contracted with the American Hospital Association (AHA) to implement a national quality improvement collaborative, the AHRQ ICU Safety Program. The underlying patient safety methodology of this 12-month program was the evidence-based CUSP model used in previous AHRQ HAI prevention initiatives—a model designed to sustainably improve safety in multiple healthcare settings (AHRQ, 2012). The current program differed, however, from previous CUSP collaboratives because it was designed to address adult ICUs with the greatest need for improvement. The Targeted Assessment for Prevention (TAP) Strategy developed by the CDC enabled hospitals and allied hospital associations to identify which ICUs would benefit most from the program, if hospitals had conferred rights to their National Healthcare Safety Network (NHSN) data to the associations. The TAP report tool used a metric called the cumulative attributable difference (CAD). Adult ICUs were eligible to enroll in the program if they had a positive CAD for a period of 12 months of the most recently available NHSN data.[3] CAD is defined as the number of infections that must be prevented within a group, facility, or unit to achieve an HAI reduction goal. The CAD is calculated by subtracting a numerical prevention target from an observed number of HAIs. The prevention target is the product of the predicted number of HAIs and a standardized infection ratio goal.[4] The TAP reports for each unit were generated at different times; therefore, the time between CAD identification and the beginning of ICU program implementation varied from unit to unit within each cohort. The ICUs that participated in this program were characterized as having persistently elevated infection rates (PEIR) for a specified 12-month period and are referred to as PEIR ICUs in this report.

To address the needs of ICUs with persistently elevated rates of CLABSI and/or CAUTI, AHRQ awarded the AHA the contract for the original phase of the AHRQ ICU Safety Program, which was rolled out to two cohorts of adult ICUs[5] (Cohorts 1 and 2) in 2016. This contract was followed by three other contracts: the base period expansion, which implemented the program in two cohorts (Cohorts 3 and 4); the option period 1 expansion, which had one participating cohort (Cohort 5); and lastly, the option period 2 expansion, which had one cohort (Cohort 6) that implemented the program primarily during

[3] PEIR ICUs are defined as having a positive CAD greater than 0, calculated using the most recent 12 months of NHSN data available for identification.
[4] Glossary of TAP Terms: https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/tap-glossary-current.pdf.
[5] Herein, "ICUs" or "units" will refer to adult ICUs or units.

the COVID-19 pandemic in 2020-2021. Collectively, these six cohorts represented units from all 10 U.S. Department of Health and Human Services (HHS) regions.[6] The goals of the AHRQ ICU Safety Program were to—

- Recruit at least 700 ICUs with a PEIR in CLABSI and/or CAUTI from multiple HHS regions
- Adapt and augment CUSP training resources and materials for CLABSI and CAUTI prevention in PEIR ICUs
- Reduce CLABSI and CAUTI in PEIR ICUs by applying CUSP adapted to the ICU setting
- Assess the adoption of CUSP for CLABSI and CAUTI and evaluate the effectiveness of the intervention for participating ICUs

Program Spread

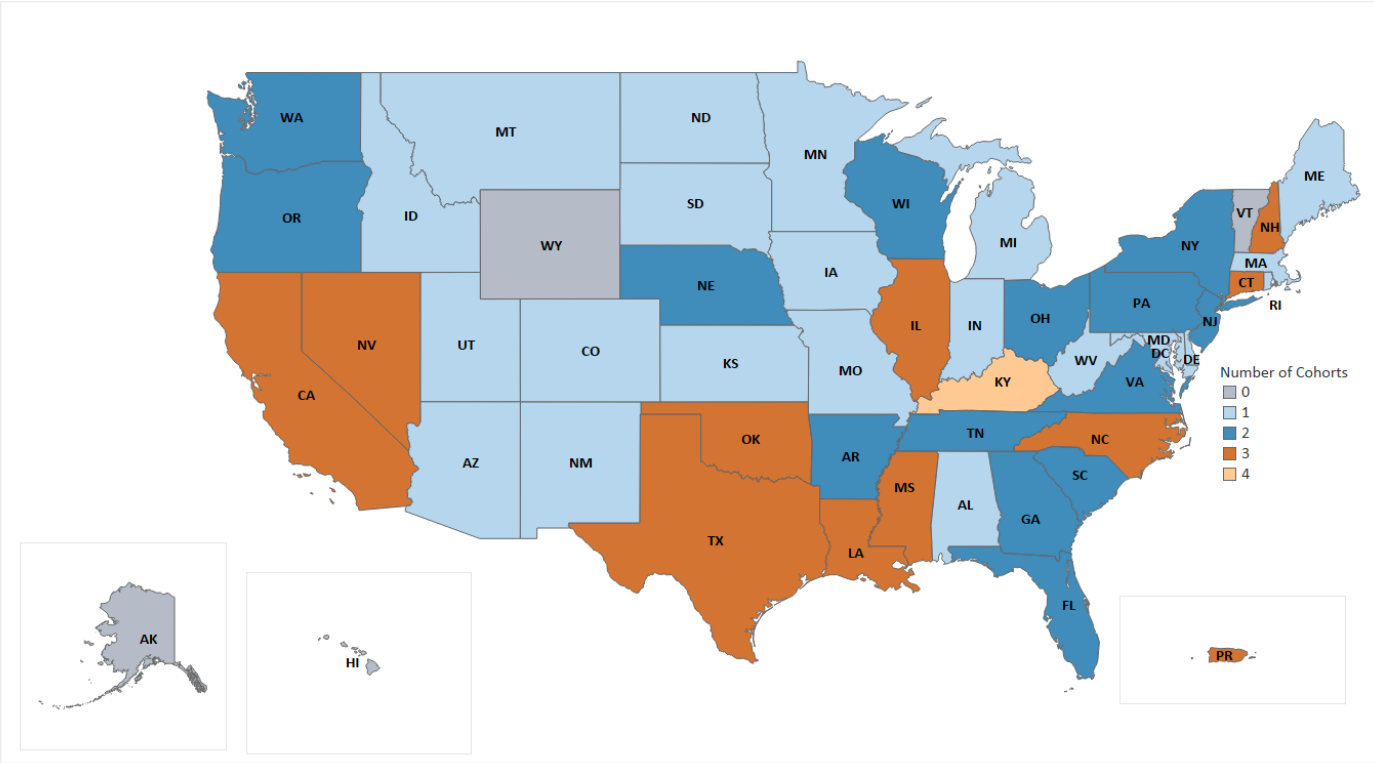
This AHRQ ICU Safety Program was intended to cover as wide a geographic area as possible and to reach as many adult ICUs with PEIR as possible using a rolling recruitment process over the program's 6-year implementation period. For the first two cohorts of the program, AHA reached out to the hospital associations in 4 of the 10 HHS regions with the highest number of hospitals with PEIR ICUs. For cohorts 3 through 5, AHA recruited States in the remaining HHS regions. Cohorts 3 through 5 also included States that had already participated, although only ICUs not previously in the program were allowed to enroll. Cohort 6, the last cohort, comprised solely States that had already participated in the program, again with only ICUs that had not previously enrolled.

Overall, AHA recruited 832 ICUs from 540 hospitals representing 46 States, the District of Columbia, and Puerto Rico (Figure A-1). Of these regions, 21 States and the District of Columbia registered in a single cohort, 14 in two cohorts, 10 States and Puerto Rico in three cohorts, and one State in four cohorts. The 12-month program was rolled out in a phased manner between February 2016 and April 2021 across the six cohorts. These ICUs are predominantly medium sized (6–15 beds) and medical/surgical units from teaching, urban, and nonprofit hospitals. Of these 832 recruited ICUs, 709 (85 percent) participated in the program and 667 (80 percent) had sufficient outcome data to be included in the program evaluation.

Figure A-1. AHRQ ICU Safety Program Reach: The District of Columbia (DC), Puerto Rico (PR), and 46 States Represented Among the 832 Units Registered to Participate (Cohorts 1 through 6), and the

[6] The HHS regions represented in each of the six cohorts are as follows: cohort 1 – regions 2, 4, 6, and 9; cohort 2 – regions 2, 4, 6, and 9; cohort 3 – regions 3, 4, and 5; cohort 4 – regions 1, 4, 5, 7, 8, and 10; cohort 5 – regions 1, 2, 4, 5, 6, 7, 9, and 10; and cohort 6 – regions 1, 3, 4, and 5.

Number of Participating Cohorts, by State or Territory



Note: Twenty-one states and the District of Columbia registered in one cohort, 14 states in two cohorts, 10 states and Puerto Rico in 3 cohorts, and 1 state in four cohorts. Four states (Alaska, Hawaii, Vermont, and Wyoming) did not register for the program.

Program Evaluation

The evaluation assessed the effects of the AHRQ ICU Safety Program on infection rates and device utilization by conducting three sets of analyses: (1) primary analyses that focused on examining the **overall effects** of the program; (2) secondary analyses that assessed whether the effects varied across subgroups of units **(differential effects)**; and, (3) exploratory analyses that examined the **association** between each outcome and ICU and hospital characteristics, as well as the performance of units in terms of maintaining or attaining zero infection rates. Each analysis is based on samples pooled across cohorts. The questions addressed in each analysis and the findings are summarized below. The evaluation methods used are described in the Evaluation Design section of this report, and the complete results are found in the Evaluation Findings section and in Appendix 4. The **primary analyses** addressed the question: *What are the effects of the AHRQ ICU Safety Program on infection rates [NHSN CLABSI and CAUTI rates, population CLABSI and CAUTI rates] and device utilization (central line and indwelling urinary catheter utilization ratios)?* The primary analysis was originally planned to be based on the

pooled sample from cohorts 1 to 6. However, in light of the unforeseen occurrence of the COVID-19 pandemic, and the disruptions it brought to the healthcare setting in general and to the Cohort 6 program implementation in particular, the primary analyses were also examined in two other samples: **(1) one that excluded Cohort 6 (that is, included Cohorts 1 to 5 only), and (2) one that focused only on Cohort 6**. Taken together, these three sets of analyses offer a more complete picture of the program effects. Results are summarized below:

- Analysis of the ***combined Cohorts 1 to 6 sample*** did not detect an impact on the rate at which reductions in infection rates occurred and was associated with a slower rate of decline in device utilization. That is, both infection rates and device utilization had statistically significant declining trends during both the pre-intervention and intervention periods, but there was no alteration in infection rates associated with the program; there was a deceleration in the decrease in device utilization.
- Similar to the findings on the *combined cohorts 1 to 6 sample*, findings on the ***Cohorts 1 to 5 sample*** showed statistically significant declining trends in infection rates and device utilization during both the pre-intervention and intervention periods. The analysis did not detect an impact on the rates at which reductions in either infection rates or device utilization occurred.

Taken together, the above findings suggest that the unprecedented experiences of cohort 6 may have driven the statistically significant deceleration in the reduction in device utilization that was observed during the intervention period in the entire cohorts 1 to 6 sample.

The **secondary analyses** examined the question: *Do the effects on NHSN infection rates and/or device utilization ratios vary by cohort, by level of participation, by level of CUSP adoption (available for Cohorts 3 to 6 only), by whether a unit had a positive or negative CAD during the pre-intervention period, and by whether a unit had a site visit*? Given inherent differences across cohorts such as differences in the uptake of program components, the concurrence of the Cohort 6 implementation and the COVID-19 pandemic, and differences in pre-intervention infection and utilization rates among participating units, AHA conducted subgroup analyses that examined whether there were differential effects across cohort groups (Cohorts 1 and 2, Cohorts 3, 4 and 5, and Cohort 6), levels of participation (low, moderate, or high), degree of adoption of the CUSP principles (low, moderate, or high), pre-intervention CAD values (positive or negative), and site visit status (did or did not have a site visit). These subgroup analyses yielded some statistically significant differential effects across subgroups based on cohort, participation level, pre-intervention CAD value, and site visit status, but not across subgroups based on CUSP

adoption level. These heterogeneous effects are generally characterized by variations that fall under three types of subgroup-specific effects: (1) a "null" effect where infection rates or device utilization declined at similar rates during both the pre-intervention and intervention periods; (2) a slower pace during the intervention period compared to the pre-intervention period; or (3) a reversal in the trend from decreasing during the pre-intervention period to increasing during the intervention period. None of the statistically significant subgroup-specific effects are characterized by a faster rate of reduction during the intervention period compared to the pre-intervention period. In sum, these secondary analyses findings indicate that while there were variations in the effectiveness of the program across certain subgroups and outcomes, consistent with the findings on the overall sample, the analysis did not detect an acceleration in the reduction in infection rates or device utilization for any of the subgroups examined.

The **exploratory analyses** focused on two questions: *(a) which hospital/ICU characteristics were associated with NHSN infection rates and/or device utilization? (b) What percent of participating ICUs attained or maintained zero aggregate NHSN CLABSI or CAUTI rates from the pre-intervention to the intervention period?*

Findings on the first question indicate that, controlling for all other characteristics, ICU type is associated with all four outcomes, and cohort group is associated with all outcomes except NHSN CAUTI rates. The nature of these associations varied across outcomes and are described in the Evaluation Findings Section. Unit-reported focus on CLABSI and CAUTI during the program were associated with increased CLABSI and CAUTI rates, respectively, but not with device utilization. Larger ICUs and ICUs in larger hospitals as well as in hospitals that are teaching, urban, or government owned (compared with either non-government/nonprofit or for profit) were associated with higher central line utilization.

Findings on the second question suggest that in the subset of units with baseline aggregate rates greater than zero, roughly 25 percent and 20 percent managed to attain zero NHSN CLABSI and CAUTI rates, respectively, during the intervention period. For context on where these units started in terms of their infection rates, the units that attained zero CLABSIs during post-intervention had CLABSI rates between 0.33 to 5.10 during pre-intervention, and those that attained zero CAUTI rates during post-intervention had pre-intervention CAUTI rates between 0.37 to 6.94. The majority of these units (56 percent for CLABSI and 62 percent for CAUTI, respectively) had pre-intervention rates between 0.5 and 1.5 infections per 1,000 device days; 7 percent and 10 percent, respectively, had less than 0.5 CLABSI or CAUTI rates; and the remaining 37 percent and 29 percent, respectively, had pre-intervention CLABSI or

CAUTI rates greater than 1.5. Lastly, 49 percent and 37 percent of units that had zero CLABSI or CAUTI infections, respectively, during pre-intervention[7] managed to maintain zero infections during the intervention period.

Lessons Learned: Program Implementation Barriers and Facilitators and Benefits of Participation

To better understand the factors that limit or extend program effects, data on perceived program implementation barriers and facilitators, and program participation benefits were collected from unit members, unit leads, and state leads across all six cohorts. Data sources included ICU assessments, ICU action plans, exit interviews, site visits, case studies, and cohort closeout meeting discussions with State and unit leads.

Implementation Barriers

In exit interviews and case studies, unit and State leads cited implementation barriers that they experienced while implementing the program. These align with three of the five domains identified in the systematic review by Vaughn, et al. (2018) as characterizing struggling healthcare organizations: (1) weak organizational structure (e.g., limited program ownership and involvement by senior leadership, unit management, and/or frontline staff), (2) inadequate infrastructure (e.g., insufficient staffing and staff turnover, minimal quality improvement systems, competing priorities, inadequate training of staff and staff knowledge deficits, and lack of resources), and (3) system shocks (e.g., senior leader turnover; unit manager, program unit lead, and/or other staff turnover; unit reorganizations; new electronic health record installations; financial difficulties; and hospital mergers). Note that all these barriers have been previously reported in a published manuscript on cohorts 1 and 2 (Meddings et al., 2020), and these barriers have been consistent across cohorts.

The system shock brought upon by the COVID-19 pandemic, however, was unique and posed considerable challenges to the final cohort (Cohort 6) that took part in the program between December 2019 and April 2021 (with a program pause during March through July 2020 due to the pandemic). During the pandemic, ICUs reported staff shortages and high staff turnover, less attention to device maintenance and removal, suspension of multidisciplinary rounds and audits, increased device

[7] Note that while the AHRQ ICU Program sought to enroll only ICUs that had a positive CAD in CLABSI or CAUTI during the identification period, there was up to an 18-month lag between the identification period and the pre-intervention period, and some ICUs may have attained zero infection rates during the pre-intervention period.

utilization and longer duration of devices, need to limit patient exposure, increased blood draws from central lines, excess urine culturing, increased antibiotic use, decreased antibiotic stewardship, and supply disruptions.

Implementation Facilitators

Facilitators to implementation, which were reported through unit virtual learning group (VLG) presentations, unit case studies, and/or unit and State lead exit interviews, included active engagement of one or more senior leaders, the unit medical director, and/or the nurse manager; as well as, engagement from the physician, nurse, and frontline staff who serve as program champions. Facilitators to implementation also included high-impact practices (e.g., daily multidisciplinary rounds and shift huddles, standardized education on device need and use, automated strategies to facilitate real-time feedback to staff, public posting of infections and other performance data, nurse-driven protocols, regular competency audits, and engaging patients and families in urinary catheter use), as well as the use of evidence-based products (e.g., full sterile drapes, chlorhexidine-based wipes, and standardized catheter kits) and equipment to support infection prevention (e.g., bladder scanners and scales to weigh urinary pads).

Benefits of Participation

Unit leads and other ICU team members reported multiple benefits from program participation, including a change in the mindset among staff that all ICU patients need indwelling devices, the ability to customize approaches to CLABSI and CAUTI prevention strategies based on unit need, and the opportunity to learn from peers within and across States and regions, have site visits from subject matter experts and State leads, and learn about and apply CUSP.

State leads reported benefitting from the individual coaching sessions with their assigned performance improvement coach, coaching trainings held during cohort kickoff and closeout meetings, monthly conference calls with other State leads, and access to a comprehensive array of program tools and resources to support their participating ICUs. Most State leads stated they would take part in the program again if given the opportunity. State leads reported benefiting from additional program tools added in the expansion phase in Cohorts 3-5 (e.g., coaching training, CUSP training videos, and event reporting templates). State leads who participated in Cohort 6 found the VLG summaries with topic time markers especially valuable for staff busy caring for COVID-19 patients.

Evaluation Limitations

This evaluation has several limitations related to data collection, overall evaluation design, and program implementation. Some examples of limitations that, along with the implementation barriers described above, may have contributed to the lack of statistically significant program effects include: pre-intervention infection rates that may have been already relatively low because of prior national initiatives on CLABSI and CAUTI prevention, making it less likely to see any further substantial improvements in rates; competing priorities from involvement in concurrent initiatives; reduced statistical power to detect program effects in some of the subgroup analyses because of smaller sample sizes; and an inability to tease apart program effects from the confounding effects of the COVID-19 pandemic on Cohort 6 outcomes. A more comprehensive list of limitations is provided in the Limitations section of this report.

Conclusions

The use of CUSP has demonstrated success in reducing CLABSI in the ICU in some studies (Pronovost et al., 2006; Lin et al., 2011; Berenholtz et al., 2014) and CAUTI in non-ICUs in another study (Saint et al., 2016). Results of the first two cohorts from this program (Meddings et al., 2020) suggest CUSP may be challenging to apply to struggling ICUs because organizational challenges might make them unprepared to start using CUSP. Some participating ICUs had a weak organizational structure, an inadequate infrastructure, and/or systems shocks—characteristics associated with healthcare organizations struggling to reduce their HAIs (Vaughn et al., 2019).

Despite the lack of statistically significant findings for the AHRQ ICU Safety Program, quality improvement and patient safety programs like this are critically important. The AHRQ ICU Safety Program was designed to work in ICUs with PEIR and participating units varied in their performance. Of the participating units with at least one CLABSI during pre-intervention, almost 25 percent attained zero CLABSI rates, and of those with at least one CAUTI during pre-intervention, almost 20 percent attained zero CAUTI rates during their intervention period. Other notable findings are:

- Although the program did not accelerate the reduction of infection rates, the downward trends in CLABSI and CAUTI rates during both the intervention and pre-intervention periods suggest that ICUs continued to improve patient safety and prevent infections. Even though not statistically significant, there were consistent improvements in rates and utilization.

- The program was able to recruit and provide training and coaching to 709 ICUs that participated in the program across 46 States, the District of Columbia, and Puerto Rico.
- Almost half of the States or territories that participated in the program found the program valuable enough to enroll in more than one cohort—14 States or territories participated in two cohorts and 11 States or territories in three or four cohorts.
- Secondary analyses show that the majority of units in cohorts 3 through 6 had moderate or substantial levels of CUSP adoption—a foundational component for a culture of safety.
- Unit and State leads expressed a greater understanding of specific challenges in addressing HAIs in ICUs, which would not have been possible without the unit focus of this program.

The National Program Team developed high-quality materials and educational content tailored for and well-received by participating state leads and units. These materials have been developed into a toolkit designed to be used outside the program structure that will continue to support ICU teams with resources after the project ends and will be available to units that did not participate in the project. The AHRQ Toolkit for Preventing CLABSI and CAUTI in ICUs is described in Section B. The National Program Team also developed program modification recommendations listed in Section H for any organization seeking to implement a future similar ICU HAI prevention collaborative.

B. Program Description

Program Rationale and Goals

Healthcare-associated infections (HAIs) affect 1 in 31 hospitalized patients (Centers for Disease Control and Prevention [CDC], 2019) and are largely preventable. When the Agency for Healthcare Research and Quality (AHRQ) Safety Program for Intensive Care Units (ICUs): Preventing CLABSI and CAUTI was initiated in 2015, central line-associated bloodstream infections (CLABSIs) were estimated to have a 12–25 percent mortality rate (Liang, 2011[8]). Although rarely lethal, catheter-associated urinary tract infections (CAUTIs) accounted for 70–80 percent of all hospital-associated urinary tract infections (CDC, 2019). The cost of both HAIs is substantial in terms of morbidity and financial resources expended (Liu et al., 2020). Two previous AHRQ-funded national programs that used the Comprehensive Unit-based Safety Program (CUSP) model to reduce CLABSI (AHRQ, 2013) and CAUTI (Saint et al., 2016) in hospitals

[8] Most recent available CLABSI mortality statistic for U.S. acute care hospitals.

were associated with greater than a 40 percent reduction in CLABSI overall among more than 1,000 ICUs and a 30 percent reduction in CAUTI among more than 650 non-ICUs. However, ICUs did not achieve a statistically significant reduction in CAUTI (Saint et al., 2016), and despite an overall CLABSI reduction, there was variation among ICUs, and some continued to have elevated CLABSI rates (Berenholtz et al., 2014).

As a result, AHRQ contracted with the American Hospital Association (AHA) to implement and evaluate a national quality improvement (QI) collaborative, the AHRQ Safety Program for ICUs: Preventing CLABSI and CAUTI (AHRQ ICU Safety Program). This program differed from previous CUSP collaboratives because it was designed to address adult ICUs with the greatest opportunity for improvement—characterized as ICUs with persistently elevated infection rates (PEIR) or PEIR ICUs.[9] The 12-month program was rolled out in a phased manner between February 2016 and April 2021 in which six cohorts of States and regions recruited a total of 832 ICUs to participate in the program. Over this 5-year period, 709 ICUs participated in the program for the full 12 months for an overall retention rate of 85 percent. Table B-1 outlines the contract period and evaluation timelines (pre-intervention and program/ intervention periods) for each of the six cohorts.

Table B-1. Evaluation Timeline of the AHRQ ICU Safety Program: Cohorts 1 to 6

Sample	Contract Period	Contract Period Dates	Pre-intervention Period	Program/Intervention Period
Cohort 1	Original	Sep 2015–Oct 2018	Feb 2015–Jan 2016	Feb 2016–Jan 2017
Cohort 2	Original	Sep 2015–Oct 2018	Oct 2015–Sep 2016	Oct 2016–Sep 2017
Cohort 3	Expansion Base Period	Sep 2017–Sep 2019	May 2017–Apr 2018	May 2018–Apr 2019
Cohort 4	Expansion Base Period	Sep 2017–Sep 2019	Aug 2017–Jul 2018	Aug 2018–July 2019
Cohort 5	Expansion Option Period 1	Sep 2018–Mar 2020	Feb 2018–Jan 2019	Feb 2019[1]–Jan 2020
Cohort 6	Expansion Option Period 2	Sep 2019–Apr 2022	Dec 2018–Nov 2019	Dec 2019–Apr 2021[2]

[1] Cohort 5 implementation began January 31, 2019, with the first onboarding webinar, but because that was the last day of the month, for the purposes of evaluation, February 2019 is considered the first program month for Cohort 5.
[2] Cohort 6 implemented the program from December 2019 to February 2020, paused implementation from March to July 2020 because of the COVID-19 pandemic, and then resumed implementation from August 2020 to April 2021.

[9] PEIR ICUs are defined as having a positive cumulative attributable difference (CAD) greater than 0, calculated using the most recent 12 months of National Healthcare Safety Network (NHSN) data available during the identification period. CAD is the number of infections that must be prevented within a group, facility, or unit to achieve an HAI reduction goal, and is calculated by subtracting a numerical prevention target from an observed number of HAIs (https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/tap-glossary-current.pdf). The prevention target is the product of the predicted number of HAIs and a standardized infection ratio goal (SIR). The SIR goals used in the CAD calculations were 0.75 for CAUTI and 0.50 for CLABSI.

The goals of the program were to—

- Recruit at least 700 ICUs with a PEIR in CLABSI and/or CAUTI in multiple U.S. Department of Health & Human Services (HHS) regions
- Adapt and augment CUSP training resources and materials for CLABSI and CAUTI prevention in PEIR ICUs
- Reduce CLABSI and CAUTI in PEIR ICUs by applying CUSP adapted to the ICU setting
- Assess the adoption of CUSP for CLABSI and CAUTI and evaluate the effectiveness of the intervention for participating ICUs

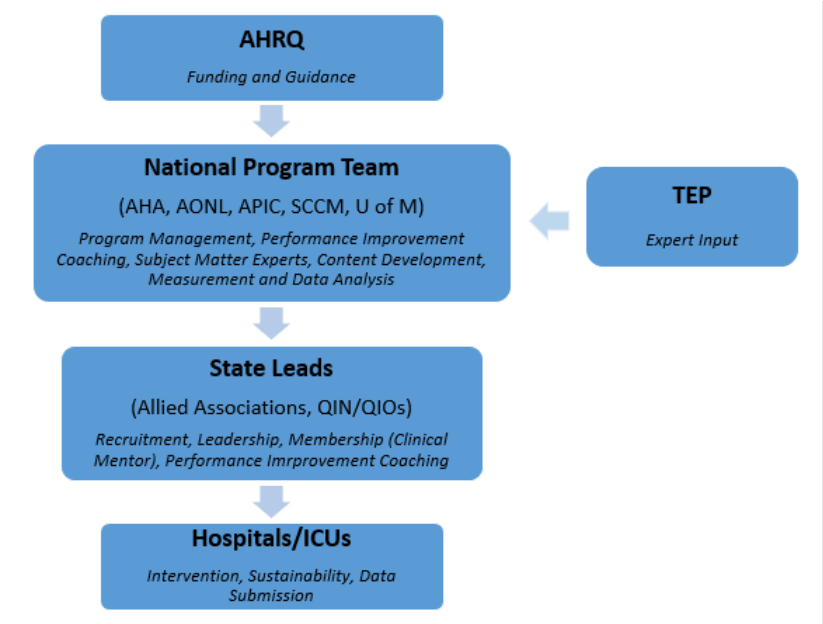
The program was intended to have the largest reach possible across the United States. Overall, 832 units from 540 hospitals were recruited into the program, and 709 ICUs across 46 States, the District of Columbia, and Puerto Rico participated fully in the program across six cohorts. Fourteen States participated in two cohorts, and seven States participated in three cohorts. Figure A1 in Appendix 1 details which States and territories participated in one or more program cohorts.

The COVID-19 pandemic required program modifications during the last cohort, Cohort 6. ICUs implemented the program between December 2019 and April 2021. To allow ICU teams to focus on dealing with the unprecedented challenges and demands particularly in the initial phase of the COVID-19 pandemic, AHA paused the program between March 1 and July 31, 2020, and modified program requirements. Specific program modifications are addressed in this section under Program Implementation.

Program Management and Development

The AHRQ ICU Safety Program was a large QI project with many stakeholders and a complex implementation structure that included education, coaching, peer support, performance monitoring, data submission, and program evaluation. As a result, the program required a well-defined project management structure and dissemination model that included national leaders and experts, allied hospital association staff, and hospital and ICU leadership. Figure B-1 shows the program's organizational structure and how the program was disseminated to participating ICUs.

Figure B-1. Program Organizational Structure and Dissemination Model



AHA = American Hospital Association; AHRQ = Agency for Healthcare Research and Quality; AONL = American Organization for Nursing Leadership; APIC = Association for Professionals in Infection Control and Epidemiology; ICU = intensive care unit; QIN/QIO = Quality Innovation Network/Quality Improvement Organization; SCCM = Society of Critical Care Medicine; TEP = Technical Expert Panel; U of M = University of Michigan

National Partners

At the national level, the following members of the National Program Team (NPT) supported AHA in the content development, coaching, and guidance of the program: American Organization for Nursing Leadership, Association for Professionals in Infection Control and Epidemiology, Society of Critical Care Medicine, and the University of Michigan (U of M). Additionally, the American Nurses Association and the Society of Hospital Medicine were national partners in the first two cohorts. Table B-2 describes the role(s) of each NPT partner in program development and implementation.

Table B-2. NPT Role in Program Development, Implementation, and Evaluation

Organization	Role
AHA	• Program Lead/Principal Investigator • Direct communication with AHRQ • Oversight/coordination of the program • Program implementation support, such as performance improvement coaches for state leads • Lead evaluators for the expansion program (cohorts 3–6)
AONL	• Subject matter experts in nurse engagement and senior leadership
APIC	• Subject matter experts in infection prevention and control
SCCM	• Subject matter experts in quality care for critically ill and injured patients
U of M	• Lead evaluators for the original program (cohorts 1 and 2); reviewed the evaluation methodology described in this report but did not conduct the evaluation or statistical analyses contained in this report

	• Subject matter experts on CLABSI and CAUTI prevention bundles and implementing multi-center initiatives

AHRQ = Agency for Healthcare Research and Quality; AHA = American Hospital Association; AONL = American Organization for Nursing Leadership; APIC = Association for Professionals in Infection Control and Epidemiology; SCCM = Society of Critical Care Medicine; U of M = University of Michigan

In addition to the NPT, a Technical Expert Panel (TEP) met one to two times per year throughout the project to provide input to the NPT, as illustrated in Figure B1. To promote synergy and coordination with the national Hospital Improvement and Innovation Network program's HAI reduction goals, AHA kept the Centers for Medicare & Medicaid Services (CMS) and their State Quality Innovation Networks/Quality Improvement Organizations (QIN/QIOs) apprised of the program goals and implementation. Furthermore, both CMS and CDC served as ex-officio members of the TEP.

Allied Association Partners

Allied hospital associations from the participating States, the District of Columbia, and Puerto Rico played a key role in ICU recruitment, mentorship, and performance improvement coaching and monitoring. As shown in Figure B1 above, State leads managed State/regional QI initiatives sponsored by the hospital association for its members. QIN/QIO personnel served as State leads in two States because of limited hospital association capacity. State leads received financial support for their program activities. To receive full funding, State leads were required to—

- recruit eligible ICUs, which included obtaining senior leadership commitment to participate
- lead units through program implementation
- ensure ICUs met program educational and data submission requirements
- lead monthly coaching calls with participating ICUs
- monitor ICU progress in meeting the unit's action plan aims
- conduct site visits to a percentage of their participating units (Cohorts 1-2 State leads were required to visit 50 percent of their participating ICUs, Cohorts 3-5 State leads were required to visit 30 percent to reduce their workload, and Cohort 6 State leads were required to visit one site (in person prior to the pandemic or virtually during the pandemic) or have ICUs present their experience at an optional all-unit virtual meeting
- identify clinical mentors or NPT subject matter experts as needed to support ICUs
- attend monthly State leadership action council calls
- check-in monthly with their assigned AHA performance improvement coach

- provide information to AHA and the NPT on program challenges, unit action plan progress, and unit best practices through quarterly progress reports, site visit reports, and case studies

ICU Participants

ICU implementation was led by a program unit lead who was typically a nurse manager. The unit lead and a hospital senior leader were required to sign a commitment letter agreeing to participation expectations. The unit leads agreed to—

- form a CUSP team (unit team lead-, frontline staff, nurse manager, and physician manager)
- engage at least one senior leader, physician, and nurse champion
- lead the unit in the completion of the ICU Assessment and review identified gaps
- implement an action plan that addressed one to three gaps, and report monthly progress
- submit monthly infection and device utilization rate data
- participate in the educational components of the program

Program Components

Formulating the Intervention

Prior to formulating the intervention components of the AHRQ ICU Safety Program, the TEP and the NPT understood that it could build from the two previous AHRQ CLABSI and CAUTI prevention initiatives, which focused on non-ICUs, but would need to modify the curriculum and CUSP training resources and materials for ICU teams. At their initial meeting, TEP and NPT members discussed the major challenge posed by the high prevalence of central venous catheters (CVC) and indwelling urinary catheters (IUC) in the intensive care setting. In addition, despite detailed, evidence-based guidelines describing intervention bundles to prevent CLABSIs and CAUTIs, some ICUs continued to have elevated rates of these infections. The TEP and NPT found the evidence report based on the comprehensive literature review of the latest evidence on successful cultural or adaptive interventions very helpful in determining the program components.

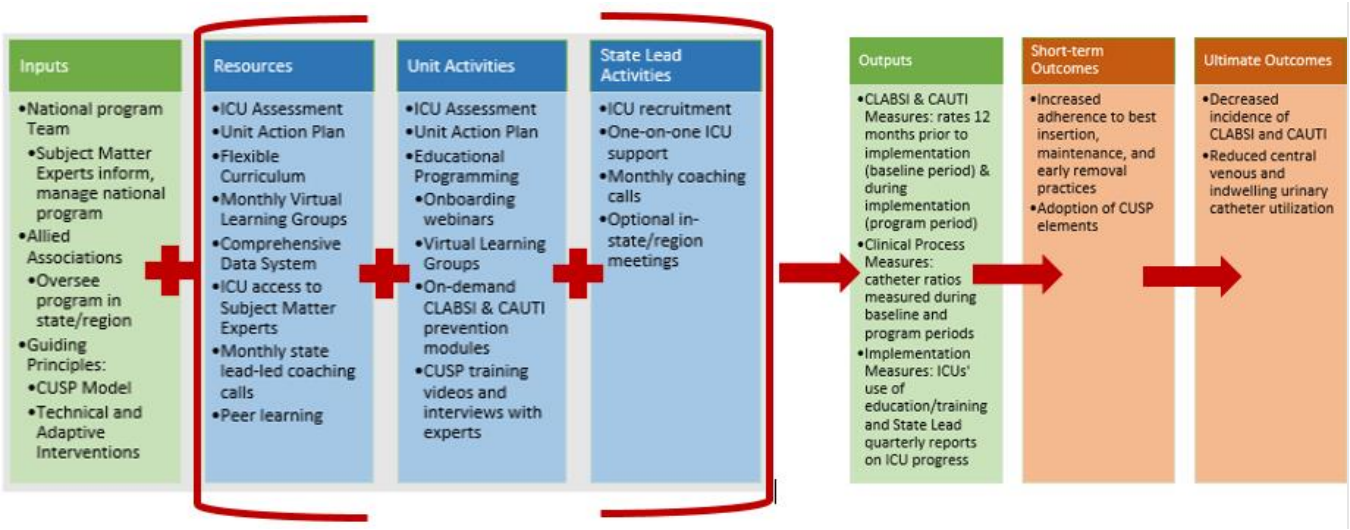
The NPT used the first 5 months of the original contract to formulate the components of the AHRQ ICU Safety program. During this time, U of M members of the NPT prepared a comprehensive evidence report, an AHA contractor conducted interviews with healthcare and nonhealthcare experts in evidence-based practice (EBP) adoption, and the NPT considered Roger's Diffusion of Innovations theory that describes the way new ideas, behaviors, or technologies are adopted by categories of populations to

inform program content and implementation. Other influences included Berwick's article on innovation dissemination in healthcare (Berwick, 2003) and a key lesson from the previous AHRQ program, "On the CUSP: Stop CAUTI," that lasting organizational change requires both evidence-based socio-adaptive processes along with technical ones (Saint et al., 2016). These influences led to the NPT's development of the two-tiered approach to CLABSI and CAUTI prevention, a key feature of the AHRQ ICU Safety Program.

AHRQ ICU Safety Program Logic Model

Based on components of previous AHRQ HAI prevention initiatives and the evidence report recommendations regarding the ICU environment and potential innovation adoption challenges of PEIR units, the NPT developed the program logic model, Figure B-2 below, to illustrate how the inputs, resources, and activities of the AHRQ ICU Safety Program were expected to produce the desired ultimate outcomes: (1) decreased incidence of CLABSI and CAUTI, and (2) reduced CVC and IUC utilization.

Figure B-2. Program Logic Model



CAUTI = catheter-associated urinary tract infection; CLABSI = central line-associated bloodstream infection; CUSP = Comprehensive Unit-based Safety Program; ICU = intensive care unit

Two major components of the AHRQ ICU Safety Program were the CUSP method and the two-tiered interventions to CLABSI and CAUTI prevention. The CUSP method and the tiers were addressed throughout the program curriculum and ICU teams were taught how to apply CUSP tenets in various aspects of the ICU Safety Program, for example, in the application of the two-tiered interventions.

The CUSP Method

The underlying patient safety methodology of the AHRQ ICU Safety Program is the evidence-based Comprehensive Unit-based Safety Program (CUSP) used in previous AHRQ HAI prevention initiatives (Berenholtz et al., 2014, Saint et al., 2016). The CUSP method integrates teamwork, communication, and patient safety culture with evidence-based practices to sustainably improve culture and patient safety. The main tenets of CUSP that guide practices to promote patient and staff safety are understanding the science of safety, identifying defects, engaging a senior executive, learning from defects, and implementing teamwork and communication. These tenets are explained in detail below:

- **Understanding the Science of Safety.** Staff must understand the science of safety to improve system performance. Errors happen, in part, because people are not perfect. Thinking about errors in terms of surrounding circumstances or in a systems context can help reduce those errors. Strategies such as standardizing care, creating independent checks, and learning from defects can help to improve systems that support the care provided. It is essential to implement these strategies with a mindset of a nonpunitive response to errors. Concepts like Just Culture and High Reliability Organizations are approaches that support a learning environment and invite diverse input from teams to support wise decisions and system improvements.[10]
- **Identifying Defects.** Safety is everyone's responsibility and cannot be achieved without consistently looking for how things might fail through identifying potential and actual defects. This process helps prevent future errors by evaluating errors that have already occurred, as well as potential errors or near misses that have not yet happened. Frontline staff should be encouraged to identify defects while being supported by a culture of a nonpunitive response to errors. The identification of defects and near misses should be viewed as learning opportunities and fundamental to a culture of safety. Invaluable to identifying defects are the diverse perspectives of the frontline staff, including their insights into processes that may contribute to defects.[11]
- **Engaging the Senior Executive.** Leadership commitment to safety is imperative. Senior executives must communicate safety principles and an organizational commitment to safety. Senior leaders play an essential role in building staff engagement and accountability, and

[10] Agency for Healthcare Research and Quality. Module on How to Apply CUSP for Mechanically Ventilated Patients. https://www.ahrq.gov/hai/tools/mvp/cusp.html. Accessed February 16, 2022.
[11] Agency for Healthcare Research and Quality. Module on How to Apply CUSP for Mechanically Ventilated Patients. https://www.ahrq.gov/hai/tools/mvp/cusp.html. Accessed February 16, 2022.

creating the infrastructure for safe care by providing necessary material, operational, and training resources to frontline and other staff. A culture of safety is established when the senior executive sets expectations and reinforces them through actions within the organization; therefore, a partnership with the senior leader can facilitate learning across the organization.

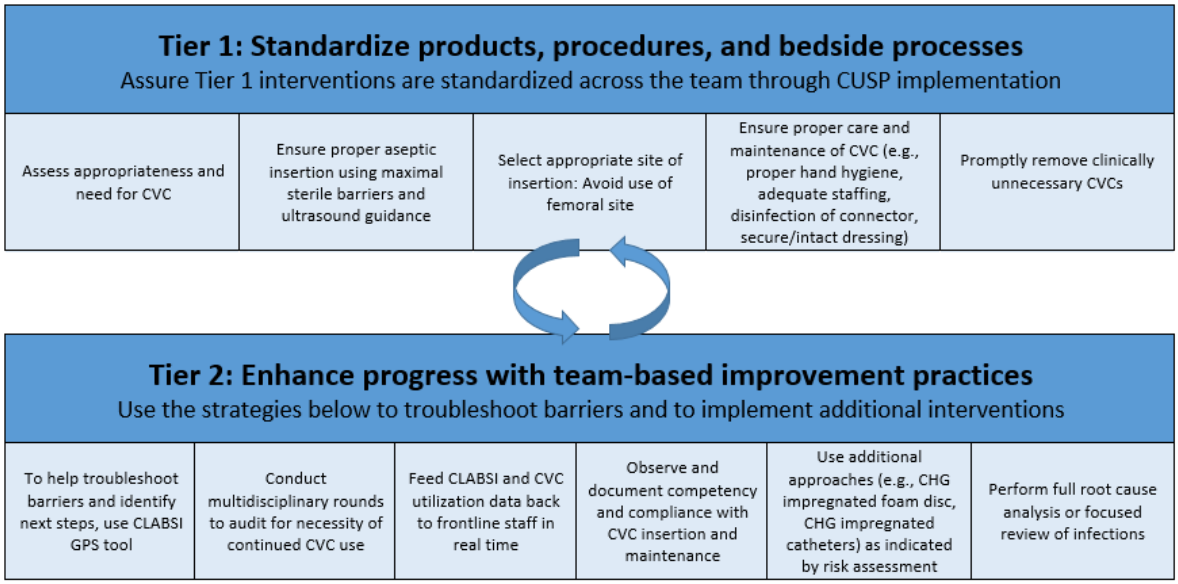
- **Learning From Defects.** All defects, including near misses or precursors, can be learning opportunities. CUSP tools like the Learning From Defects tool can help facilitate analysis of the event to identify root causes and strategies to mitigate the risk of the event occurring in the future. Lessons learned can be shared with the team and other teams within the organization in such ways as huddles or safety rounds, and at the unit and organizational level.
- **Implementing Teamwork and Communication.** Tools and processes that improve teamwork and communication are a critical component of the CUSP method, facilitating each of the other tenets of CUSP and patient care in general. Working together in teams can be a challenge; tools like TeamSTEPPS® and interdisciplinary rounds can support teams to improve their teamwork skills.

The strengths of the CUSP method are that it works with a wide range of QI approaches and tools, incorporates the main elements of TeamSTEPPS®, accepts that all culture is local and culture improvement must be done at the unit level, does not accept that harm is an acceptable "cost of doing business," and can be applied to many different healthcare settings.

Two-Tiered Approach to CLABSI and CAUTI Interventions

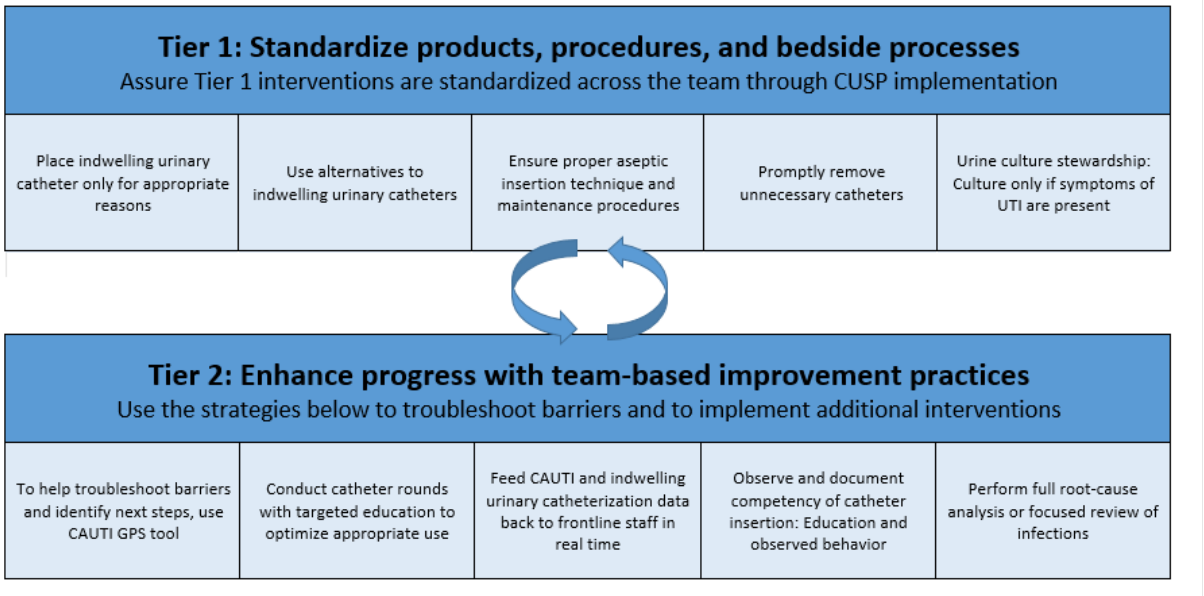
The program curriculum emphasized both the technical and socio-adaptive aspects of CLABSI and CAUTI prevention and included a tiered approach to interventions (Patel et al., 2019, Meddings et al., 2019). In the expansion phase of the program, the NPT changed how the tiered approaches were taught. ICU teams were coached to apply Tier 1, or more technical, interventions with every applicable patient and to use the team-based Tier 2, or more socio-adaptive, interventions to help ensure that Tier 1 activities were applied consistently. Figures B-3 and B-4 illustrate the two-tiered interventions for CLABSI and CAUTI. The figures include arrows to indicate that strategies may be applied with varying frequency to accommodate the specific needs of individual ICU cultures and concerns (Meddings et al., 2019). This approach is consistent with the CUSP model that acknowledges the importance of safety culture and combining socio-adaptive with technical interventions (AHRQ, 2012).

Figure B-3. CLABSI Tiered Approach[12]



CHG = chlorhexidine; CLABSI = central line-associated bloodstream infection; CVC = central venous catheter

Figure B-4. CAUTI Tiered Approach[13]



CAUTI = catheter-associated urinary tract infection; UTI = urinary tract infection

[12] This material was expanded, enhanced, and adapted for the AHRQ toolkit from materials developed for CLABSI prevention by faculty and staff at the Department of Veterans Affairs and the University of Michigan.
[13] This material was expanded, enhanced, and adapted for the AHRQ toolkit from materials developed for CAUTI prevention by faculty and staff at the Department of Veterans Affairs and the University of Michigan.

ICU Assessment

The ICU Assessment was a questionnaire completed at the start of program implementation by the unit CUSP team. Developed by the NPT, it consisted of questions about current infection prevention and safety culture practices and helped the unit uncover gaps that may have contributed to high device utilization rates and CLABSIs and CAUTIs. In addition to informing the unit's action plan, the results from this assessment helped State leads target their coaching and provided insights that informed the updating of educational programming, tools, and resources.

Unit Action Plan

Each unit from Cohorts 3 to 6 developed a Unit Action Plan following a template provided by AHA that specified unit aim(s) and planned intervention(s) to address gaps identified in the ICU Assessment. Each plan was required to address why the unit had chosen the gap(s) and had to have specific, measurable, and timebound desired aim(s), unit strengths that could be used, specific steps the unit would take to achieve the desired aim(s), and an indication whether the unit was going to focus on CLABSI, CAUTI, or both infections. Prior cohorts (Cohorts 1 and 2), on the other hand, were encouraged but not required to create action plans. Units from these two cohorts reported their intended focus either through their ICU Assessment or through their State leads

Data Submission

Units submitted their number of CLABSIs and CAUTIs, and their number of device days and patient days, all on a monthly basis. More information about data collection is included in the Data Collection and Measures portion of Section C, Evaluation Design and Methodology.

Coaching ICU Teams and State Leads

Individual and Group Coaching Calls

State leads coached their units through monthly calls that were either one-on-one or group conversations. They often alternated between individual and group calls each month to provide more opportunities for units to network and share unit successes and challenges. On individual calls, for example, State leads would ask unit leads to discuss action plan progress. Group calls were an opportunity for all units to review key concepts and prevention strategies, and for unit leads to share program challenges and successes. AHA performance improvement coaches (PICs) routinely attended

these calls, and NPT subject matter experts (SMEs) attended some calls to address a common challenge the ICUs in the State or region were experiencing.

Site Visits

Site visits allowed units to have protected time to openly discuss in person any unit challenges with their State lead and the NPT SME who might have been in attendance, who provided advice during the site visit on strategies to overcome these unique challenges. The site visit was also an opportunity for units to showcase their successes, which helped build and sustain motivation for the program interventions. In advance of the visit, the assigned AHA PIC held planning calls with the State lead, the unit lead, and the NPT SME to discuss site visit aims, expectations, and the meeting agenda. PICs discussed the CLABSI and CAUTI Guides to Patient Safety (GPS) (see discussion of tools below) as a resource and during the expansion contract period, all units completed the CLABSI/CAUTI GPS to inform site visit planning. NPT SMEs often took part in safety rounds, team huddles, patient safety committee meetings, and led discussions with participants. After site visits, State leads followed up with the units with supporting educational materials that were often shared by SMEs and submitted a report to the NPT summarizing their experience.

Optional In-Person Meeting

State leads were encouraged to host an optional, in-person meeting for their units at any time during the program implementation period. If held near the start of the implementation, the meeting focused on program components and expectations, and encouraged networking among participating ICUs across the State. If held near the end of the implementation, these meetings focused on successful strategies for overcoming challenges and sustainability of the program efforts. Meeting topics included engaging the team, applying CUSP, and promoting nursing and physician engagement, as well as CAUTI- and CLABSI-specific interventions. These meetings usually featured unit presentations and problem-solving workshop sessions. In addition, NPT SMEs sometimes attended and presented at these meetings.

State Lead Coaching Competency Self-Assessment Survey

Beginning in the expansion period with Cohort 3, State leads completed a self-assessment survey in which they rated their competency levels in three domains (performance improvement implementation and coaching, using data to drive improvement, and applying CUSP principles in ICUs) into six competency stages (no experience, novice, advanced beginner, competent, proficient, and expert [Brenner, 1984]). Completed prior to the start of program implementation, the questionnaire also asked

State leads to describe additional topics or skills about which they wanted to learn more. The top three areas identified were (1) planning and developing quality improvement initiatives, (2) using data to drive action planning and guide implementation and evaluation of performance improvement strategies throughout a program, and (3) mentoring/coaching of a group for performance improvement. This feedback informed topics covered on monthly State Lead Action Council (SLAC) calls and the coaching training State leads received by the external coaching consultant discussed below.

State Lead Coaching Training

All cohort 1 to 6 State leads received training on how to coach their ICUs during the program kickoff and closeout meetings at AHA headquarters. For cohorts 1 and 2, AHA staff with coaching expertise provided this training, which covered the basics of coaching, motivational interviewing, and practice sessions. Closeout meeting training focused on sustainability and additional skill-building practice sessions. An external coaching expert provided State leads for Cohorts 3, 4, and 5 with coaching training and the kickoff and closeout meetings. In addition, State leads from Cohorts 3, 4, and 5 had the opportunity to bring some of their more engaged unit leads to participate in the coaching training. Unfortunately, the COVID-19 pandemic prevented program closeout coaching training for Cohort 6 State leads and some of their unit leads.

In addition to these formal trainings, AHA PICs provided coaching support to state leads throughout the 12-month program. During Cohort 5, PICs and NPT SMEs provided more targeted coaching in a multilayered process throughout the program. Coaching began with monthly SLAC calls with a discussion and group coaching on the key concepts that the unit participants were exposed to through the virtual learning groups (VLGs). This content was expanded upon in one-on-one calls that occurred between PICs and State leads. State leads were then expected to review this material with unit leads in their one-on-one coaching calls.

Other State Lead Support

AHA provided the following support and training to state leads:

- ICU recruitment materials
- State lead kickoff meeting, which provided coaching training and served as CUSP boot camps
- PIC assigned to each state lead to support recruitment, implementation, and coaching
- Online data and report submission instructions
- Access to SMEs as needed to attend group coaching calls and to support individual units

- Data Exploration Tool to support coaching of unit leads on unit performance
- Program implementation and educational event calendar
- Monthly SLAC calls
- Monthly program newsletter
- Sample coaching call and statewide meeting agendas and case study and site visit report templates
- State lead closeout meeting, which provided additional coaching training and an opportunity for State leads to provide feedback to AHA about their program experience

Case Studies

State leads were required to submit case studies beginning in Cohort 3 that highlighted one or more of their participating ICUs. These case studies helped state leads in coaching ICUs in their States or regions and helped AHA staff identify future presenters on VLG webinars. Lastly, case studies kept the NPT and AHA staff apprised of effective strategies ICUs used to overcome challenges in preventing CLABSIs or CAUTIs.

Curriculum, Tools, and Resources

The educational curriculum emphasized both the technical and adaptive aspects of CLABSI and CAUTI prevention by utilizing the CUSP method and the tiered interventions woven throughout the curriculum. The curriculum began with onboarding webinars with SME presentations to orient ICU teams to program goals, components, and requirements. The onboarding was followed by webinars focused on specific topics and peer-to-peer learning and mentoring through unit team presentations and real-time ICU team interactions called Virtual Learning Group webinars. On-demand learning modules on CLABSI and CAUTI prevention and CUSP training videos and audio interviews were also part of the curriculum. Each educational component is described below, with Appendix 1 containing more specifics. All webinars were recorded and available on the program website to allow for viewing by participants unable to attend a live event. ICU participants and State leads had access to these recordings on the program website, as well as all tools and other program resources.

Onboarding Webinars

ICU unit leads and other CUSP team members were requested to participate in all onboarding webinars to learn the essential concepts needed to implement the program (CUSP methodology, forming a team,

the science of safety, using data to drive change, and developing an action plan). ICU teams were asked to view the recorded webinars if they were unable to attend the live events.

VLGs

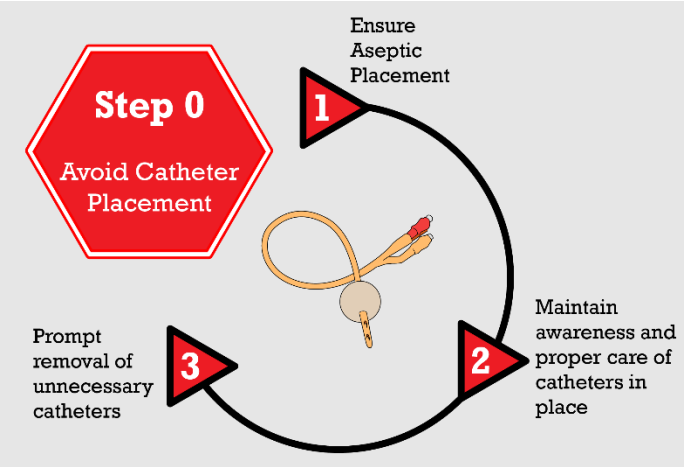
VLG webinars enabled ICU teams to participate in peer-to-peer learning and mentoring. These monthly, hourlong webinars were facilitated by AHA PICs. The discussions addressed core program concepts, highlighted best practices from participating ICUs, and encouraged peer interaction through live, online question-and-answer periods. ICU teams were asked to view the recorded webinars if they were unable to attend the live events.

VLG webinars addressed the topics: improving teamwork and communication using TeamSTEPPS®, engaging senior leaders, identifying and addressing defects, conducting multidisciplinary rounds, engaging physicians in CLABSI and CAUTI prevention, engaging patients and their families, and celebrating success and sustaining improvement gains.

On-Demand Learning Modules

The on-demand learning modules were 14- to 29-minute videos designed for ICUs to access as needed throughout the program period depending on their identified gaps and action plan. The modules were organized around "disrupting the life cycle" (Figure B-5) of the CVC and the IUC (Patel et al, 2018). Four CLABSI prevention modules addressed: indications for use, alternatives to CVCs, avoiding placement, and determining appropriateness; CVC insertion bundle; CVC maintenance; and CVC removal. Six CAUTI prevention modules addressed: avoiding placement and determining appropriateness of IUCs; alternatives to IUCs; IUC insertion bundle; IUC maintenance; prompting removal of unnecessary IUCs; and urine culturing stewardship in the ICU.

Figure B-5. Disrupting the Lifecycle of the Urinary Catheter [a]



[a]Patel PK, Gupta A, Vaughn VM, et al. Review of Strategies to Reduce Central Line-Associated Bloodstream Infection (CLABSI) and Catheter-Associated Urinary Tract Infection (CAUTI) in Adult ICUs. J Hosp Med. 2017 Nov 8 [online ahead of print]. Used with permission.

CUSP Training Videos and Audio Interviews With CUSP Experts

Developed at the end of the ICU original program phase, AHA produced six videos (4–6 minutes/each) to address common challenges in how to implement CUSP methods in ICUs to prevent CLABSI and CAUTI. These videos addressed—

- Having difficult conversations about preventing infections in the ICU
- Creating team buy-in to work toward zero preventable infections in ICUs
- Addressing attitudes and beliefs about preventing infections in ICUs
- Increasing ownership and engagement at multiple levels to prevent infections in ICUs
- Empowering nurses to implement a protocol for urinary catheter removal
- Speaking up during central line insertion to prevent infections

Developed in the same timeframe as the videos, AHA also recorded six complementary interviews with CUSP experts. Each interview matches the topic area of one of the CUSP training videos described above. The experts discuss, based on their own experience, how ICU teams can execute the training video concepts. Each interview runs 15–18 minutes.

CUSP Tools

The following CUSP tools were recommended in all six cohorts, except for the Team Checkup tool.

- The program adapted the Learning From Defects Tool into two separate, shorter tools to be used by the team for just in time review of an infection to support team identification and learning from defects—one for CLABSI and one for CAUTI.
- The Staff Safety Assessment Tool is designed to tap into frontline knowledge to find risks on the unit that can impact safety. All healthcare providers and administrative staff can use this tool. It can be completed at any time and should be completed at least twice a year.
- The Team Checkup Tool evaluates three primary domains: (1) adoption of CUSP activities, (2) implementation of CLABSI and CAUTI reduction steps, and (3) progress barriers. Cohorts 1 and 2 participating units were required to complete the tool monthly. However, due to the data collection burden expressed by unit teams, the questions were incorporated into the ICU Assessment that units completed at the program start. Additionally, State leads referred to these three domains when completing their State Lead Quarterly Report questions.

Other Tools and Resources

- Audio Interview Files: Three interviews were developed and disseminated during Cohorts 1 and 2 and addressed the roles and responsibilities of senior leadership in supporting this and other patient safety programs, along with strategies and tools senior leaders can use to support their ICU teams and communicate ICU safety efforts with patients, families, visitors, hospital committees, departments, and the hospital board.
- Making It Work (MIW) Tip Sheets: In keeping with ICUs' need for short, "how-to" reference aids, the NPT created one- to three-page MIW tip sheets designed to be portable and used at the bedside or at the nurses' station. In addition to suggested strategies, conversation starters and references to relevant program materials are included. The MIW tip sheets were developed during Cohorts 3 through 6 and cover these topics:
    - Assembling the CUSP Team
    - Engaging Physicians in Preventing CLABSI and CAUTI
    - Engaging Physician Champions in Preventing CLABSI and CAUTI
    - Celebrating Successes and Supporting Spread
    - Overcoming the "Just in Case" Mindset
    - Engaging Senior Leaders in Preventing Healthcare-associated Infections (HAIs)
    - Managing Urinary Retention and Catheterization in ICU Patients With Primary Neurologic Disorders

    - Chlorhexidine Bathing and Perineal Cleaning
    - Empowering Nurses To Implement Nurse-Driven Protocols for Reducing CAUTI in the ICU Setting
    - Engaging Staff Beyond the CUSP Team
    - Multidisciplinary Rounding for Patient Safety
    - Spot Coaching To Support Behavior Change
- Guide to Patient Safety (GPS) for CLABSI and GPS for CAUTI: These tools were developed by U of M researchers to help hospitals detect potential challenges and identify approaches to overcoming them. As part of their preparation before a site visit, ICUs completed one or both depending upon which or both HAI(s) the unit was addressing. Their completed form was shared with the State lead, SME, and AHA PIC who were attending the site visit.
- Data Exploration Tool: This online tool contained State- and unit-level infection and device utilization rate information in a single, online location. This facilitated coaching of State leads by AHA PICs and coaching of ICUs by State leads.
- CLABSI/CAUTI Quizzes and Answer Keys: Four quizzes for each of the CLABSI prevention on-demand modules and six quizzes for each of the CAUTI prevention on-demand modules were created to help team members assess their knowledge.
- Why I Care Poster Template: This template asked ICU team members to share why they care about patient safety. These comments can be displayed in the unit for other staff and visitors to see.
- Program Listserv: Unit leads and State leads were able to communicate as frequently as needed on the AHRQ ICU Safety Program listserv to ask questions and receive answers and resources from other ICU leads across the country and from AHA PICs and SMEs.

Program Implementation

State Lead and ICU Recruitment

AHRQ enlisted the aid of the CDC in identifying the four HHS regions with the highest proportion of hospitals with PEIR ICUs. This allowed the program to capture the attention of allied hospital associations that would support the reduction of CLABSIs and CAUTIs in their member hospitals with eligible ICUs. Cohort 1 had the highest volume of both registered ICUs and ICUs that remained in the program. Cohort 2 state lead recruitment focused on the remaining six HHS regions. Cohorts 3-5 then

targeted states that had not yet participated, and the last cohort, Cohort 6, was comprised of state leads who had participated in previous cohorts and who recruited units new to the program.

As noted under State Lead Training and Support, AHA PICs supported state leads in their recruitment of eligible ICUs. The CDC played a significant role in the recruitment of the first three cohorts because National Health Safety Network (NHSN) regulations prevented AHA and allied associations access to the names of specific hospitals and ICUs whose NHSN data demonstrated eligibility to participate in the program. For these cohorts, the CDC identified states and regions, which had at least 10 eligible ICUs and directly contacted hospital NHSN administrators initially through phone calls, then later through e-mails, to discuss the program opportunity and encourage participation. Using methodology like the CDC's, AHA analyzed Hospital Compare data to identify hospitals likely to have PEIR ICUs. AHA staff then used this information to contact prospective state leads to ask them to either access their own data if they had their own statewide NHSN database or to ask hospitals to analyze their own ICUs' data to determine eligibility for the defined pre- intervention period. AHA also provided information to allied hospital associations on how hospitals could use the CDC's Targeted Assessment Program (TAP) data report tool (CDC 2019) to run reports to determine whether their ICU(s) were eligible for the program.

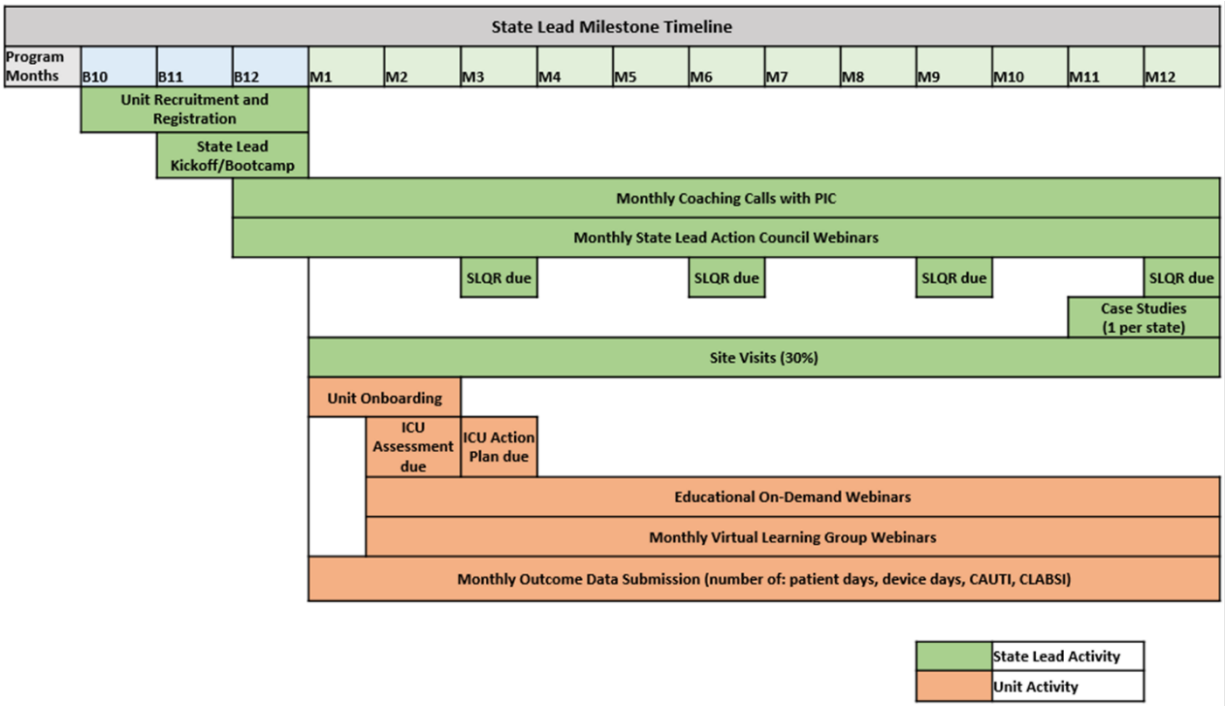
For cohorts 1 and 2, neither AHA nor State leads were able to verify units' PEIR status, resulting in the participation of some non-PEIR ICUs. This led AHA and State leads to add an extra verification step beginning in cohort 3 to ensure ICUs that joined truly qualified for the program. Cohort 3 state leads verified ICU eligibility to participate, either by using State-based data systems, or lacking such a mechanism, by asking hospitals to run TAP reports for the appropriate timeframe. Beginning with Cohort 4, allied associations could obtain a list of eligible ICUs from the CDC.

Cohort 4 coincided with NHSN regulation changes that allowed their sharing of information to AHA and the allied hospital associations, enabling a more streamlined recruitment process. Although they had low or zero infection rates for the pre-intervention period calculation, some ICUs wanted to participate in the program, particularly those in hospitals that had eligible ICUs. Beginning with cohort 3 and continuing through Cohorts 4, 5, and 6, ICUs were allowed to audit the program if there was at least one eligible ICU from the same hospital enrolled in the program. A total of 22 ICUs audited the program; however, they were not allowed to submit infection rate or device utilization data to prevent their impact on program evaluation.

Allied Association and ICU Implementation Timeline

The following figure shows the activities and deliverables of the 15 months of State-level participation, and 12 months of ICU-level participation.

Figure B-6. Allied Hospital Association and ICU Implementation Timeline[14]



Key: PIC = performance improvement coach; SLQR = State lead quarterly report

Note: Site visit requirements for allied association leads (State leads) were changed from 50 percent of units for cohorts 1 and 2 to 30 percent of units for cohorts 3–5, as indicated in this figure. Additional modifications to site visit requirements were made for the COVID pandemic that occurred during cohort 6 (see below).

Program Intervention and Implementation Modifications and Enhancements

As noted above, the program evolved over its 5 years of implementation in different ICUs across different States and regions. The NPT made these modifications and enhancements based on lessons about ICUs' program experience, successes, and barriers in implementing the program. This information was obtained through monthly State lead check-in calls, ICU site visits and case studies, ICU presentations on monthly VLGs, State lead quarterly reports, monthly coaching calls State leads held with ICUs in their State or region, unit lead and State lead exit interviews conducted by AHA staff and NPT members, and unit and State lead program reflections expressed at cohort closeout meetings.

[14] Allied hospital association is an umbrella term that refers to State hospital associations as well as associations for the District of Columbia and Puerto Rico. "State lead" refers to the lead staff responsible for coordinating the program in the District of Columbia, Puerto Rico, and the States that participated in the program.

Analyses regarding program participation in different educational and training offerings, as well as compliance with program documentation requirements, also informed program changes. Lessons from cohorts 1 and 2 resulted in the largest number of program changes implemented during cohorts 3 and carried through successive cohorts.

Although lessons learned throughout all the cohorts is the subject of Section F of this report, it is worth noting the experiences of the original contract period cohorts, Cohorts 1 and 2, to help explain most of the modifications and enhancements made for Cohorts 3 and carried through Cohort 6 (with additional modifications made to accommodate the COVID-19 pandemic for Cohort 6 ICU participants).

Summary of Lessons From Cohorts 1 and 2

The experience of ICUs that participated in the original contract informed program modifications and enhancements described below.

- Six common challenges were identified:
    - Holding difficult conversations with colleagues about infection prevention practices
    - Creating team buy-in and motivation to get to zero infections
    - Addressing attitudes and beliefs about infection prevention strategies and techniques
    - Increasing ownership and engagement at multiple levels to prevent HAIs in ICUs
    - Empowering nurses to effectively implement a nurse-driven protocol for removing urinary catheters
    - Empowering staff to speak up to stop a central line insertion if they see a breach in aseptic technique

As noted above, these challenges informed the CUSP training videos and audio interviews described above.

- ICU teams indicated they knew what to do but needed support in how to apply CUSP and technical and adaptive EBP. This need was reinforced by ICU feedback that the VLGs were the most beneficial aspect of the program for gaining access to SMEs to learn the latest information and/or validate current ICU practices, as well as for learning new strategies, tactics, tools, and products from other ICUs across the country. (This observation remained consistent throughout all cohorts.)
- Time constraints and competing priorities and initiatives were named as a key factor in—

- low viewership of all educational programming by ICU teams; additionally, ICUs wanted to select what they viewed and found some of the education repetitive
- low viewership by senior leaders of three podcasts focused on the roles and responsibilities of senior leadership in helping to ensure their participating ICUs' success in preventing HAIs (e.g., why their support is important, how to monitor HAIs, and how to support ICU CUSP teams)
- low ICU compliance with completion of the post-implementation ICU Assessment and the monthly Team Checkup Tool

- Site visit participation by one or more SMEs was viewed as an added value to ICU site visits during the original contract period, and SME attendance was strongly promoted in later cohorts.

Modifications and Enhancements to Educational Content, Tools, and Other Resources

Beginning with Cohort 3, the following program modifications were made in addition to ICU action plans and case studies:

- ICU Assessment Crosswalk: Links to AHRQ ICU Safety Program and external resources were added to each assessment question to support CUSP teams when they identified practice gaps after completing the ICU Assessment.
- CUSP videos and audio files of interviews with CUSP experts disseminated beginning with cohort 3.
- "A Playbook for Preventing CLABSI and CAUTI in the ICU Setting" was created based on lessons learned from Cohorts 1 through 5. It was disseminated to ICU and State leads beginning with Cohort 6 for their use and feedback to inform the program's legacy toolkit, which resides on the AHRQ website, "AHRQ Toolkit for Preventing CLABSI and CAUTI in ICUs," described in more detail below.
- Onboarding webinars were changed from a mix of prerecorded and live webinars to all live webinars for Cohorts 3 and 4, and the two-tiered approaches were more explicitly tied to CUSP concepts for Cohorts 5 and 6.
- Making It Work tip sheets were developed during Cohorts 3–6.

Modifications and Enhancements to Program Implementation

- ICU enrollment eligibility screening changes

- Hospital CEO commitment letter: Beginning with Cohort 3, hospital CEOs were required to sign a commitment letter specifying their support for the participation of their eligible ICU(s) and agreement to the program requirements and time commitment.
- ICU action plans: After the original contract period, all ICUs were required to develop ICU action plans to address one to three gaps identified from their ICU Assessment. The action plans were submitted into the program web portal.
- Removal of post-implementation ICU Assessment: The NPT learned that competing priorities and time constraints experienced by ICU teams prevented them from completing the post-implementation ICU assessment. Beginning with Cohort 3, ICUs were required only to complete the baseline ICU Assessment.
- Incorporation of Team Checkup Tool questions into ICU Assessment and State Lead Quarterly Reports: ICUs found they were providing the same information each month on the monthly Team Checkup Tool questions. Beginning with Cohort 3, these questions were incorporated into the baseline ICU Assessment and state lead quarterly report.
- State lead coaching trainings (twice during the cohort) were provided by AHA staff during the original contract period. Beginning with Cohort 3, the two training sessions were provided by an external coaching expert to promote more standardized coaching methods used by state leads. Other coaching modifications are noted above.
- State and regional meetings were required for Cohorts 1 and 2 but were made optional for all later cohorts. Nevertheless, many States and regions continued to hold at least one in-person meeting for their participating ICUs.
- Change from State-based clinical mentors to NPT SMEs supporting State leads in coaching ICU teams: Clinical mentors (mostly nurses and some physicians) were funded during Cohorts 1 and 2. When the funding concluded, the NPT SMEs stepped into this role, which was well received by unit and state leads.
- Site visit requirements: Cohort 1 and 2 State leads were required to conduct site visits in 50 percent of their participating ICUs. This requirement was lowered to 30 percent for State leads in subsequent cohorts.
- Site visit enhancements: The GPS tool began to be used after the original contract period to enhance site visit planning between the ICU, its State lead and the AHA PIC. NPT SMEs also began to attend some site visits beginning in Cohort 3.

- Case studies: Case studies were not required during the original contract period. State leads participating in Cohort 3 were required to submit two cases per State or region. This requirement was reduced to one case study per State/region for Cohorts 4 and 5.

Program Implementation Modifications Due to COVID-19

In addition to the 4-month program pause mentioned above, the COVID-19 pandemic required several program adjustments for the last cohort of the project, Cohort 6.

- Data submission during the pause: Units did not have to submit infection rate or device utilization data during the 4-month program pause. Fortunately, all 49 Cohort 6 units did supply these data either during the pause or soon thereafter.
- VLG webinars: In keeping with past practice, unit presentations were planned for September 2020 through April 2021 VLGs. However, these presentations did not occur after November 2020 because of competing COVID-19 patient priorities. AHA created written VLG summaries with time stamps linked to content topics within the VLG to allow users to view the most relevant section(s) of the VLG recordings because of time constraints.
- Site visits: Because Cohort 6 was implemented during the COVID-19 pandemic, a virtual site protocol was implemented, and the State lead of each participating state or region was required to conduct one virtual site visit.
- Case studies: Each Cohort 6 State lead was required to submit one case study developed by one of their participating units. However, in the States in which no unit had the capacity to generate one, AHA allowed the site visit report to fulfill the case study requirement.
- State/regional closeout meetings: As with site visits, those States opting to hold a closeout meeting of their units did so virtually. These meetings included presentations from their participating ICUs that addressed challenges and lessons learned.

The AHRQ Toolkit for Preventing CLABSI and CAUTI in ICUs

An online toolkit was developed to offer ICUs targeted help in reducing CLABSI and CAUTI outside the program structure. Built by clinicians for clinicians, it is designed to support ICUs in reducing CLABSI and CAUTI. The toolkit is based on various AHRQ ICU Safety curriculum resources and was informed by the frontline staff experience of the more than 800 ICUs that participated in the program. It resides on the AHRQ website at https://www.ahrq.gov/hai/tools/clabsi-cauti-icu/index.html.

The toolkit is customizable to meet local needs and demands, offers a comprehensive approach to improve team culture and change staff behavior, and uses EBP informed by the latest research.

A unique feature is the ease with which users can access materials based on their needs. These access points were defined by observations on how ICUs engaged and used the program resources. The toolkit has three main access points for various tools:

- **Assess** the unit's current situation. Users starting the journey to look at their ICU's current clinical and safety practices related to CLABSI and CAUTI prevention can assess what is working, what is not, and pinpoint opportunities for improvement. Based on this information, units can create a reduction plan.
- **Implement** an improvement plan. The toolkit advises users to "walk through" the entire toolkit, if needed to create a comprehensive reduction plan.
- **Overcome** common barriers. Users who encounter challenges after implementing a reduction plan can get specialized assistance from the toolkit resources in this section of the toolkit.

The toolkit should be important to the critical care community because of its evidence-based adaptive as well as technical interventions—the two-tiered CLABSI and CAUTI approaches—and its incorporation and clear explanations of the CUSP method. The three access points allow clinicians to access specific resources with ease depending on the phase of work they are in with their unit regarding infection reduction.

C. Evaluation Design and Methodology

Evaluation Questions

To evaluate the performance of the Agency for Healthcare Research and Quality Intensive Care Unit (AHRQ ICU) Safety Program, the American Hospital Association (AHA) addressed the following primary, secondary, and exploratory questions on participating ICUs:

1. *Primary Question*:
    - *What are the effects of the AHRQ ICU Safety Program on National Healthcare Safety Network (NHSN) central line-associated bloodstream infection (CLABSI) and catheter-associated urinary tract infection (CAUTI) rates, population CLABSI and CAUTI rates, and indwelling urinary catheter and central line utilization ratios?*
2. *Secondary Questions*:

- *Do effects on NHSN infection rates and/or device utilization ratios vary?*
    a. *By cohort?*
    b. *By degree of program participation?*
    c. *By level of adoption of Comprehensive Unit-based Safety Program (CUSP) elements?*
    d. *By cumulative attributable difference (CAD) (positive or negative)?*
    e. *By site visit status (with or without a site visit)?*

3. *Exploratory Questions*:
    - *Which hospital/ICU characteristics are associated with NHSN infection rates and/or device utilization ratios?*
    - *What percentage of participating ICUs maintained or attained zero aggregate NHSN CLABSI or CAUTI rates from the pre-intervention period to the intervention period?*

The study design, data collection measures, samples, and the analytic strategy used to address these questions are discussed below.

Evaluation Design

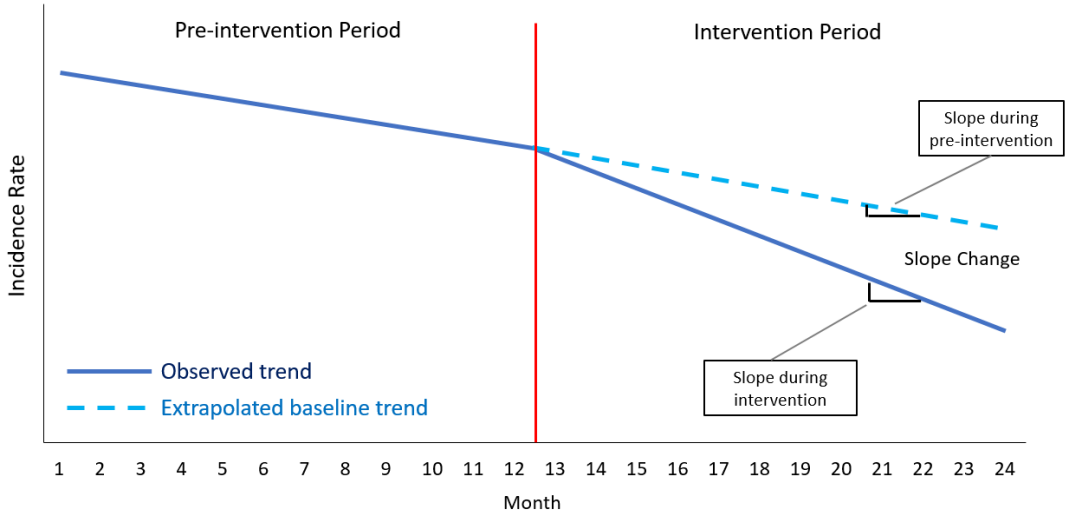
AHA employed a rigorous quasi-experimental approach called interrupted time series (ITS) to estimate the effects of the AHRQ ICU Safety Program on the pooled sample of participating units within cohorts 1 to 6 (Bernal et al., 2017). With this design, a sufficiently long series of observations accrued before and during the intervention in each participating ICU permits the use of a unit as its own control, minimizing the confounding effects of both observed and unobserved unit characteristics (under the assumption that those characteristics are stable over time), thus offering a strong basis for causal inference. It assumes that, absent the intervention, the trend in outcomes over time during the pre-intervention period will continue during the intervention period. Therefore, any deviations in the pattern of outcomes from this pre-intervention period trend during the intervention period represent the effect of the intervention. In a typical ITS analysis, these deviations are measured through: (1) a shift in outcome level immediately after the start of intervention, and (2) a change in slope from the pre-intervention period to the intervention period. Because the first month of the AHRQ ICU Safety Program implementation focused only on onboarding units to the program, no immediate reductions in infection rate or device utilization were expected, and indeed, none were found in either the ICU original program period (analysis of Cohorts 1 and 2), or the expansion base period program period (analysis of Cohorts 3

and 4). For these reasons, the current analyses assessed only changes in slopes. Specifically, for the primary question, the following parameters of interest were examined (see Figure C-1):

1. Reduction in rates over time (slope) in the pre-intervention period
2. Reduction in rates over time (slope) in the intervention period
3. Differences in rates of change (slope change) between pre-intervention and intervention periods

Secondary questions on program effects examined how the above parameters varied across subgroups of participating ICUs. Exploratory questions assessed which ICU or hospital characteristics were associated with the outcomes.

Figure C-1. Illustration of the Parameters of Interest in the Interrupted Time Series Analysis for the Primary Question



Data Collection and Measures

Participating units from all cohorts were expected to collect and submit clinical outcome data (number of CLABSIs and CAUTIs) and clinical process data (number of device days and patient days), and to complete an ICU Assessment. For all cohorts, AHA tracked each unit's participation in the program's training components. Table B-1 in Appendix 2 details the data collection measures, schedule, and a brief description of the measures follows.

Clinical Outcome and Clinical Process Measures

The primary clinical outcome measures for this program were monthly NHSN CLABSI and CAUTI rates, and population CLABSI and CAUTI rates,[15] and the process measures were central line utilization ratio and urinary catheter utilization ratio. Appendix 2, Section B provides details about how these data were collected and how they were used to calculate the above measures.

Implementation Measures

To examine program implementation, AHA tracked each ICU's participation in the intervention components and its adoption of specific CUSP elements. Unless otherwise noted, each type of participation data was tracked on units from all cohorts.

Program Participation

AHA measured program participation based on the following data[16]:

- Submission of the ICU Assessment (Cohorts 1 and 2 only[17])
- Submission of the Team Checkup Tool (Cohorts 1 and 2 only[18])
- Attendance in onboarding webinars (both live and recordings)
- Attendance in virtual learning groups (VLGs) (both live and recordings)
- Download of CLABSI and/or CAUTI prevention on-demand education modules

[15] As many quality improvement interventions (including the AHRQ ICU Safety Program) also target reduction in device utilization, population CLABSI and CAUTI rates were also measured as they are standardized by the number of patient days rather than by the number of device utilization days. The former is more stable over time than the latter and, hence, allows the population rates to reflect reductions in CLABSI and CAUTI episodes due to reductions in utilization (Fakih et al., 2012). The downside of the population rates, however, is that they tend to underestimate the CLABSI and CAUTI rates because their denominators (the number of patient days) pertains to all patients including those who did not get the device and so were not at risk of developing these infections.

[16] Because State leads were required to conduct site visits on only a prespecified percent (50 percent for cohorts 1 to 2, 30 percent for cohorts 3 to 5, and one site visit per State for cohort 6) of their units, not all units were offered the opportunity to have a visit. Moreover, the criteria used to select units for a site visit varied across cohorts (e.g., some State leads targeted units that might not be doing so well in terms of their outcomes while some targeted units that might have effective practices to share), and the presence of subject matter experts (SMEs) in site visits differed across cohorts (SMEs did not participate in site visits for cohorts 1 and 2, but, when warranted, attended some site visits in cohorts 3 to 6). For these reasons, site visit was not included in the participation criteria for any of the cohorts.

[17] Submission of the ICU Assessment was not included in the participation criteria for cohorts 3 to 6 because all units in these cohorts fulfilled this requirement. Similarly, submission of the ICU Action Plans (which was collected only in cohorts 3 to 6) were not included in the participation criteria for cohorts 3 to 6 because all units in these cohorts fulfilled this requirement.

[18] The Team Checkup Tool was collected from units in only cohorts 1 and 2.

For educational offerings (onboarding webinars, VLGs, and on-demand modules), an ICU was given credit for participating if they clicked on a link to that offering via Adobe, Comprehensive Data System (CDS),[19] or SurveyMonkey.[20]

To measure the degree of participation, AHA (in consultation with the NPT and AHRQ) created a composite measure that was used to categorize ICUs as having a low, moderate, or substantial level of participation based on the units' participation in the above program components. Because program components were substantially different between Cohorts 1 and 2, and Cohorts 3 to 6, the criteria for level of participation were defined differently for these two sets of cohorts. Details on the criteria used are provided in Appendix 2, Section B.

Adoption of CUSP Elements (Cohorts 3 to 6 Only)

Information about the degree to which ICUs from Cohorts 3 to 6 integrated the CUSP methodology was obtained from the State Lead Quarterly Reports (SLQRs) completed by State leads based on their monthly check-in calls with unit leads. A composite measure of each participating ICU's adoption of CUSP elements was calculated based on State leads' responses to the 11 "yes/no" questions from the SLQR (Table B-4 in Appendix 2). To better understand the adoption of various aspects of CUSP, the 11 questions were further categorized into five subdomains: Goals, Testing, Leader Support, Champion, and Data. A composite score was created for each subdomain using the same procedure as the overall CUSP composite score. Details on calculating the overall and subdomain composite measures are given in Appendix 2, Section B. For the purposes of the evaluation, these composite measures were used as a proxy measure for CUSP adoption.

Additional Data Sources

AHA and the NPT gathered additional qualitative data through exit interviews with four State leads, one nurse mentor and four unit leads in Cohorts 1 and 2, eight State leads and six unit leads in Cohorts 3 and 4, two State leads and three unit leads in Cohort 5, and seven unit leads (but no State leads) in Cohort 6.

[19] CDS was used to house all educational webinars and materials, collect and display unit-level outcomes data, collect ICU Assessments and Action Plans (along with Site Visit Reports and State Lead Quarterly Reports for cohort 6), and track unit participation.
[20] Participation data was tracked via Adobe for cohorts 1 and 2. For cohorts 3 to 6, participation data was tracked mainly through CDS, but in a few cases via SurveyMonkey, when there were issues accessing CDS in the beginning of the program.

Additional qualitative data for Cohorts 3 to 6 were obtained through ICU Action Plans, SLQRs, site visit reports, case studies, and State lead closeout and all-unit meeting discussions.

Analytic Samples

Table C-1 summarizes overall recruitment and retention rates. Of the 832 units that registered to participate from Cohorts 1 to 6, a total of 122 (14.7 percent) withdrew before the end of the implementation period for each cohort, resulting in a retention rate of 85.3 percent (n=709) when including the 18 units that audited the program.[21] Cohort-specific retention rates (Appendix 2, Table C-2) and the reasons for unit withdrawal from the program are discussed in Appendix 2.

Table C-1. Overall Recruitment and Retention

Cohort	Registered Hospitals	Registered Units	Withdrawn Units	Active Units[1]	Retention Rate[2]	Auditing Units	Participating Units	Evaluation Units[3]
Cohorts 1 to 6	540	832	122	709	85.3%	18	691	667

[1]Active units = auditing units + participating units
[2]Retention rate = active units/registered units
[3]Evaluation units include participating units that had outcome data in at least 3 months of the pre-intervention period and at least 3 months of the intervention period.

When evaluating the impact of the program, AHA limited the sample to units that completed the program and had at least 3 months of outcome data in both the pre-intervention period and the intervention period. These units, referred to in this report as "evaluation units," comprise the analytic samples.[22] Because of differences in outcome submission rates across units, the above sample inclusion criteria resulted in an overall analytic sample of 667 units, and analytic samples that differed slightly across outcome. There were 658 units for the NHSN CLABSI rate, 658 units for the population CLABSI rates, 659 units for the central line utilization, 664 units for the NHSN CAUTI rate, 663 units for the population CAUTI rate, and 663 units for the urinary catheter utilization. Figure C-1 in Appendix 2 summarizes the creation of the unit-level analytic samples for each of the six outcomes, and the breakdown of each sample by cohort.

Demographic Measures

As part of the registration process, ICUs submitted unit-level information including number of beds and ICU type. AHA also used the AHA Annual Survey to obtain data on hospital characteristics including

[21] Five units from cohort 5 were marked as audit for not completing a program element, the ICU Action Plans.
[22] At least 3 months of data were required from both the pre-intervention and intervention periods to be able to disentangle intervention effects from secular time trends in each unit.

number of beds, ownership type, and teaching status.[23] These elements were essential to understanding the characteristics of program participants in order to target coaching activities and develop and refine educational materials to address participants' needs. Some of these characteristics were also used as control variables in the statistical models to minimize confounders when estimating program effects.

Sample Characteristics

Tables C-3 and C-4 in Appendix 2 show the characteristics, respectively, of the 667 participating ICUs that were included in the evaluation and the corresponding 435 hospitals in which they were located. Overall, unit bed size ranged from 4 to 62 beds with a median of 15 beds (mean=16.3, SD=7.6). Cohort 1 and Cohort 6 had an average bed size slightly higher than the overall average (17.6 and 18.8 respectively), and Cohort 2 had the smallest average bed size (14.0). When ICU bed sizes were categorized into small (1–5 beds), medium (6–15 beds), large (16–30 beds), and very large (>30 beds), the majority of units fell into either medium (49.4 percent) or large (43.7 percent), with a small proportion classified as small (1.1 percent) and very large (5.9 percent). When ICUs were classified into four broad categories based on their specialty or subspecialty (NHSN location type), medical/surgical units were the most prevalent (74.8 percent), followed by cardio/cardiothoracic units (15.0 percent), neurological/neurosurgery units (5.9 percent), and burn/trauma units (4.4 percent). The distribution of specialty types generally followed a similar pattern at the cohort level, with the exception of Cohorts 1 and 2 which had slightly higher proportions of burn/trauma units (6.1 percent and 4.1 percent, respectively) than neurological/neurosurgery units (3.4 percent and 3.8 percent).

At the facility level, hospitals were predominantly teaching (72.0 percent), urban (88.3 percent), and nongovernment/nonprofit (69.2 percent). This trend was also similar at the cohort level. Across all cohorts, the mean (median) hospital bed size was 365.4 (283.0), with hospitals ranging in size from 30 to 2,875 beds (SD = 325.2).

Analytic Methods

The analysis for each of the six outcomes (NHSN CLABSI and CAUTI rates, population CLABSI and CAUTI rates, and urinary catheter and central line utilization ratios) is based on data pooled across cohorts, and includes a descriptive analysis followed by statistical modeling. The descriptive analysis included run

[23] Hospital characteristics come from the 2016 AHA Annual Survey for cohorts 1 and 2, from the 2018 AHA Annual Survey for cohorts 3 to 5, and the 2019 AHA Annual Survey for cohort 6. In the case of one cohort 3 hospital and one cohort 5 hospital where AHA data was not available, the 2018 NHSN Survey was used. Data on unit bed size and ICU location type was provided by participants upon registration.

charts that display monthly aggregate rates, which were calculated as the total number of infections (or total number of device days) across all ICUs divided by the total number of device days (or total number of patient days) across all ICUs, in a given month. In addition to the monthly aggregate rates, the aggregate rate during the pre-intervention period and the aggregate rate during the intervention period were also calculated. All these rates are provided in Tables A1 to A6 in Appendix 5 for reference.[24]

ITS regression models were used to estimate the effect of the program on each outcome. In these models, the dependent variable was ICU-specific monthly infection rate or ratio,[25] calculated as the total number of infections (or total number of device days) for a specific ICU divided by the total number of device days (or total number of patient days) for that ICU, in a given month. The primary question of overall program impact was addressed using two sets of models. An unadjusted model did not take into account hospital or unit characteristics, and an adjusted model controlled for the potential confounding effects of these characteristics: ICU type, cohorts, hospital ownership, infection focus, number of hospital and ICU beds, teaching status, and urbanicity. Running both models allowed us to assess whether program effect findings were sensitive to controlling for characteristics. As shown in the modeling results section below, controlling for hospital and ICU characteristics did not affect the evaluation's general conclusions in any major way.[26] Given this pattern, and for simplicity of interpretation, the secondary questions on heterogeneity of program effects across subgroups of participating ICUs employed only unadjusted models.

All statistical modeling used two-level, repeated measurements (level 1) nested within each ICU (level 2), negative binomial models[27] with a random intercept that allowed for heterogeneity of mean rates or ratios across ICUs.[28] These models also accounted for potential correlations among repeated

[24] Note that this simple "before" and "after" comparison of aggregate rates can result in misleading conclusions about the treatment effect because it does not take into account the trends over time during the two periods (rather, it simply combines all numerators and all denominators across all ICUs and months within each period) and the correlations among repeated observations over time within the same unit. ITS analysis, on the other hand, takes both of these into account.

[25] Strictly speaking, the dependent variable was the (natural) log of the ICU-level monthly infection rate or ratio.

[26] The direction, magnitude, and statistical significance of findings were generally very similar.

[27] Two-level Poisson regression models were also explored for the primary analysis of the four outcomes (CLABSI and CAUTI rates, and urinary catheter and central line utilization), but in all cases, model fit statistics (i.e., Akaike Information Criterion favored the negative binomial regression models.

[28] These random deviations of ICU-specific rates or ratios from the overall mean rate or ratio across all ICUs are assumed to have a mean of zero.

measurements within each ICU.[29] In all cases, a linear relationship was assumed between each outcome and time.[30]

All analyses were limited to participating ICUs that completed the program,[31] had at least 3 months of outcome data in the pre-intervention period and at least 3 months of outcome data during the intervention period. In the adjusted analysis, units with missing hospital and/or ICU characteristics were excluded. The analyses used data extracted on June 30, 2021, 2 months after the end of the intervention period for Cohort 6.

The statistical significance of estimated program effects and associations were assessed using two-tailed hypothesis tests and a significance level of 0.05. All statistical modeling was conducted in Stata 15 using the mixed effects negative binomial module called *menbreg*. More details about the analytic approach and model specifications follow.

Primary Analysis: Overall Effects

The following modelling strategy was used for each outcome:

First, AHA ran an unadjusted regression model that estimated the change in outcome over time (trend or slope) during the pre-intervention period as well as during the intervention period, and the difference between the two (i.e., difference in slopes). This approach included a main effect for continuous time (month[32]), plus an interaction term between time and the intervention-period indicator (where the latter that was set equal to 1 during intervention and 0 during pre-intervention).[33] In this model, the main effect of continuous time is interpreted as the trend (or slope) during the pre-intervention period, and the interaction effect is interpreted as the change in trend from the pre-intervention period to the intervention period. The intervention slope is then calculated as the pre-intervention trend plus the interaction effect (i.e., the pre-intervention slope plus the change in slope from pre-intervention to

[29] Ignoring these correlations can lead to underestimation of the standard errors of estimated program effects, which in turn, increases the likelihood of finding a significant effect when, in fact, there is none. An unstructured covariance matrix was assumed in the statistical modeling.
[30] More complicated functional specifications, such as quadratic or cubic functions of time, were not considered.
[31] Because analysis was limited to units that completed the program, findings on program effects represent "treatment on treated" as opposed to "intent-to-treat" estimates.
[32] Although time is in measured in discrete units of months, it is (as commonly done in interrupted time series analysis) treated as having an underlying continuous distribution.
[33] Specifically, the unadjusted models took the following form: $ln(rate) = \beta_0 + \beta_1 Time + \beta_2 P \times Time$, where $ln(rate)$ is the natural log of either the infection rate or device utilization ratio, $Time$ is measured in months, taking the values -12 to -1 for months 1 to 12 of the pre- intervention period, and 0 to 11 for months 1 to 12 of the intervention period, and P is the intervention period indicator which equals 1 during intervention and 0 during the pre-intervention period.

intervention period). Note that in a typical ITS analysis, the statistical models also allow for the possibility of immediate level shifts. Because immediate reductions in rates or device utilization were not expected at the start of the intervention (and indeed none emerged in prior analyses on cohorts 1 and 2, and on cohorts 1 to 5), the current analyses employed models that excluded immediate level shifts.

To estimate regression-adjusted program effects, AHA also supplemented the unadjusted model with multivariable regression models that adjusted for select hospital and ICU characteristics (listed in Section E under Exploratory Aims). These characteristics were included simultaneously in the multivariable models and were retained in the model regardless of statistical significance.

Secondary Analysis: Differential Effects by Cohort, Level of Participation, Degree of CUSP Adoption, CAD Values, and Site Visit Status

The models in the primary analysis provide overall estimates of the program's effects on each outcome. To test whether overall effects might mask variations in effects across subgroups, AHA examined effects on subsamples defined by cohort groups (Cohorts 1 and 2, Cohorts 3, 4, and 5, and Cohort 6), levels of participation (low, moderate, or substantial), degree of adoption of the CUSP principles (low, moderate, or substantial), pre-intervention CAD values (positive or negative),[34] and site visit status (with or without an in-person or virtual site visit).

Examining heterogeneity of program effects across cohorts is important not only because of external factors (e.g., the COVID-19 pandemic) that may have influenced each cohort separately, but also because of the changes/refinements in the program across cohorts (see Appendix 1 for a description of the program modifications across cohorts). Given that the program components were more similar for cohorts 1 and 2, and for cohorts 3, 4, and 5, and given that cohort 6 was implemented under very different conditions because of the COVID-19 pandemic, AHA conducted a more parsimonious set of cohort comparisons by grouping cohorts into the three groups specified above.[35]

[34] Subgroup analysis entails conducting multiple hypothesis tests, increasing the chances for spurious findings (i.e., finding statistically significant difference simply by chance when in fact there is none). There were no adjustments made for multiple comparison for two reasons: (1) the subgroup analyses are exploratory rather than confirmatory, and (2) we wanted to maximize statistical power – that is, the chances of finding an effect if indeed there is one.

[35] Assessing differential effects across individual cohorts (cohorts 1 to 6) would have resulted in 15 = (6x5/2) pairwise comparisons among the six cohorts.

Criteria for classifying participating units into participation levels differed between Cohorts 1 and 2, and to cohorts 3 to 6 (as described in Section C). This means that observed variations in program effects across participation levels may be confounded with the method used to define the participation levels. Also, because CUSP adoption was not measured for Cohorts 1 and 2, subgroup analysis by CUSP adoption levels were conducted only for Cohorts 3 to 6.

Further, although AHA and the Centers for Disease Control and Prevention sought to enroll only ICUs that had a positive CAD during the identification period, some units attained a negative CAD prior to the start of their intervention. Hence, to assess if effects were moderated by whether a unit had a positive CAD during the pre-intervention period, AHA used the most recent four quarters of data prior to intervention (as opposed to during the identification period) to calculate the CAD of participating units and classify them into having a positive or negative CAD. Appendix 2 (CAD Values for ICUs) provides more detail about how the CAD was calculated,[36] as well as the distribution of units by CAD values, and classifies units into having positive or negative CAD.

Lastly, to assess the benefits of ICUs receiving a visit from a State lead and, in some cases, together with an SME, we classified units into those that received a site visit during the intervention period and those that did not. As noted in Section B, however, the percentage of units that State leads were required to visit as well as the criteria used to select units for a visit varied across cohorts. Hence, the effect of site visits are likely confounded with cohort effects. (Section D and Appendix 3, Table A-2 provide details about site visit participation.)

For these subgroup analyses, AHA used the same analytic samples as in the primary analysis but augmented the unadjusted models with subgroup indicators and interaction effects.[37]

Exploratory Analysis

AHA employed the following strategy for exploratory questions:

[36] Briefly, CAD was calculated by subtracting a numerical prevention target from an observed number of HAIs during the most recent four quarters of data prior to the start of the intervention. The prevention target is the product of the predicted number of HAIs and a standardized infection ratio goal (SIR). The SIR goal used in the CAD calculations were 0.75 for CAUTI and 0.50 for CLABSI.

[37] Specifically, AHA incorporated two-way interactions between subgroup indicators and the intervention-period indicator, two-way interactions between subgroup indicators and time (in months), and three-way interactions between subgroup indicators, intervention-period indicator, and time.

- **Models assessing how hospital/ICU characteristics are associated with NHSN infection rates and device utilization**. The relationships between hospital/ICU characteristics and each of the outcomes were estimated using the same multivariable models from the primary adjusted analysis. As noted above, these models simultaneously incorporated all hospital/ICU characteristics as main effects. This means that the coefficient of each predictor in the estimated model can be interpreted as the effect of the characteristic on the outcome controlling for all other characteristics included in the model (that is, the effect of the characteristic over and above the effects of all other characteristics included in the models).
- **Analysis assessing the extent to which units attained or maintained zero infection rates or device utilization ratios**. Among ICUs that had greater than zero aggregate rates during the pre-intervention period, AHA calculated the percentage of units that managed to achieve zero aggregate NHSN rates during the intervention period. Similarly, the percentage of units that maintained zero aggregate rates in both the pre-intervention and intervention periods was also calculated.

D. Program Implementation Results

This section examines the extent to which units included in the evaluation participated in the core components of the Agency for Healthcare Research and Quality Intensive Care Unit (AHRQ ICU) Safety Program, as well as the extent to which their State leads submitted reports, conducted site visits, and prepared case studies. Because the outcome analyses examine not only overall effects of program intervention but also differential effects across subgroups, including those defined by levels of participation and Comprehensive Unit-based Safety Program (CUSP) adoption, the implementation analyses focus on each unit's overall level of participation across all program components, and overall level of CUSP adoption. Note that the analyses in this section do not attempt to explain variation in the extent to which units implemented various components of the program. In addition, this section summarizes the distribution of infection focus across units and describes how the American Hospital Association (AHA) determined infection focus for each unit. All results presented in this section pertain only to evaluation units – the units included in the evaluation.

Program Participation Levels

Appendix 3 shows the percentage of units that participated in the various program components. Per Appendix 3, Table A-1, the overall ICU Assessment submission rate for the 667 ICUs included in the

evaluation was 95.8 percent (Cohort 1: 93.3 percent, Cohort 2: 85.8 percent, Cohort 3: 100 percent, Cohort 4: 100 percent, Cohort 5: 100 percent, Cohort 6: 100 percent). Beginning with Cohort 3, performance improvement coaches coached their State leads to hold their units accountable for submitting the assessment by informing units that nonsubmission could result in withdrawal from the program. This "coaching for accountability" likely contributed to the attainment of a 100 percent submission rate for Cohorts 3 to 5.

Overall, 46.6 percent of evaluation units received a site visit, with more than half of Cohort 3 (56.1 percent), Cohort 4 (51.9 percent), and Cohort 5 (55.1 percent) units receiving a visit, more than a third of Cohort 1 (38.8 percent) and Cohort 2 (44.3 percent), and just under a quarter of Cohort 6 (22.4 percent) units receiving a visit (Appendix 3, Table A2). It should be noted that site visit requirements differed by cohort, with state leads from Cohorts 1 through 3 required to conduct and complete site visits for 50 percent of their eligible units, versus a requirement of 30 percent for Cohort 4 and Cohort 5, and Cohort 6 requiring one site visit per State lead (all but one State[38] conducted virtual visits due to the COVID-19 pandemic; a few States did early in-person visits prior to the pandemic). Overall, almost half (49 percent) of the site visits occurred in the middle of the 12-month implementation period (between months 5 and 8), and roughly a quarter each occurred in the first 4 months (24 percent) and the last 4 months (27 percent), respectively. (Appendix 3, Table A2).

Because the applicability of the remaining program components and educational offerings differed between Cohorts 1 and 2 and Cohorts 3 through 6, they are discussed separately for these two groups.

Cohorts 1 and 2: Participation in Individual Program Components

For cohorts 1 and 2, Appendix 3 Tables A3 through A7 show the number and percentage of evaluation units that viewed the following educational offerings: onboarding webinars, virtual learning groups (VLGs), and CLABSI and CAUTI (central line-associated bloodstream infection and catheter-associated urinary tract infection) Prevention on-demand modules.

Overall, "Building an Implementation Team" and "Using Quality Improvement to Get to Zero" had the highest viewership among onboarding webinars (76.4 percent and 60.5 percent respectively). However, for both webinars, Cohort 1 had higher viewership than Cohort 2, with 82.4 percent of Cohort 1 units viewing "Building an Implementation Team" versus 67.0 percent of Cohort 2 units; and 81.2 percent of

[38] Tennessee was able to conduct in-person site visits early in program implementation and prior to the pandemic affecting the State.

Cohort 1 units viewing "Using Quality Improvement to Get to Zero" versus 28.3 percent of Cohort 2 units. This pattern was also true for the three data-focused onboarding webinars. While viewership ranged from 24.0 percent to 35.1 percent overall, Cohort 1 viewership ranged from 39.4 percent to 49.1 percent and Cohort 2 viewership ranged from 0 percent to 13.2 percent (Appendix 3, Table A3).

Over the course of the program, units in Cohorts 1 and 2 were encouraged to participate in monthly hour long VLG webinars featuring ICU teams discussing how they implemented the program in their hospitals. All participants were asked to share program successes and challenges, ask questions of each other and engage in peer-to-peer learning. Overall, 35.4 percent of units in Cohorts 1 and 2 participated in at least half of these VLGs, while 9.2 percent did not participate in any (Appendix 3, Table A4).

All units in Cohorts 1 and 2 were given access to five CAUTI and four CLABSI Prevention on-demand modules. Evaluation units accessed CAUTI modules more than CLABSI modules, with 53.1 percent of units accessing CAUTI modules versus 32.8 percent for CLABSI. Twenty-eight percent of units accessed more than half of the CAUTI modules, and 26.6 percent accessed more than half of the CLABSI modules. Overall, the most accessed CAUTI module was "IUC 101: Indwelling Urinary Catheter Indications" (47.6 percent), and the most accessed CLABSI module was "CVC 101: Avoiding Placement of CVC—Indications and Alternatives" (30.6 percent) (Appendix 3, Tables A5–A8).

Cohorts 3 to 6: Participation in Individual Program Components

For Cohorts 3 to 6, Appendix 3 Tables A9 through A15 show the number and percentage of evaluation units that viewed the following educational offerings: onboarding webinars, VLGs, and CLABSI and CAUTI prevention on-demand modules. ICUs were given credit for participation in a specific educational offering if they accessed the offering's link in the Comprehensive Data System or SurveyMonkey. In addition, Table A16 (Appendix 3) shows the number and percentage of units that were reported in State Lead Quarterly Reports (SLQRs) and participated in case studies.

The number of onboarding webinars differed by cohort, with Cohort 3 having four, Cohorts 4 and 5 having six, and Cohort 6 having five. The most accessed onboarding webinars by cohort were "Program Overview" for Cohort 3 (89.4 percent); "Quality Improvement in Action" and "Preventing CLABSI and CAUTI using a Tiered Approach with CUSP Principles" for Cohort 4 (each at 82.1 percent); and "Building an Engaged CUSP Team" for Cohort 5 (83.1 percent) and Cohort 6 (100.0 percent). Cohort 5 averaged lowest viewership for onboarding webinars ranging from 66.1 percent to 83.1 percent.

Over the course of the project, units had access to 11 live or recorded VLGs. Overall, 44.9 percent of evaluation units accessed over half of the VLGs offered and 10.1 percent did not access any (Appendix 3 Table A11). Of the three VLGs offered to all cohorts, "Action Plan to Translate Research into Practice" was the most accessed (68.7 percent) following "Engaging Physicians in CLABSI and CAUTI Prevention in the ICU" (50.5 percent), and "Using Safe Design Principles to Identify and Learn from Defects" was the least (39.4 percent) accessed. The most accessed VLG by cohort was "Preventing CLABSI and CAUTI Using a Tiered Approach with CUSP Principles" for Cohort 3 (77.2 percent), "Action Plan to Translate Research into Practice" for Cohorts 4 (66.0 percent) and 5 (67.3 percent), and "Teamwork and Communication" for Cohort 6 (83.7 percent) (Appendix 3, Table A-10).

All units in Cohorts 3 through 6 were given access to 6 CAUTI and 4 CLABSI Prevention on-demand modules. About 28 percent of units accessed more than half of the CAUTI modules and 26.3 percent accessed more than half of the CLABSI modules. Overall, the most accessed CAUTI module was "IUC 101: Avoiding Placement and Determining Appropriateness of Indwelling Urinary Catheters" (41.9 percent), and the most accessed for CLABSI was "CVC 101: Central Venous Catheter Indications and Alternatives" (29.8 percent) (Appendix 3, Tables A-12–A-15).

Unit-level CUSP information was collected in SLQRs and submitted by State leads. The percentage of units for which State leads submitted SLQRs (Appendix 3, Table A-16) varied by quarter. The submission rate ranged from 96.7 percent to 100 percent of units for Cohort 3, 83.0 percent to 98.1 percent for Cohort 4, 84.7 percent to 97.5 percent for Cohort 5, and 91.8 percent to 100 percent for Cohort 6.

About 17 percent of ICUs from Cohorts 3 through 6 were featured in case studies[39] (Appendix 3, Table A-16). The ICU Action Plan was administered to Cohorts 3 through 6 only and was submitted by all evaluation units (not shown).

Overall Level of Participation (Cohorts 1 to 6)

To examine the degree to which units participated in program components and to assess whether the level of program participation altered the impact of the program on infection rates and device utilization (see subgroup analysis by participation level in Section E), each unit was classified as having low,

[39] Each State lead in cohort 3 was required to complete two case studies while each State lead in cohorts 4, 5, and 6 was required to complete one case study. State leads chose which units to include in case studies. Cohorts 1 and 2 did not have case study submission in the state lead scope of work, and no case studies were submitted.

moderate, or substantial level of participation as described in Section C. The resulting distribution of ICUs by participation levels is found in Table D-1.

As previously noted, different participation criteria were used for Cohorts 1 and 2, and Cohorts 3 to 6. Therefore, differing distributions in participation levels between these two cohort groups may be due to differences in the criteria used. Across all units, the three participation categories were evenly distributed (minimal: 27.9 percent, moderate: 42.4 percent, substantial: 29.7 percent). Cohorts 4 and 5 had the highest percentage of minimal participation (30.2 percent and 40.7 percent respectively); Cohorts 2 and 6 had most of their units fall into the moderate participation category (50.0 percent and 53.1 percent); and Cohorts 1 and 4 had the highest percentage of substantial participation (37.0 percent and 37.4 percent respectively).

Table D-1. Participation Levels, Overall and by Cohort

Cohort	N	Minimal Participation	Moderate Participation	Substantial Participation
Cohort 1	165	35 (21.2%)	69 (41.8%)	61 (37.0%)
Cohort 2	106	31 (29.2%)	53 (50.0%)	22 (20.8%)
Cohort 3	123	32 (26.0%)	45 (36.6%)	46 (37.4%)
Cohort 4	106	32 (30.2%)	43 (40.6%)	31 (29.2%)
Cohort 5	118	48 (40.7%)	47 (39.8%)	23 (19.5%)
Cohort 6	49	8 (16.3%)	26 (53.1%)	15 (30.6%)
Overall	667	186 (27.9%)	283 (42.4%)	198 (29.7%)

Adoption of CUSP (Cohorts 3 to 6 only)

To examine the degree to which Cohorts 3 to 6 units adopted CUSP principles, and to assess whether the level of CUSP adoption altered the impact of the program on infection rates and device utilization (see subgroup analysis by CUSP adoption level in Section E), each unit from Cohorts 3 to 6 were classified as having low, moderate, or substantial level of CUSP adoption as described in Section C. Table D-2 shows the resulting distribution of units across categories, overall and by cohort. Overall, 22.8 percent of ICUs had low adoption levels, 28.2 percent had moderate adoption levels, and 49.0 percent had substantial adoption levels. When looking at individual cohorts, the categorization resulted in both Cohorts 5 and 6 having about two-thirds of their units in the substantial adoption level, and Cohorts 3 and 4 having a more even distribution across the three levels of CUSP adoption.

Table D-2. Levels of CUSP Adoption, Overall and by Cohort

Cohort	N	Low [0 to .70]	Moderate [>.70 to .85]	Substantial [>.85 to 1.0]
Cohort 3	123	39 (31.7%)	28 (22.8%)	56 (45.5%)
Cohort 4	106	27 (25.5%)	44 (41.5%)	35 (33.0%)
Cohort 5	116	18 (15.5%)	26 (22.4%)	72 (62.1%)
Cohort 6	49	6 (12.2%)	13 (26.6%)	30 (61.2%)
Overall	394	90 (22.8%)	111 (28.2%)	193 (49.0%)

Source: AHA's analysis based on data from four SLQRs cohorts 3 through 6. **Note**: SLQR information was not submitted by a state lead for two cohort 5 units and therefore have an "unknown" level of CUSP adoption.

As noted in Appendix 3, Section C, to better understand the adoption of various aspects of CUSP, units were also classified into low, moderate, or substantial levels of adoption of the following five subdomains (see Appendix 3, Table C-1): Goals (meeting as a team to review progress on or working toward attaining action plan goals), Testing (conducting a defect analysis), Leader Support (meeting with or conducting rounds with hospital leadership), Champion (engaging with a physician or nurse champion), and Data (sharing CLABSI and/or CAUTI data with frontline staff or posting the number of days since last infection).

When these subdomains (Appendix 3, Figure B-1) were considered, it was found that "Goals" had the highest average composite score overall (91 percent), followed by "Champion" (88 percent). "Leader Support" (74 percent) and "Testing" (70 percent) had the lowest scores. These results suggest that while engaging with physician and/or nurse champions is common, engaging with senior leadership is less so. Also, the difference between the "Data" subdomain (85 percent) and "Testing" subdomain (70 percent) suggests that the practice of sharing data on CLABSI and CAUTI outcomes are more widespread than conducting root cause analyses of defects. Appendix 3, Section B provides overall and cohort-specific descriptive statistics on the subdomain scores.

Unit and Hospital Characteristics, by Levels of Program Participation and CUSP Adoption

Appendix 3, Section C shows unit and hospital characteristics for the overall sample of Cohorts 1 to 6 units, as well as units grouped by level of overall participation in the program's educational offerings (low, moderate, substantial), and by level of CUSP adoption (low, moderate, substantial; Cohorts 3 to 6 only). Below we highlight some key differences in hospital and unit characteristics delineated across participation levels and across CUSP adoption levels based on results of statistical tests shown in Appendix 3, Table C-1, but make no attempt to explicitly identify similarities.

Overall Participation Level in Educational Offerings (Cohorts 1 to 6)

The only statistically significant difference in ICU and hospital characteristics across participation levels involved ICU bed size. Specifically, units categorized as having substantial participation were, on average, larger in bed size (mean=17.9, N=198) than those categorized as having moderate participation (mean=16.0, N=283) or low participation (mean=15.2, N=186). Similar results were obtained when ICU bed size was categorized into small to medium (1–15 beds), large (16–30 beds), and very large (>30 beds). That is, a larger percentage of units with substantial participation (53.5 percent) were categorized as large ICUs compared to either moderate (40.8 percent) or low (37.5 percent) participation units.

Overall CUSP Adoption Level (Cohorts 3 to 6 only)

Unit bed size did not differ across CUSP adoption levels but hospital size did. Specifically, when hospitals are categorized into small (<100 beds), medium (100–299 beds), and large (300+ beds), statistical tests show that the low adoption group had a greater percentage of units belonging to medium-sized hospitals (61.1 percent) than either the moderate (44.1 percent) or substantial (45.1 percent) adoption groups. Conversely, the low adoption group had a lower percentage of units belonging to large hospitals (25.6 percent) than either the moderate (48.6 percent) or substantial (50.3 percent) adoption groups. Moreover, the substantial CUSP adoption group had a greater percentage of units in teaching hospitals (86.0 percent) compared to the low adoption group (71.1 percent), in urban areas (96.9 percent) compared to the low adoption group (84.4 percent), and in for-profit hospitals (16.6 percent) compared to the moderate adoption group (5.4 percent).

Infection Focus

Table D-1 in Appendix 3 shows the distribution of participating units' infection focus overall and by cohort. Overall, slightly more than half (50.2 percent) of units stated they would focus on both CLABSI and CAUTI (Appendix 3, Table D-1), about a quarter (25.5 percent) on CAUTI only, and 16.6 percent on CLABSI only. The distribution of infection focus varied across cohorts (Appendix 3, Table D-2). Details about these differences are discussed in Appendix 3.

E. Evaluation Findings

This section examines whether the Agency for Healthcare Research and Quality Intensive Care Unit (AHRQ ICU) Safety Program had an effect on units' National Healthcare Safety Network (NHSN) and population central line-associated bloodstream infection (CLABSI) and catheter-associated urinary tract

infection (CAUTI) rates as well as indwelling urinary catheter and central line utilization ratios, during their participation in the program. As explained in Section C, the effect of the program was estimated by comparing the outcomes of units before the intervention to their outcomes during the intervention. This section summarizes findings on overall effects (primary analysis) as well as effects on subgroups of participating units (secondary analysis), associations between the outcomes and hospital and unit characteristics, and performance of units in maintaining or attaining zero infections (exploratory analysis). **The primary analysis was originally planned to be based on the pooled sample from all six cohorts.** However, considering the unforeseen occurrence of the COVID-19 pandemic and the disruptions it brought to the healthcare setting in general, and to the Cohort 6 program implementation in particular, **the primary analyses now include two other sets of analyses: (1) one that excluded Cohort 6 (that is, Cohorts 1 to 5 only), and (2) one that focused on only Cohort 6**. Taken together, these three sets of analyses offer a more complete picture of the program effects. As preplanned, all secondary and exploratory analyses are based on the full Cohorts 1 to 6 sample. Overall and subgroup findings reported below come from the unadjusted analysis. Overall findings from the adjusted analysis that accounted for ICU and hospital characteristics are very similar to the unadjusted analysis and are provided in Appendix 4.[40] All results in this section and in Appendix 4 pertain only to evaluation units—that is, units that had at least 3 months of outcome data during both the pre-intervention and intervention periods.[41]

Presentation of Results

Results are presented numerically through tables summarizing estimated effects (Table E-1 and Appendix 4), and also illustrated graphically (Figure E-1). A brief explanation of these tables and graphs follows.

***Tables of Estimated Program Effects*.** Table E-1 (second and third columns, respectively) below shows the estimated pre-intervention and intervention *slopes* expressed in the form of **incidence rate ratios (IRR)**, where:

[40] Note that for parsimony and ease of interpretation, all subgroup analyses used unadjusted models.
[41] As noted in Section C (Analytic Samples), the evaluation inclusion criteria of units having at least 3 months of outcome data during both pre-intervention and intervention periods resulted in analytic samples that differed slightly across outcomes. Moreover, because units with missing hospital and ICU characteristics were excluded from the adjusted analysis, within each outcome, the sample sizes for the latter are smaller than those for the unadjusted analysis.

- IRR < 1 indicates the outcome is decreasing over time (negative slope); IRR > 1 indicates the outcome is increasing over time (positive slope); IRR = 1 (zero slope) indicates the outcome is not changing over time.

Table E-1 (last column) also shows the pre-intervention to intervention *change in slopes* or the *program effect* in the form of the **ratio of IRRs (R-IRR),** that is, the ratio of the intervention slope to the pre-intervention slope. In the context of this evaluation:

- R-IRR < 1 represents a favorable effect; R-IRR > 1 represents an unfavorable effect; and R-IRR = 1 represents no effect.

The tables of estimated program effects also report the following: (1) a 95 percent confidence interval (CI), where a CI that includes 1 indicates that the effect is not statistically significant, and a CI that does not include 1 indicates that the effect is statistically significant; (2) percent change: Calculated as 100 × (IRR–1), or as 100 × (R-IRR–1), percent change provides an indication of the degree or magnitude of the effect – the larger the percent, the greater the magnitude of the effect, and, (3) *p*-value based on two-sided test of the null hypothesis of "no effect" or "no difference." For all findings, *p*-values less than .05 were considered statistically significant.

Graphs of Estimated Trend Lines (shown below). For each outcome, estimated trend lines are plotted (in solid blue or red) as illustrated in Figure E-1, which shows results for the primary analyses (corresponding graphs from the secondary analyses are provided in Figures B-1 to B-5 in Appendix 4). In these graphs, months to the left of the vertical black line (months 1–12) represent the pre-intervention period and months to the right (months 13–24) represent the intervention period. The trend lines come from fitting unadjusted two-level negative binomial models[42] to the observed unit-level infection rates or utilization ratios, using time, and the interaction between time and the intervention period indicator as predictors. The trend line can be interpreted as the line that "best fits" participating units' infection rates or utilization ratios over time and provides a "best guess" of the true but unknown trend line for the target population of units. Differences in slopes between the pre-intervention and intervention trend lines provide estimates of the program's effects (as explained in Figure C1 and Section C). Red trend lines signify that the program effect is statistically significant, while blue trend lines indicate it is

[42] For simplicity of interpretation, unadjusted models were used as the basis for the graphical displays of estimated trend lines. As visible from the table of findings in Appendix 4, estimated program effects from the unadjusted models were generally very similar to those from the adjusted models.

not statistically significant. Along with the trend lines, monthly aggregate rates (green dots) before and during the intervention are also plotted for reference.[43]

Primary Aim

The American Hospital Association (AHA) used interrupted time series (ITS) analysis to address the primary question assessing the overall effects of the AHRQ ICU Safety Program on **NHSN CLABSI and CAUTI rates, population CLABSI and CAUTI rates, central line utilization, and indwelling urinary catheter utilization** in participating ICUs. Specifically, the slope of the infection rate or utilization ratio during the intervention period (12 months of program implementation) was compared to the slope during the pre-intervention period (12 months prior to start of program implementation) by examining the following parameters[44] (see Figure C-1 in Section C):

a. Reduction in rates over time (slope) in the pre-intervention period
b. Reduction in rates over time (slope) in the intervention period
c. Differences in rates of change (slope change) between pre-intervention and intervention periods

Given that Cohort 6 units implemented the program during the COVID-19 pandemic and ended up having a four-month pause in implementation as well as profound changes in patient case mix and greater clinical practice pressures, the primary aim was addressed using three different samples: (1) the full sample of Cohorts 1 to 6; (2) one that excluded Cohort 6; and (2) one that included only Cohort 6.

Findings for the three samples are summarized in Table E-1, and are displayed graphically in Figure E-1. Detailed results for each outcome are given in Tables A-1 to A-18 in Appendix 4.

Table E-1. Estimated Program Effects from the Primary Unadjusted Analyses of Three Analytic Samples: Cohorts 1 to 6, Cohorts 1 to 5, and Cohort 6: IRR or R-IRR (95% CI) [Percent Change]

[43] As mentioned before, for each month, the aggregate rate for a particular measure was calculated as the sum of numerators divided by the sum of the denominators, where summation was done across all units in the analytic sample for that measure and month. Note that these rates (given in tabular form in Appendix 5) were not used in the statistical models for estimating program effects. Instead, unit-level infection rates and utilization ratios (or more precisely, their natural log), were used as outcomes in these models.

[44] As explained in Section D, the statistical models for the current analyses did not include parameters for immediate level shifts (differences in intercepts) because these was no expected reductions in rates or device utilization immediately after the start of the program, and indeed, none were found in prior analyses of earlier cohorts (Cohorts 1 and 2, and Cohorts 3 and 4).

Cohorts	Outcome	Pre-Intervention Slope or IRR	Intervention Slope or IRR	Ratio of Intervention Slope to Pre-Intervention Slope (R-IRR)
Cohorts 1 to 6	NHSN CLABSI rate	**0.985* (0.974–0.996) [-1.5]**	**0.980* (0.967–0.993) [-2.0]**	0.995 (0.973–1.017) [-0.5]
	Population CLABSI rate	**0.981* (0.970–0.992) [-1.9]**	**0.979* (0.965–0.992) [-2.1]**	0.998 (0.976–1.021) [-0.2]
	Central line utilization	**0.995* (0.994–0.996) [-0.5]**	**0.999* (0.997–1.000) [-0.1]**	**1.003* (1.001–1.005) [0.3]**
	NHSN CAUTI rate	**0.979* (0.970–0.988) [-2.1]**	**0.981* (0.970–0.992) [-1.9]**	1.002 (0.984–1.020) [0.2]
	Population CAUTI rate	**0.973* (0.964–0.982) [-2.7]**	**0.976* (0.965–0.987) [-2.4]**	1.003 (0.985–1.022) [0.3]
	Urinary catheter utilization	**0.993* (0.992–0.994) [-0.7]**	**0.996* (0.995–0.997) [-0.4]**	**1.002* (1.001–1.004) [0.2]**
Cohorts 1 to 5	NHSN CLABSI rate	**0.986* (0.974–0.997) [-1.4]**	**0.975* (0.961–0.990) [-2.5]**	0.989 (0.967–1.013) [-1.1]
	Population CLABSI rate	**0.982* (0.970–0.993) [-1.8]**	**0.973* (0.958–0.987) [-2.7]**	0.991 (0.968–1.014) [-0.9]
	Central line utilization	**0.996* (0.995–0.997) [-0.4]**	**0.997* (0.996–0.998) [-0.3]**	1.001 (0.999–1.003) [0.1]
	NHSN CAUTI rate	**0.981* (0.972–0.990) [-1.9]**	**0.979* (0.968–0.991) [-2.1]**	0.998 (0.979–1.017) [-0.2]
	Population CAUTI rate	**0.975* (0.966–0.984) [-2.5]**	**0.973* (0.961–0.984) [-2.7]**	0.998 (0.979–1.017) [-0.2]
	Urinary catheter utilization	**0.993* (0.993–0.994) [-0.7]**	**0.994* (0.993–0.995) [-0.6]**	1.001 (0.999–1.002) [0.1]
Cohort 6	NHSN CLABSI rate	0.980 (0.944–1.017) [-2.0]	1.013 (0.972–1.056) [1.3]	1.034 (0.963–1.110) [3.4]
	Population CLABSI rate	0.973 (0.937–1.010) [-2.7]	1.027 (0.985–1.070) [2.7]	1.055 (0.983–1.133) [5.5]
	Central line utilization	**0.992* (0.988–0.996) [-0.8]**	**1.017* (1.013–1.021) [1.7]**	**1.025* (1.018–1.032) [2.5]**
	NHSN CAUTI rate	**0.958* (0.926–0.992) [-4.2]**	1.009 (0.968–1.051) [0.9]	1.053 (0.983–1.127) [5.3]
	Population CAUTI rate	**0.950* (0.917–0.984) [-5.0]**	1.020 (0.979–1.062) [2.0]	**1.074* (1.002–1.150) [7.4]**
	Urinary catheter utilization	**0.992* (0.989–0.995) [-0.8]**	**1.012* (1.008–1.015) [1.2]**	**1.020* (1.014–1.026) [2.0]**

*Statistically significant at α = 0.05.

IRR = incidence rate ratio; R-IRR = ratio of IRRs; CI = confidence interval.

Notes: Percent change = 100 × (IRR–1), or 100 × (R-IRR–1). IRR < 1 indicates a decreasing trend (negative slope); IRR > 1 indicates an increasing trend (positive slope). R-IRR < 1 represents a favorable effect; R-IRR > 1 represents an unfavorable effect; Results come from unadjusted models. Models that adjusted for hospital and ICU characteristics yielded similar results. Sample sizes: (1) Cohorts 1 to 6: NHSN CLABSI: 658 units; population CLABSI: 658; central line utilization: 659; NHSN CAUTI: 664;

population CAUTI: 663; and, urinary catheter utilization: 663; (2) Cohorts 1 to 5: NHSN CLABSI: 609 units; population CLABSI: 609; central line utilization: 659; NHSN CAUTI: 664; population CAUTI: 663; and, urinary catheter utilization: 663. (3) Cohort 6: NHSN CLABSI: 49 units; population CLABSI: 49; central line utilization: 49; NHSN CAUTI: 49; population CAUTI: 49; and, urinary catheter utilization: 49.

***Cohorts 1 to 6 Results*.** Findings from the analysis of all six cohorts (Table E-1 and Figure E-1a) show consistent statistically significant reductions in both infection rates (NHSN CLABSI and CAUTI rates, and population CLABSI and CAUTI rates) and device utilization (central line and indwelling urinary catheter utilization) during both the pre-intervention period and the intervention period (see second and third columns of Table E-1). When comparing the rate change over time (slope) during the intervention period to the rate change over time during the pre-intervention period (see last column of Table E-1), no statistically significant differences were found for infection rates. There were, however, statistically significant differences in device utilization, with both central line utilization **(IRR=1.003, CI: 1.001–1.005, p=0.001)** and urinary catheter utilization **(IRR=1.002, CI: 1.001–1.004, p<0.001)** declining at a slower pace (by 0.3 percent and 0.2 percent, respectively) during the intervention period compared to the pre-intervention period. These findings suggest that although both infection rates and device utilization continued to decline during the intervention period, the analysis did not detect an impact on the rate at which reductions in infection rates occurred and was associated with a slightly slower pace of reduction in device utilization.

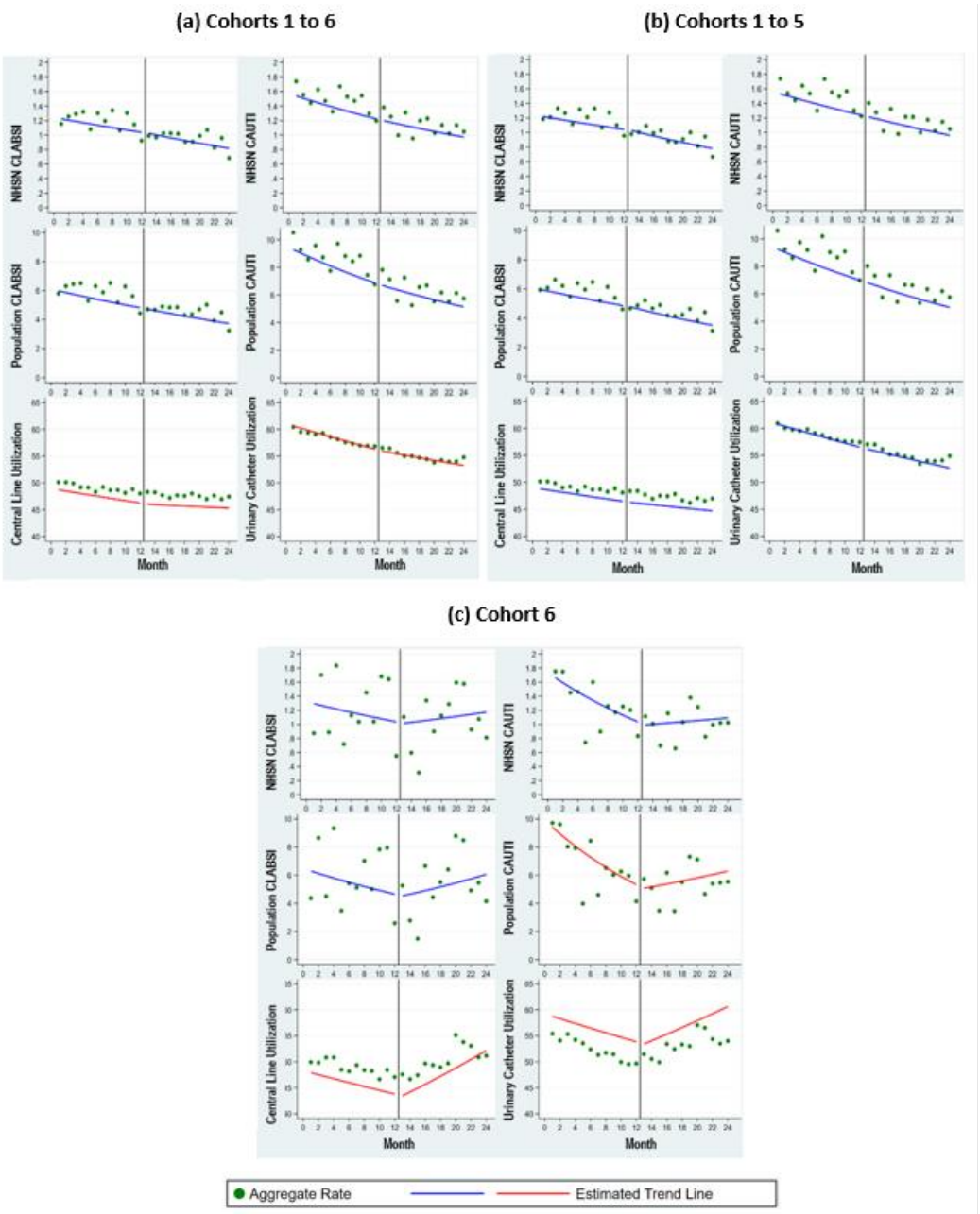
Cohorts 1 to 5 Results. Findings from the analysis that included only Cohorts 1 to 5 (Table E-1 and Figure E-1b) mirrored the findings from the Cohorts 1 to 6 sample with two notable exceptions. When Cohort 6 was excluded, the previously statistically significant effects on central line and urinary catheter utilization—indicating that the program was associated with a slower rate of reduction during the intervention period compared to the pre-intervention—were no longer statistically significant.

Cohort 6 Results. As is evident in Table E-1 and Figure E-1c, analysis of the sample that included only Cohort 6 yielded patterns that are remarkably different from those of the Cohorts 1 to 6 and Cohorts 1 to 5 samples. Whereas the latter two samples showed monotonically decreasing trends in all outcomes (albeit *not* all statistically significant) during both the pre-intervention and intervention periods, Cohort 6 exhibited a reversal in trend from decreasing (negative slope) during the pre-intervention period to increasing (positive slope) during the intervention period that was consistent across all six outcomes, although statistically significant for only three of the six. Specifically, while no statistically significant changes in slopes were observed for central line and urinary catheter utilization when examining only Cohorts 1 to 5, the Cohort 6 analysis yielded statistically significant increases in slopes (from negative to

positive) for these two outcomes: a 2.5 percent increase for central line utilization **(IRR=1.025, CI: 1.018–1.032, p<0.001)**, and a 2.0 percent increase for urinary catheter utilization **(IRR=1.020, CI: 1.014–1.026, p<0.001)**. In addition, a 7.4 percent increase in slope (from negative to positive) was also observed for population CAUTI rates **(IRR=1.074, CI: 1.002–1.150, p<0.001)**, an effect that was not statistically significant in the Cohorts 1 to 5 and Cohorts 1 to 6 samples.

Overall observation. Taken together, the above findings suggest that the unprecedented experiences of Cohort 6 may have driven the statistically significant slowing down of the reduction in device utilization that was observed during the intervention period in the Cohorts 1 to 6 sample. Without Cohort 6, as shown in the Cohorts 1 to 5 analysis, the rate of reduction in device utilization remained the same across the two periods.

Figure E-1. Aggregate Infection Rates, Device Utilization Ratios, and Estimated Trend Lines from the Unadjusted Models Fitted to the Three Analytic Samples



NHSN = National Healthcare Safety Network, CLABSI = central-line associated bloodstream infection, CAUTI = catheter-associated urinary tract infection; ICU = intensive care unit

Notes: Red trend lines indicate that the overall effect (i.e., the pre-intervention to intervention change in slopes) on the specified outcome was statistically significant; blue trend lines indicate that overall effect was not statistically significant. Months to the left of the vertical black line (months 1 to 12) represent the pre-intervention period and months to the right (months 13 to 24) represent the intervention period. Results come from unadjusted models. Models that adjusted for hospital and ICU characteristics yielded similar results. Sample sizes: (1) Cohorts 1 to 6: NHSN CLABSI: 658 units; population CLABSI: 658; central line utilization: 659; NHSN CAUTI: 664; population CAUTI: 663; and, urinary catheter utilization: 663; (2) Cohorts 1 to 5:

NHSN CLABSI: 609 units; population CLABSI: 609; central line utilization: 659; NHSN CAUTI: 664; population CAUTI: 663; and, urinary catheter utilization: 663. (3) Cohort 6: NHSN CLABSI: 49 units; population CLABSI: 49; central line utilization: 49; NHSN CAUTI: 49; population CAUTI: 49; and, urinary catheter utilization: 49.

Secondary Aims

To examine potential underlying variations in program effects, AHA examined whether effects differed across subsets of participating units defined by (1) cohort groups, (2) participation level, (3) CUSP adoption level (cohorts 3 to 6 only), (4) pre-intervention cumulative attributable difference (CAD) values (positive vs. negative), and (5) site visit status (had a site visit vs. had no site visit). As preplanned, **all subgroup analysis were conducted based on only the Cohorts 1 to 6 sample**. Similar to the primary analyses, AHA used ITS models to estimate the pre-intervention to intervention change in slopes within each subgroup (within-subgroup effects), then augmented the models with interaction effects to assess whether there are differential effects—that is, whether there were differences in effects between pairs of subgroups. All secondary analyses used unadjusted models and focused on four outcomes: NHSN CLABSI and CAUTI rates and indwelling urinary catheter and central line utilization ratios. **Across the 20 sets of subgroup analyses (four outcomes by five types of subgroups), AHA estimated a total of 52 within-subgroup effects and 44 pairwise differential effects**.[45] As noted in Section C (Evaluation Design) and in line with common practice in multiple testing, these exploratory subgroup analyses did not account for multiple comparisons and used the conventional 0.05 significance level (alpha).[46] Results are summarized below and detailed findings are provided in Section B, Appendix 4. Given this section examined only NHSN, but not population, infection rates, for brevity, we refer to NHSN CLABSI and NHSN CAUTI rates simply as CLABSI and CAUTI rates in the discussion below.

Did program effects vary across subgroups, and if so, for which outcomes?

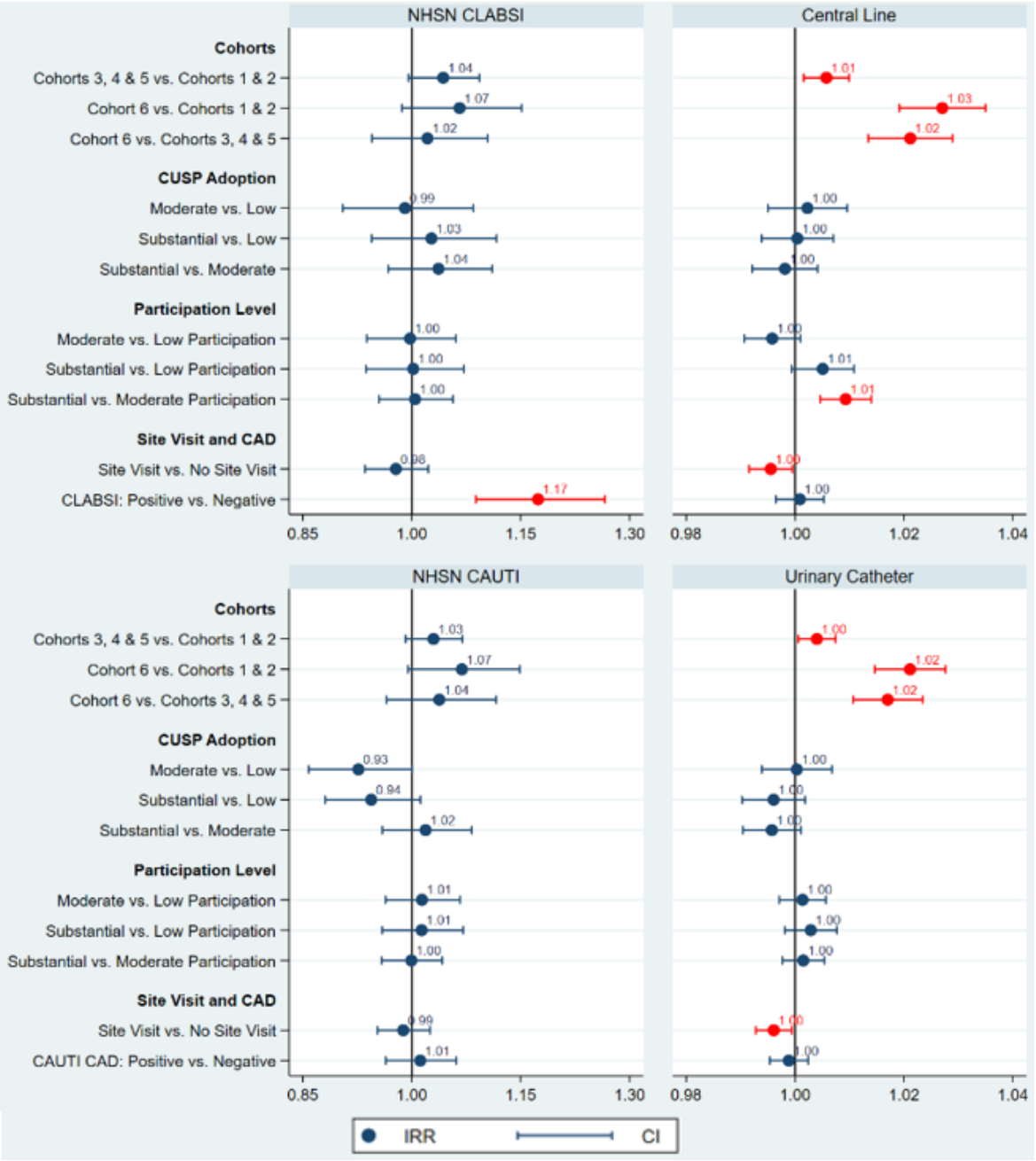
[45] *Number of within-subgroup effects estimated*: Three subgroup categories by four outcomes equals 12 within-subgroup effects for each of the following analysis—by cohort group, by participation level, and by CUSP adoption level analyses—yielding a total of 36; two categories by four outcomes equals 8 within-subgroup effects for each of the following—by CAD and by site visit status—yielding a total of 16; hence, at total of 36 + 16 = 52 within-subgroup effects. *Number of pairwise differential effects estimated*: Three pairwise differences by four outcomes equals 12 differential effects for each of the following analysis—by cohort group, by participation level, and by CUSP adoption level analyses—yielding a total of 36; one pairwise difference by four outcomes equals 4 differential effects for each of the following analysis—by CAD and by site visit status—yielding a total of 8; thus, a total of 36 + 8 = 44 differential effects.

[46] Accounting for multiple comparisons would have further diminished the already limited statistical power associated with tests for interaction effects, making it even less likely to detect an effect if indeed it exists. The downside of not accounting for multiple comparisons, however, is that it increases the likelihood of false positives, that is, of finding a statistically significant effect simply by chance, when in reality, there is none. Given these analyses are exploratory, we chose to err on the side of the latter as is commonly recommended in practice (Schochet, 2008).

Figure E-2 provides an at-a-glance visual **summary of the results of the 44 tests of differential effects conducted, of which 10 (23 percent) emerged as statistically significant**. For each outcome in this figure, estimated differential effects between pairs of subgroups (e.g., moderate vs. low CUSP adoption) are expressed in the form of IRRs and 95 percent CIs. A red CI indicates a statistically significant differential effect, and a blue CI indicates a nonsignificant effect. A brief overview of the differential effects follows; the nature of these effects are further explicated later through Figures B1 to B5 in Appendix 4.

- The analysis did not detect differential effects on infection rates across cohort groups, but found differential effects on device utilization. This suggests that the overall finding of no detectable program effect on CLABSI and CAUTI rates holds across cohort groups, but the overall effect of a slower rate of reduction in central line and urinary catheter utilization during the intervention period is not uniform across cohort groups.
- With respect to participation levels, no differential effects were found for infection rates or urinary catheter utilization. With respect to central line utilization, the only statistically significant difference in effects was between the moderate and substantial groups. These results suggest that the overall finding of no detectable program effect on infection rates was consistent across participation levels, and similarly, the overall effect of a slower decline in urinary catheter utilization during the intervention period compared to the pre-intervention period appeared to hold regardless of a unit's level of participation.
- The level of CUSP adoption did not moderate the effects of the program on any of the four outcomes, signaling that the overall "null" effects on infection rates and a slower decline in device utilization during the intervention period compared to the pre-intervention period hold regardless of the degree with which units adopted CUSP principles.
- The effect of the program on CLABSI rates differed between units with a negative baseline CAD and units with a positive baseline CAD, but no differential effects were found for the other three outcomes, suggesting that the overall findings for these three outcomes apply uniformly to both groups.
- Site visit status moderated program effects on infection rates but not on device utilization, indicating that the overall finding of a slower decline in device utilization during the intervention period compared to the pre-intervention period held regardless of whether a unit had a site visit or not, but that the effect on infection rates differed between these two groups.

Figure E-2. Summary of Differential Effects by Subgroup for NHSN CLABSI and CAUTI Rates, and Central Line and Urinary Catheter Utilization (Cohorts 1 to 6 Sample)



NHSN = National Healthcare Safety Network, CLABSI = central-line associated bloodstream infection, CAUTI = catheter-associated urinary tract infection, CAD = cumulative attributable difference), CUSP = Comprehensive Unit-based Safety Program

Notes: The black vertical line corresponds to an IRR = 1. A 95% CI that *does not cross* the black line (shown in red) indicates a *statistically significant* differential effect (change in slope from pre-intervention to intervention period, and a CI that *crosses* the black line (shown in blue) indicates that the differential effect is *not statistically significant*.

Exploratory Aims

Unit-Level Performance Improvement and Infection Focus

For NHSN CLABSI and CAUTI rates, AHA determined the number of ICUs that maintained zero infections and the number of ICUs that achieved zero infections (Table E-2), overall and by infection focus (see Section D for the distribution of infection focus among participating units). These unit-level performance metrics were defined as follows:

- Maintained zero: ICUs that had zero infections during the pre-intervention period and continued to have zero infections in the intervention period
- Achieved zero: ICUs that had at least one infection during the pre-intervention period then subsequently reduced their infections to zero during the whole intervention period

As noted earlier, ICUs were asked to indicate which infection they would focus on in their Action Plans. To determine if focus on a specific infection yielded a higher percentage of maintaining or attaining zero rates for that particular infection, these percentages were also calculated for (a) the subset of units that declared a focus on CLABSI (that is CLABSI only, or both CLABSI and CAUTI), and (b) the subset of units that declared a focus on CAUTI (that is CAUTI only, or both CLABSI and CAUTI).

Of the 658 ICUs in the overall CLABSI sample, 25.5 percent (168 units) had zero infections in the pre-intervention period, 49.4 percent of which (83 units) were able to maintain zero infections in the post-intervention period. Of the 490 units with at least one CLABSI during pre-intervention, 24.7 percent were able to achieve zero infections during post-intervention. For context on where these units started from in terms of their infection rates, the units that attained zero CLABSIs during post-intervention had CLABSI rates between 0.33 to 5.10, with an average of 1.50 (and a median of 1.14), during pre-intervention. The majority of them (56 percent) had pre-intervention CLABSI rates between 0.5 and 1.5, 7 percent had rates less than 0.5, and the remaining 37 percent had rates greater than 1.5. When narrowing this analysis to the 440 units that focused on either CLABSI only or both infection types, 23.0 percent (101 units) had zero infections during pre-intervention, and a slightly lower proportion of these units maintained zero when compared to the analysis using the overall sample (46.5 percent vs. 49.4 percent). Of the units with at least one CLABSI during pre-intervention, a lower proportion were able to achieve zero when compared to the overall sample (20.7 percent vs. 24.7 percent) (Table E-2).

Of the 664 ICUs in the overall CAUTI sample, 13.7 percent (91 units) had zero infections during the pre-intervention period, 37.4 percent (34 units) of which were able to maintain zero infections in the post-intervention period. Of the 573 units with at least one CAUTI during pre-intervention, 19.7 percent were able to achieve zero infections during post-intervention. For context on where these units started from in terms of their infection rates, the units that attained zero CAUTIs during post-intervention had pre-intervention CAUTI rates between 0.37 to 6.94, with an average of 1.48 (and a median of 1.14). The majority of them (62 percent) had pre-intervention CAUTI rates between 0.5 and 1.5, 10 percent had rates less than 0.5, and the remaining 29 percent had rates greater than 1.5. When narrowing this analysis to the 503 units that focused on either CAUTI only or both infection types, 13.5 percent (68 units) had zero infections during pre-intervention, with a slightly higher proportion of these units maintaining zero infections when compared with the analysis using the overall sample (39.7 percent vs. 37.4 percent). Of the units with at least one CAUTI during pre-intervention, a slightly lower proportion was able to achieve zero when compared to the overall sample (19.3 percent vs. 19.7 percent) (Table E-2).

Table E-2. Percentages of ICUs that Maintained or Attained Zero Infections: Cohorts 1 to 6

Infection Category	Sample	N	Had Zero Infections During Pre-intervention	Maintained Zero Infections During Intervention	Achieved Zero Infections During Intervention
NHSN CLABSI Rates	Overall sample	658	168/658 (25.5%)	83/168 (49.4%)	121/490 (24.7%)
	ICUs focused on CLABSI only or both infections	440	101/440 (23.0%)	47/101 (46.5%)	70/339 (20.7%)
NHSN CAUTI Rates	Overall sample	664	91/664 (13.7%)	34/91 (37.4%)	113/573 (19.7%)
	ICUs focused on CAUTI only or both infections	503	68/503 (13.5%)	27/68 (39.7%)	84/435 (19.3%)

F. Lessons Learned: Benefits of Participation, Program Strengths, and Facilitators and Barriers of Implementation

To better understand the factors that limit or extend program effects, data were collected on perceived benefits of participation, program strengths, and facilitators and barriers of implementation through

multiple sources: State Lead Quarterly Reports, intensive care unit (ICU) presentations on virtual learning groups (VLGs), unit case studies, site visit reports, Cohorts 1 to 6 exit interviews with unit and State leads (a total of 20 unit and 13 State leads), State and unit lead discussions at cohort closeout meetings, as well as feedback from the national program team.

Benefits of Participation

ICU Experience

The majority of unit and State leads who provided feedback about the program said they found it valuable, and several State leads said they would have recommended continuing the program for a longer period with their participating ICUs had that been allowed. Unit leads ascribed these benefits to participating in the program:

- "The program helped us not be afraid to look bad." "Being part of a State and national initiative taught us we were not alone."
- Changing care providers' mindsets: "Not every ICU patient needs an indwelling urinary catheter or central line, and not everything in the ICU requires split-second timing."
- Learning about the reliable alternatives to indwelling urinary and central venous catheters
- Being empowered to question the necessity of catheters or their continued use with the medical staff
- Having the ability to customize central line-associated bloodstream infection (CLABSI) and catheter-associated urinary tract infection (CAUTI) prevention strategies based on the unit's specific challenges
- Obtaining access to subject matter expertise, particularly at onsite visits attended by an SME
- Learning from peers through VLGs and the program Listserv®
- Improving unit teamwork and communication between nurses and physicians
- Using Comprehensive Unit-based Safety Program (CUSP) tools to address multiple types of potential harms
- Having access to a comprehensive set of program tools and resources

State Lead Experience

Many State leads indicated they would participate again in the program if given the opportunity, and 21 States[47] participated in more than one cohort. They all considered the program a success in terms of introducing an initial assessment of ICU practices and challenges, requiring an action plan (starting in the expansion phase), and focusing on frontline staff who are critical to healthcare-associated infection (HAI) prevention. State leads reported the tremendous value of site visits in building relationships, gaining a greater understanding of the ICU environment, and providing the opportunity for onsite coaching, encouragement, and recognition of the unit's work with senior leaders when they attended site visits. One State lead noted that the "program gives structure, time boundaries, and accountability that helps them [ICUs] advance their work." Other program benefits highlighted by State leads through interviews and the other sources of feedback were—

- Acquiring new knowledge of process improvement strategies, including coaching skills
- Learning about reliable alternatives to indwelling urinary catheters and central venous catheters
- Gaining access to a comprehensive array of program tools and resources
- Learning how other States and their ICUs are reducing infections
- Having direct access to unit managers and staff, rather than the typical connection to senior leaders; this provided State leads with a greater understanding of the ICU environment and ICU team member challenges
- Having an intentional focus on frontline staff and empowering them to be actively involved in the program
- Learning the unit-based approach of CUSP and the Agency for Healthcare Research and Quality (AHRQ) ICU Safety Program
- Having an intentional focus on frontline staff and empowering them to be actively involved in the program
- Having a tiered intervention structure that enabled units to tailor their interventions to their unit's specific challenges and needs

[47] Fourteen States participated in two cohorts: Arkansas, Florida, Georgia, Louisiana, Nebraska, New Jersey, Nevada, New York, Ohio, Pennsylvania, South Carolina, Tennessee, Virginia, and Washington. Another six States/territories participated in three cohorts: California, Connecticut, Illinois, Kentucky, Oklahoma, Puerto Rico, and Texas.

Summary of Program Strengths

Regardless of their success in reducing CLABSIs, CAUTIs, and/or device utilization, the majority of unit and tate leads reported these program strengths in exit interviews and at cohort closeout meetings:

- Comprehensive array of program education, tools, and other resources, especially the ICU Assessment and unit action plans
- Customizable curriculum
- Focus on frontline staff
- Focus on standardization of evidence-based practices
- Access to and site visits from national subject matter experts
- Peer learning on VLG webinars and through the program Listserv®
- Program helped change the mindset that all ICU patients need indwelling devices

Summary of Program Implementation Facilitators

In exit interviews and at cohort closeout meetings, unit and State leads also provided feedback about what units did, what they wish they had done sooner in program implementation, and what they wished they could have done in the absence of barriers. The following represents their observations of what facilitated or would have facilitated or improved program implementation.

At Startup

- Communicate how the AHRQ ICU Safety program connects to organizational and unit patient safety goals, including the goal of zero HAIs
- Be thoughtful in the selection of CUSP team members and program champions, picking informal as well as formal influencers enthusiastic about the program's goals
- Incorporate program elements into existing infection prevention and quality improvement methods already being used at the organization (e.g., Lean Six Sigma, High Reliability Organizations)
- Choose physician, nurse manager, and frontline staff champions who are enthusiastic about the program goals, who take ownership of patient safety in the unit, and who can drive change
- Use nurse and physician champions more effectively:

- To implement program interventions around behavior change requires multiple champions: senior leader champions and a nurse-physician champion team that covers all shifts and physician rotations
- Select physician and nurse champions who are enthusiastic about the program and who also have the personal characteristics to influence team members and are sensitive to the local unit culture; merely appointing individuals is ineffective
- Provide nurse and physician champions with a written description of their respective roles and responsibilities as champions
- Have a physician champion address units on how best to identify physician champions most likely to stay engaged and able to influence clinicians (including physician trainees) to adopt program interventions; this information can be provided on a State/region webinar, conference call, or in-person meeting

This feedback on the importance of multiple champions to change behaviors is in line with the literature (Damschroder et al., 2009, Snyder et al., 2021).

During Implementation

Engagement (Frontline Practitioners, Nurse Managers, Physicians, and Senior Leadership)

- Encourage State leads to understand the current priorities of each unit to help the unit team align those with program requirements
- Coach unit leads to understand how they can best engage their team members and champions in the program
- Sustain senior leadership engagement in HAI reduction by involving the chief financial officer and other senior leaders in discussions about value-based purchasing, Centers for Medicare & Medicaid Services penalties for HAIs, and return on investment from HAI prevention efforts

Practices

- Standardize education on indwelling urinary catheter (IUC) and central venous catheter (CVC) use and implement competency-based training for frontline staff
- Address barriers to implementing alternatives to IUCs and CVCs, when appropriate

- Continue to monitor device necessity daily; engage patients and their families in appropriate catheter and central line use and the reasons for prompt removal of these devices when no longer necessary
- Train ICU teams in multidisciplinary rounding and ways to reduce catheter use in patients transferred from other units (e.g., emergency departments and operating rooms)
- Hold regular, informal huddles with staff to gather their thoughts about successes and barriers in the unit, as well as their suggestions for how to implement best practices
- Share feedback on unit process and outcome data, and linking those data to the unit's implementation of specific prevention strategies
- In addition to the ICU Assessment, administer other assessments/audits throughout the program to identify and address opportunities for improvement

Data Transparency

- Be transparent with performance data: share data with the entire unit, including frontline staff, and post data in "real time" and in a location in the unit visible to staff and the public

Other

- Create a task force to discuss ways to reduce nurse and physician burnout (e.g., ways to reduce burden of electronic health record documentation and staffing models to support individual workflow/task completion)

Sustaining Work After Program Ends

Asked how they would sustain the work after the program ended, unit leads stated they would do the following:

- Educate inexperienced staff and conduct annual competency reviews of all staff
- Continue audits and watch out for "drift" from both evidence-based practice and adaptive/cultural strategies such as teamwork and communication
- Review device necessity daily
- Standardize policies, procedures, and products
- Trial small tests of change and use event reporting tools
- Recognize and reward success

- Publicly display performance data to keep the goal of zero HAIs front of mind for all providers and staff

Unit and State Lead Recommendations for Program Enhancements

When asked how the program might be improved, unit and State leads who participated in exit interviews made the following additional suggestions to facilitate program implementation for future cohorts or for a future similar program:

- Have a structured orientation for all champions that includes simulation exercises
- Extend the program to 18 months; "adaptive change takes time"
- Collect infection rate and device utilization data for 6–12 months post-implementation to assess longer term effects, including program "hardwiring"
- Conduct site visits attended by subject matter experts for all participating ICUs (rather than only a subset), and conduct site visits closer to the start of the program to foster team member recognition and to build enthusiasm and accountability
- Create an optional unit team lead training conducted at the start of the program

Barriers to Implementation

The quality of program implementation and unit-level contextual factors may have contributed to the general overall findings of no discernible effect in this evaluation. This section describes barriers to implementation self-reported by participating ICUs and State leads through ICU Assessments, ICU Action Plans, Site Visit Reports, as well as State lead and unit lead exit interviews conducted by American Hospital Association (AHA) staff and closeout meeting discussions. Barriers to implementation remained consistent through Cohorts 1 to 6.

Many of these barriers align with three of the five domains identified in the systematic review by Vaughn et al., (2018) as characteristics of struggling healthcare organizations: (1) weak organizational culture (*norms, values, and basic assumptions of a given organization*); (2) inadequate infrastructure (*inadequate staffing (recruitment and retention) or resources*, *including poor technological or quality*

improvement infrastructure), and (3) system shocks (*an organizationwide event or change that detracts from day-to-day operations).*[48] The barriers described below are grouped into these domains.

Weak Organizational Culture

At the start of the project, (1) lack or absence of physician and nursing support and/or engagement, (2) competition with other patient safety initiatives, and (3) lack of ownership by ICU staff on the project were reported through the ICU Assessment as among the top three barriers to program success (Table F-1). However, lack of staff buy-in was the top barrier reported through Action Plans and site visit reports (Table F-2). Responses from State lead exit interviews conducted (Cohorts 1 to 6) and unit lead exit interviews (Cohorts 3 to 6) also aligned with the weak organizational culture domain. Specifically, both groups reported lack of buy-in from all levels (e.g., frontline staff, nurses, physicians, leadership) as barriers to the success of the program. In addition, a few unit leads clarified that not having frontline champions on all shifts as well as physician champions covering all rotations posed additional barriers to success.

Table F-1. Anticipated Barriers Reported by Units in the ICU Assessment, Percentage of Units

Barriers	Cohort 1 (N=154) (%)	Cohort 2 (N=91) (%)	Cohort 3 (N=123) (%)	Cohort 4 (N=106) (%)	Cohort 5 (N=118) (%)	Cohort 6 (N=49) (%)	Overall (N=641) (%)
Physician support and/or engagement	25.3	34.1	44.7	41.5	44.1	51.0	**38.4**
Competition with other patient safety initiatives	26.6	25.3	35.0	35.8	35.6	38.8	**32.1**
Ownership by ICU staff	29.2	44.0	23.6	31.1	28.8	30.6	**30.6**
Standardized processes to effect change	29.2	38.5	21.1	24.5	24.6	20.4	**26.7**
Team to focus on the project	23.4	18.7	31.7	24.5	17.8	32.7	**24.2**
Nursing support and/or engagement[2]	N/A	35.2	24.3	33.0	23.7	34.7	**22.2**
Communication among team members	17.5	13.2	28.5	18.9	22.9	20.4	**20.4**
Financial resources	29.2	20.9	17.1	17.0	19.5	4.1	**20.0**
Number of nurses in the ICU[2]	N/A	19.2	25.2	17.0	22.0	38.8	**17.5**
Number of physicians in the ICU[2]	N/A	13.2	20.3	21.7	23.7	18.4	**15.1**
Patient and family engagement	20.1	9.9	7.3	9.4	11.9	0.0	**11.4**
Insufficient human resources[1]	44.2	N/A	N/A	N/A	N/A	N/A	**10.6**
Other direct care resources[2]	N/A	12.1	12.2	16.0	17.8	0.0	**10.0**
Teamwork among team members	10.4	9.9	5.7	6.6	4.2	6.1	**7.3**
Lack of team member motivation[1]	27.3	N/A	N/A	N/A	N/A	N/A	**6.6**

[48] The two other domains are lack of a cohesive mission and vision and dysfunctional external relations (Vaughn et al., 2018).

Ownership by senior leadership	5.2	1.1	2.4	2.8	3.4	4.1	**3.3**
Lack of collective mindfulness of patient safety[1]	9.1	N/A	N/A	N/A	N/A	N/A	**2.2**
Ownership by ICU management	3.2	4.4	0.8	0.0	0.0	0.0	**1.6**

[1] The ICU Assessments for cohorts 1 and 2 had slightly different questions compared to cohorts 3 to 6; however, the majority of questions were directly analogous. Cohort 1 ICU Assessments' questions differed for the three questions indicated.
[2] For these questions, cohort 1 ICU Assessments did not have directly analogous questions in the Cohorts 2 to 6 ICU Assessments. In cohorts 3 through 6, units were asked in Question 9 of the ICU Assessment: "From the statements below, what would you anticipate will be the top three barriers to implementing this quality improvement initiative in your ICU? Select three."

Table F-2. Percent of Participating Units That Reported the Specified Barrier in their Action Plans and Site Visit Reports, Cohorts 3 to 6[1]

Barriers	Action Plans[2] (N=394) (%)	Site Visit Reports[3] (N=128) (%)	Overall (N=128) (%)
Staff Buy-In	38.6	25.8	**35.4**
Staff Compliance/Engagement With Program Education and Implementation	34.5	11.7	**28.9**
Priorities & Resources	28.7	19.5	**26.4**
Standardized Processes, Products and Equipment	6.6	27.3	**11.7**
Teamwork & Communication	9.4	11.7	**10.0**
Other Barriers	10.9	1.6	**8.6**
COVID	1.3	6.3	**2.5**
No Barriers	0.3	4.7	**1.3**

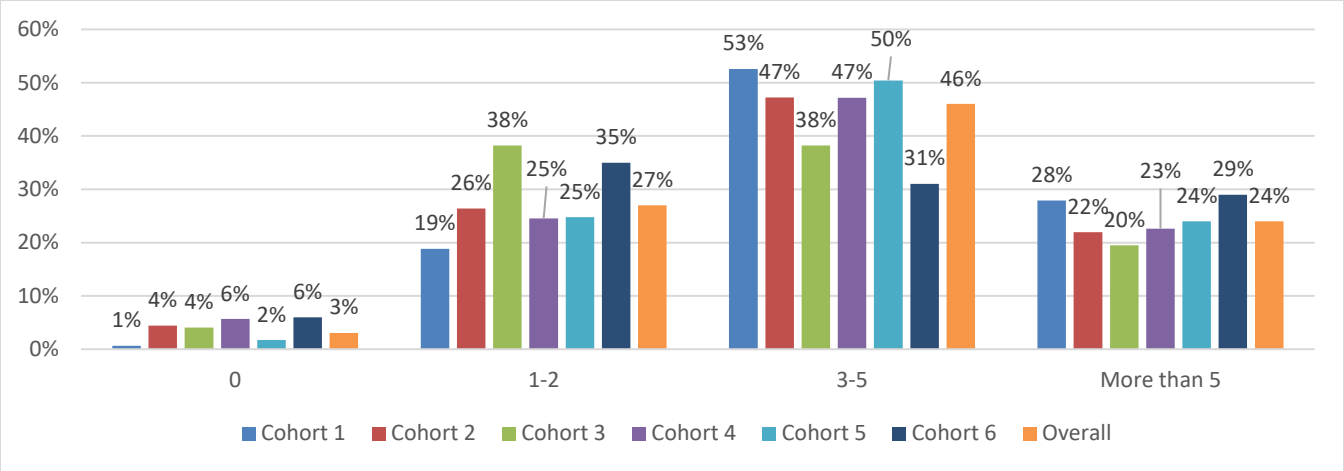
[1] ICU Action Plans and Site Visit Reports were not collected for cohorts 1 and 2. Only a sample of ICU Action Plans and Site Visit Reports from cohorts 3 through 5 were analyzed for this report. All cohort 6 Site Visit Reports were analyzed.
[2] ICU Action Plans were completed between the third and fifth month of the implementation.
[3] Site visits conducted within the last six months of implementation.
Source: AHA's analysis based on participation data and ICU Action Plan and Site Visit Reports.

Inadequate Infrastructure

From the Action Plans and site visit reports (Table F-2), lack of standardized processes, products, and equipment was reported in 44.3 percent of the 79 action plans analyzed, making it the second most reported barrier to implementation (next to staff buy-in which was reported in 59.5 percent of Action Plans). Unit and State lead exit interviews also revealed that inadequately staffed teams and staff turnover posed challenges to program success. Several unit leads reported in their interviews that any one of the following could greatly decrease program success: the absence of nurse and physician champions, the lack of a robust CUSP team, the expectation that the program can be implemented by the hospital infection preventionist and/or by a few individuals, as well as frequent turnover of unit leads.

Through the ICU Assessment, not having a team to focus on the program was among the top five barriers reported by participating units (Table F-1). In addition, 70 percent of all units reported that they were currently participating in three or more quality initiatives (Figure F-1). An analysis (Table F-3) of the relationship between participation level (low, moderate, and substantial) and the number of concurrent quality initiatives at the start of the program (0 to 2, 3 to 5, more than 5) shows that the group with more than five initiatives had a greater percentage of units at the substantial participation level (32.0 percent) compared with those with zero to two initiatives (28.5 percent) and those with three to five initiatives (31.9 percent). However, a chi-square test indicates that the association between these two variables was not statistically significant (p-value=0.8537).

Figure F-1. Number of Concurrent Quality Initiatives in Participating Units as Reported in the ICU Assessments: Overall and By Cohort (N=591 units; C1: 154 units; C2: 91 units; C3: 123 units; C4: 106 units; C5 118 units; C6 49 units)



Source: AHA's analysis based on the ICU Assessment Question 2. "How many quality improvement initiatives is your ICU currently working on?"

Note: 26 units did not submit an ICU Assessment (11 from C1 and 15 from C2). For Cohorts 1 and 2, these results are from the baseline ICU Assessment.

Table F-3. Association between Level of Participation and Number of Concurrent Quality Initiatives Reported in the ICU Assessment: Cohorts 1 to 6 (N=641 units)

Participation Level	0 to 2 Initiatives	3 to 5 Initiatives	More than 5 Initiatives	Total
Low	52 (26.9%)	72 (24.4%)	42 (27.5%)	166
Moderate	86 (44.6%)	129 (43.7%)	62 (40.5%)	277
Substantial	55 (28.5%)	94 (31.9%)	49 (32.0%)	198
Total	193 (100%)	295 (100%)	153 (100%)	641

Source: AHA's analysis based on participation data and ICU Assessment.

Note: 26 units did not submit an ICU Assessment (11 from C1 and 15 from C2). For cohorts 1 and 2, these results are from the baseline ICU Assessment.

Cohort 6 COVID-19 Experience

The National Program Team (NPT) and AHRQ purposely paused the program in March 2020 due to COVID-19. During the pause, AHA stayed very connected with State leads to understand when units might be ready to resume the program. Units participated in a "restart"/kickoff VLG webinar in August 2020 based on data and date unit leads indicated was reasonable to restart their active participation. However, although these webinars continued monthly from August 2020 through April 2021, units were no longer asked to present for the webinars given the high patient volume they continued to report.

To better understand the pandemic's effect on Cohort 6 ICUs, AHA staff interviewed seven unit leads who shared their experiences. In general, the COVID-19 pandemic was extremely disruptive for ICU operations and took a major emotional and physical toll on care providers, who dealt with an unprecedented crisis. Staffing challenges during the pandemic were significant and included nursing staff turnover due to the reassignment of unit staff to other ICUs, and the introduction of new physicians, float, and contract staff unfamiliar with the ICU environment, as well changes in the patient mix in some ICUs (e.g., switching a unit to a COVID unit and/or moving other patients to other ICUs). In addition, nursing shortages were created when staff departed the unit to take traveling nurse assignments in other hospitals.

The need to care for COVID-19 patients and to limit staff contact with these individuals led to less attention to catheter maintenance and prompt removal. In addition, the crisis disrupted senior leadership and champion support of the program.

Other Practice Disruptions

- The inability to have family at the beside increased nursing workload through the absence of someone to advocate for patient needs and wants, as well as through the burden on nurses to provide frequent patient updates to family members and help families stay connected to COVID-19 patients via electronic media
- The loss of visitors took an emotional toll on all staff, who witnessed patients dying without family members present
- There was less attention to device maintenance and withdrawal
- Device utilization and antibiotic use increased
- Multidisciplinary rounds and audits were suspended
- Blood and urine culturing and blood draws from central lines increased
- Access to adequate supplies was disrupted
- CUSP team meetings were canceled, and there was no time to use available program resources

Specific Strategies Used During the Pandemic To Support the Program

- Providing targeted education on device insertion, maintenance, and removal to float and contract staff

- Focusing on a limited number of prevention strategies or modified current practice given the challenges posed by the pandemic (e.g., used the "disruption of the lifecycle of devices[49]" as the central communication and teaching tool or modified the rounding process to fewer individuals who met outside patient rooms)
- Holding smaller CUSP huddles led by charge nurses rather than bigger meetings with unit leadership
- Using the program's Listserv® to learn how other units were addressing challenges

Lessons From the Pandemic Experience

- The experience created more cohesive ICU teams, and there was increased physician and staff engagement reported by most respondents
- The pandemic provided motivation and justification for standardized system supports, underscored by the increase in infections, especially CLABSI during COVID-19 patient surges (Fakih et al., 2021)
- Leaders and staff recognized the need for more panning for how the unit will ensure the maintenance of infection prevention practices during the next pandemic or other crisis

COVID-19 Stress Metric

To assess the impact of the pandemic on program implementation and infection rates, the NPT created a monthly COVID-19 Stress Metric (CSM) for hospitals modeled after the University of Washington's Institute for Health Metrics and Evaluation framework for measuring COVID-19 stress using a publicly available national dataset managed by the U.S. Department of Health & Human Services (HHS).[50] The NPT calculated the metric for participating hospitals and used it to classify Cohort 6 units as having low or high stress levels during the months of July 2020 through April 2021. Because this dataset was at the hospital level, participating units belonging to the same facility have the same value of CSM. Two key findings were that units with higher overall COVID-19 stress did not appear to coincide with higher CLABSI or CAUTI rates, and that participating units as a whole—regardless of COVID-19 stress—saw an increase in CLABSI rates and a slight increase in central line utilization. Further, during the winter

[49] The AHRQ ICU Safety Program curriculum includes five learning module videos on how to reduce CLABSIs in the ICU setting that address avoiding central line placement and determining appropriateness of central lines, alternatives to central lines, proper central line insertion, and prompt central line removal. The program has five analogous learning modules related to indwelling urinary catheters to reduce CAUTIs, as well as a sixth module on urine culturing stewardship.
[50] https://www.healthdata.org/sites/default/files/files/Projects/COVID/briefing_US-2020.12.04_.pdf (pages 23 and 24).

months (November 2020 to January 2021), most units were in the high COVID-19 stress group. Surprisingly, the number of units participating did not fall off after the program pause, and subsequent attendance at monthly program webinars was higher than for previous cohorts.

Appendix 7 has more information about how the metric was developed and applied, and how COVID-19 affected Cohort 6 program participation, implementation, and outcomes.

G. Discussion and Evaluation Limitations

Findings from the primary analyses (Table E-1 and Figure E-1) on the combined Cohorts 1 to 6 sample showed that the program had no detectable effects on infection rates (National Healthcare Safety Network [NHSN] and population rates of central line-associated bloodstream infection [CLABSI] and catheter-associated urinary tract infection [CAUTI]) but was linked to a statistically significant slower rate of decline in both central line and urinary catheter utilization during the intervention period as compared with the pre-intervention period. On the other hand, analysis of Cohorts 1 to 5 revealed no statistically detectable effects on either infection rates or device utilization—in all cases the outcomes were declining at similar rates during the pre-intervention and intervention periods. Analysis of only Cohort 6—whose last 9 months of program implementation coincided with the COVID-19 pandemic—revealed a pattern markedly different from those in previous cohorts, namely a reversal from a decreasing trend during the pre-intervention to an increasing trend during the intervention period for all six outcomes (though not all the effects were statistically significant). It is evident that cohort 6 outcomes, particularly central line and urinary catheter utilization, were adversely affected by the pandemic, and that Cohort 6 was driving the statistically significant findings on device utilization in the Cohorts 1 to 6 sample. As already noted above, when Cohort 6 was excluded, the declining pre-intervention trend in device utilization simply continued at a similar pace during the intervention period.

Notwithstanding Cohort 6, the estimated effects were generally null (e.g., in the Cohorts 1 to 6 sample, the overall effects on infection rates were null, and 34 out of the 52 within-subgroup effects tested were null), and in some cases, negative (e.g., the overall negative effects on device utilization in the Cohorts 1 to 6 sample). Said differently, the program was not associated with a faster decline in infection rates and device utilization when compared to the decline that was already occurring prior to the start of the intervention.

Could these findings be due to (1) inadequate implementation, (2) limitations in the study design, (3) flaws in the logic or theory behind the program itself, (4) a combination of all three, and/or some other factors?

While we did not collect other data (e.g., changes in practices) to be able to fully assess implementation fidelity, analysis of data on the receipt of program resources indicate a lack of participation that may have contributed to the null effects. Specifically, the measure of overall participation used in this evaluation shows that about 28 percent of Cohorts 1 to 6 units had low levels of participation and about 42 percent had moderate participation (Section D), indicating that about 70 percent of units received suboptimal "dosage" levels of the program, potentially contributing to the null effects. Similar to the overall participation, component wise, program participation is also indicative of a lack of uptake of the program resources, which may have contributed to the null findings. Specifically, although viewership across individual onboarding webinars was relatively high among units in Cohorts 3 to 6 (78–82 percent), there was a large variation in onboarding viewership among units in Cohorts 1 and 2 (24–76 percent), and relatively low participation in virtual learning groups (VLGs) across all cohorts, with only about 35 percent of units in cohorts 1 and 2 and about 45 percent of units in Cohorts 3 to 6 accessing more than half of the offered VLGs. Participation in on-demand modules was even lower, with about 27 to 28 percent of Cohorts 1 and 2 units and 26 to 28 percent of Cohorts 3 to 6 units accessing more than half of the on-demand modules for CLABSI and CAUTI, respectively.

In the previous section (Section F), we discussed implementation barriers that may also have contributed to the general findings of null effects; in the next section (Section H), we offer some recommendations on areas where further research might be needed and adaptations that might make the program more effective to its intended recipients. Below, we focus on limitations related to overall evaluation design, program implementation, and data collection, and point out which of them may have contributed to the lack of statistically significant improvements in CLABSI and CAUTI rates and urinary catheter and central line utilization.

Evaluation Design

- Despite the rigor of the interrupted time series (ITS) as an evaluation method, **the lack of a comparison group** (that is, a comparable group of units that did not receive the intervention) makes it difficult to assess whether the observed effects (or lack thereof) are due to the program or due to other concurrent or confounding events. This means that it is difficult to

disentangle the effects of the program from the effects of multiple concurrent initiatives that many of the intensive care units (ICUs) in Cohorts 1 to 6 reported participating in, or of the effects of the COVID-19 pandemic on Cohort 6 units. Moreover, it is also worth noting that the null effects in this study were generally characterized by similar rates of decline in the outcomes during both the pre-intervention and intervention periods, and the lack of a comparison series precludes us from knowing whether those that did not implement the program (but had similar characteristics to the units that did) would have done worse[51] (e.g., declined at a slower rate or had a reversal in trend to increasing during the intervention). Although the program targeted ICUs that had persistently elevated CLABSI and/or CAUTI rates, data on NHSN CLABSI and CAUTI rates in ICUs across the Nation as well data on the baseline aggregate infection rates of the six cohorts (see Appendix 6) show that infection rates have consistently declined from 2015 to 2018 and only had a slight increase in 2019, suggesting that the target population may have reached or were approaching a "floor" (lower limit), making it harder to attain or discern further improvements in rates. The analytic methods used in this evaluation were not able to account for floor effects.

- Because the "diffusion of innovation" can take time, there was no expectation of immediate level shifts in infection rates or device utilization, and indeed, prior analyses for Cohorts 1 and 2, and Cohorts 3 and 4 did not find any. Hence, this report's analysis excluded level shifts in the statistical models (as in Figure 2-b in Bernal et al., 2017) and **did not test for immediate level shifts**.
- As noted in Meddings et al. (2020), because participation in the program was voluntary among ICUs recruited to participate, the findings in this report **may not be generalizable to all ICUs in the United States**, or even to the target population of ICUs with persistently elevated CLABSI and/or CAUTI rates.
- The subgroup analyses on four outcomes by five types of subgroups resulted in numerous hypothesis tests. Because the subgroup analyses were considered as exploratory, **no adjustments were made for multiple comparisons**, inflating the chances of finding spurious statistically significant effects simply by chance. On the other hand, because subgroup analyses involve smaller sample sizes, they generally have **smaller power to detect effects.**

[51] Of course, the intent of the program is to improve outcomes, not to simply maintain the status quo.

- While we attempted to understand the effects of the pandemic on the participating units (see Section F), for parsimony and to make the ITS analysis amenable to combining all six cohorts, the statistical models did not take into account the 4-month gap in implementation in cohort 6; hence, we were not able to assess the effects of the program (if any) during the gap period.

Program Implementation

- The fact that more than 70 percent of the participating ICUs in Cohorts 1 to 6 were implementing at least three concurrent initiatives and about a quarter were involved in five or more could mean that **competing priorities** may have limited participating ICUs' capacity, resources, and interest to fully engage in the program, which in turn, may have contributed to the lack of statistically significant program effects.
- The program's target population—ICUs that have persistently high CLABSI and/or CAUTI rates—may possess characteristics (not measured in this evaluation) that make them, slower in adopting change or innovation, and consequently, **in need of time longer than the 12-month intervention period** to see meaningful reductions in their infection rates and device utilization.
- There was **variability in the timing with which ICUs implemented or received the various components of the intervention**. For example, although most Cohort 3 to 6 units submitted their Action Plans by the program deadline, some delayed their submission, shortening the time available to implement the intervention, and thus, potentially weakening the program's impact. Similarly, the timing of site visits varied among the 311 (out of 667) ICUs that had a site visit (Table A-1, Appendix 3), with about 27 percent occurring during the last 3 months of the 12-month intervention period, limiting the time left for units to experience the potential benefits from the site visit.
- Because of the **program refinements made across cohorts**, the program implemented differed across some cohorts. For example, the program implemented in Cohort 4 differed from the program used in Cohort 3 (e.g., the number of onboarding webinars was increased from four in Cohort 3 to six in Cohort 4), and from the program used in Cohorts 1 and 2 (see Appendix 1 for a description of the refinements made to the program across cohorts). Likewise, because the occurrence of the COVID-19 pandemic necessitated making changes to the program, the program used during Cohort 6 differed from those in prior cohorts. Thus, program effects estimated based on a pooled sample of multiple cohorts (such as those in this evaluation) "reflect the combined effects of the different variants of the intervention over

time, essentially estimating an average treatment effect rather than the effectiveness of any one version of the evolving intervention" (Geonnotti et al., 2013).

- Furthermore, differences in program effects across cohort groups used in the subgroup analysis by cohort (Cohorts 1 and 2, Cohorts 3, 4, and 5, and Cohort 6) are **confounded with program refinements** made across these three cohort groups.
- Because the American Hospital Association's (AHA's) data collection infrastructure only allowed for the tracking of clicks when participants accessed educational materials, AHA was not able to collect more in-depth data on participants' engagement with the program's educational offerings (e.g., how long or how well participants interacted with the educational resources). Thus, the measure used for participation level in the subgroup analysis **may not be an accurate measure of program engagement**, a limitation that may have contributed to the counterintuitive finding of the program having a negative effect on central line utilization for the substantial participation group but having null effects for the low and moderate participation groups.
- Although we attempted to make the criteria as comparable as possible, **there were differences in the criteria used to classify Cohorts 1 and 2 units, and Cohorts 3 to 6 units into low, moderate, or substantial participation levels**, so observed differences in the distribution of participation levels across cohorts may be due in part to the differences in criteria used. Moreover, despite the thoughtfulness that went into developing the method for classifying units into low, moderate, and substantial participation levels, **the rating method has not been validated,** and cutoff scores for participation levels were established after examining the distributions of participation data from the various program components rather than setting them *a priori*. Reported during coaching calls between State leads and their performance improvement coaches, as well as in some ICU and State lead exit interviews, some ICUs changed their healthcare-associated infection (HAI) focus during implementation (e.g., a unit initially indicated that they would focus on CAUTI but shifted to focusing on CLABSI halfway through due to worsening CLABSI rates). Hence, in the subgroup analysis by infection focus, the focus **may not have reflected the actual focus for some ICUs.**[52]

[52] For cohorts 1 and 2 units, the focus reported at the beginning of the intervention was used except for units who also reported their infection focus in the end-of-program ICU Assessment. For cohorts 3 to 5, the focus initially indicated in the unit's Action Plan was used. Cohort 6 units reported their focus through the Action Plans they submitted at the start of the intervention, and then again, through the updated Action Plans they submitted when the program resumed after the four-month implementation gap. As noted in Section C, for these units, the focus used in analysis combined the information from the two Action Plans.

- There was also **variability in state lead coaching capacity and skills**. Some States had clinical mentors, and some had data and analytic support, while others had support only from the National Program Team (NPT). Moreover, some State leads had upwards of 43 units participating while others had between 1 to 10 units causing variability in the feasibility of and frequency for targeted coaching to all units. The evaluation was not able to measure these important factors and was not able to assess how they affected the outcomes of interest.
- Successful implementation of the Comprehensive Unit-based Safety Program (CUSP) requires developing and reinforcing a mindset of patient safety culture across all members of the team, something that is difficult to do in a national collaborative such as this program. **Patient safety mindset was not measured in this evaluation** so we were not able to assess the degree to which it was present and how it may have affected the outcomes.

Data Collection

- Because AHA was not able to collect data beyond the intervention period, we were not able to assess whether effects were **sustained or improved after the implementation period**.
- The **lag in data used for recruitment** (approximately 11 months before start of program implementation) meant that some units identified as having persistently elevated infection rates (PEIRs) during recruitment may have already been improving in their infection rates before implementation began, making it less likely to see further improvements. For example, as noted in the subgroup analysis by cumulative attributable difference (CAD) values, some 32 percent each of the CLABSI and CAUTI analytic samples had negative CAD values during pre-intervention.
- The State Lead Quarterly Report (SLQR) **instrument used to measure CUSP adoption in cohorts 3 to 6 has not been validated**, thus, making it impossible to ascertain how accurately and consistently it measured CUSP adoption levels. Anecdotal evidence suggests that there were variations in the interpretations of the questions, and also inconsistencies in how the data was collected (e.g., some State leads collected this information during coaching calls with units, some used Survey-Monkey, and some used email). Moreover, because the data were based on State leads' report on their participating units, it relied to a large extent on how closely or accurately the state leads were able to track their units' behaviors, and is subject to the usual limitations of surveys, such as subjectivity and memory recall.

- As noted in the logic model, appropriate indwelling urinary catheter and central line insertion, maintenance, and removal are posited as the program's intermediate outcomes and serve as a pathway toward the ultimate outcomes of sustained reduction in infection rates. As such, a lack of or minimal improvement in these clinical practices and culture can weaken the beneficial effects of the program and may have contributed to the lack of significant findings. Unfortunately, while some of these data were collected at the start of the intervention through the ICU Assessment, the **lack of post-intervention data on these intermediate outcomes for Cohorts 3 to 6 and the limited post-intervention data for Cohorts 1 and 2** (as noted earlier, only 34 percent of the Cohorts 1 and 2 units responded to the ICU assessment administered at the end of the program) precludes the evaluation from having a better understanding of the program's pathway to achieving its ultimate outcomes of sustained reduction in infection rates.

H. Conclusions and Recommendations

This report provides evidence on the impact of the Agency for Healthcare Research and Quality Intensive Care Unit (AHRQ ICU) Safety Program—a multimodal intervention targeting ICUs with a high burden of central line-associated bloodstream infection (CLABSI) and/or catheter-associated urinary tract infection (CAUTI)—on the following outcomes: National Healthcare Safety Network CLABSI and CAUTI rates, population CLABSI and CAUTI rates, and central line and urinary catheter utilization ratios.

Although findings from the primary analyses did not show a statistically significant change in the rates and ratios of interest, there were notable changes that ensued, which are listed below.

- The program had a wide reach and was able to **recruit and provide training and coaching to 709 ICUs** that participated in or audited the program across 46 States, the District of Columbia, and Puerto Rico. Almost half of the States that participated in the program found the program valuable enough to enroll in more than one cohort—14 States participated in 2 cohorts and 7 states in 3 cohorts.
- The downward trends in CLABSI and CAUTI rates during both the pre-intervention and intervention periods suggest that **ICUs continued to improve patient safety reflecting nationwide reductions in incidence of CLABSI and CAUTI** reported by the Centers for Disease Control and Prevention (CDC) (Weiner-Lastinger et al., 2021; CDC, 2020 and 2021). Notably the COVID-19 pandemic disrupted this improvement as illustrated by the experience with cohort 6.

- **There were unit-level improvements**. For units that started the program with at least one CLABSI or CAUTI, 25 percent and 20 percent were able to achieve zero CLABSIs and CAUTIs, respectively, during the intervention period.
- Secondary analysis shows that **most of the units in Cohorts 3 through 6 had moderate or substantial levels of CUSP adoption** – a foundational component for a culture of safety. These findings point to an overall progress in preventing healthcare-associated infections (HAI) (CDC, 2019; Rogers, 2003; Wright, 2011).
- The National Program Team (NPT) developed **high-quality materials and educational content tailored for and well-received by participating State leads and units**. These materials were developed into a toolkit that incorporates evidence-based practices set up in a comprehensive approach to improve team culture and staff behaviors. The toolkit is arranged in a way that allows customization of the tools to meet the local needs and demands of infection reduction for ICUs after the project ends. This legacy material is published on AHRQ's website in 2022 to increase sustainability of program elements and their benefits beyond the life of the project, potentially to units that did not participate.
- Lastly, all State leads expressed that they gained **a greater understanding of specific challenges in addressing HAIs in ICUs**, which would not have been possible without the unit focus of this program.

NPT Recommendations to the Field for Future Similar ICU HAI Prevention Collaboratives

Despite the lack of statistically significant findings for the AHRQ ICU Safety Program, quality improvement and patient safety programs like this are critically important and continue to be opportunities to drive reduction of CLABSI and CAUTI rates to zero in the ICU setting. The AHRQ ICU Safety Program was designed to work in ICUs with persistently elevated infection rates (PEIR) and the participating units with PEIR varied in their performance. Of all participating units, almost 25 percent with at least one CLABSI during the pre-intervention period attained zero CLABSIs, and almost 20 percent with at least one CAUTI during pre-intervention attained zero CAUTIs during their implementation period. There were, however, a sizable number of struggling ICUs that had a weak organizational structure, an inadequate infrastructure, and/or systems shocks (e.g., lack of an engaged senior leader, engaged physician and nurse champions, and frequent turnover or shortages of staff or staff who were overwhelmed with day-to-day operations when trying to implement an initiative like the

AHRQ ICU Safety Program). Based on the experiences of the AHRQ ICU Safety Program, the NPT developed recommendations for organizations that may wish to implement a similar future program in hospitals/units with PEIR, including the application of user-centered design research strategies and some other program adaptations. The NPT also recommended a more intensive "arm" of such programs to meet the needs of those hospitals/units that lack minimum infrastructure and/or champions to successfully start and implement the program. To identify those units ready to participate in the program as is, as well as those in need of more intensive support, each unit would be required to complete a readiness assessment prior to program implementation.

Incorporate User Centered Design Research and Lessons From Non-Healthcare Disciplines to Promote Innovation Adoption

- Consider selection criteria and processes that better target hospitals/units for participating in a future program to eliminate the inclusion of units less in need of the intervention (many units were reducing their device utilization and infection rates between the time they became eligible to participate in the AHRQ ICU Safety program and when the intervention began); selection criteria should consider a PEIR threshold in the pre-intervention period that helps eliminate units from participating that are already consistently close to zero and that helps avoid attributing program success due to minor rate fluctuations/noise.
- Merge insights from implementation science research and user-centered design research to better engage frontline staff in both the decision to take on the initiative and in the adaptation/tailoring of program components to meet their needs. (Klamerus et al, 2019 and Kircher et al, 2014) and to inform implementation ramp-up strategies (Kahn et al., 2017, and Stirman et al, 2012).
- Consider looking outside medicine/health care for additional guidance on how best to implement evidence-based practices in low-performing organizations (e.g., by engaging business school faculty).
- Look at how different staffing models can alleviate delays in timeline task completion because of individual workload (e.g., prompt device removal as soon as appropriate). Include subject matter expert (SME) coaching and site visits as a requirement to support implementation validation for some or all participants. Consider other forms of implementation validation through process measures.

Other Program Adaptations

For All Participating Units

- Start the intervention sooner after cumulative attributable difference (CAD) identification/recruitment by determining eligibility for program participation with the most recent infection rate data available close to program intervention (i.e.., no more than 6 months prior) to ensure that the target hospitals/units are really in need of the program; in the AHRQ ICU Safety Program, several units that participated in the program had a positive CAD during the designated period to determine program eligibility, but were well on their way to zero CLABSIs and/or CAUTIs when they completed a readiness assessment to help determine which units can begin the program as is, and which units may need a more intensive ramp-up to the program; this is in addition to the ICU Assessment, which provides information about unit HAI and safety culture practices
- Consider extending program participation from 12 to 24 months to provide more time for units to solidify their implementation practices and experience any seasonal changes in patient mix at least twice
- Collect infection rate and device utilization data for 6–12 months post-implementation to assess longer term effects, including program "hardwiring"
- Limit participation to a smaller number of units to enable more individualized support from State leads and/or SMEs
- Consider using advanced-practice practitioners to augment the program, supplementing physician champions as needed
- Explore different staffing models to support individual workflow and task completion
- Incorporate simulation into staff trainings to help team members learn how to handle different situations
- Plan for how units will ensure the maintenance of infection prevention practices during the next pandemic or other crisis

Additional Adaptations for Units in Need of More Intensive Support

- Use a more rigorous program commitment and engagement process that requires the identification of senior hospital and unit leaders and champions to orient them to the program; this would include a kickoff meeting and quarterly conference calls

- Hold unit lead training at the start of the program focused on improving unit lead coaching and program management skills
- Engage frontline staff with ICU leadership in co-designing implementation approaches relevant to their unit's needs/challenges to improve staff engagement with the program (Klamerus et al, 2019 and Altman et al, 2018)
- Provide more intensive external and internal facilitation support (e.g., ramp-up strategies for applying the core tenets of CUSP, evidence-based practices, and QI tools; multiple site visits and check-ins with SMEs and State leads; structured training of champions using simulation and more intensive engagement of them throughout the program)

Other Recommendations

AHRQ could seek to influence—

- The widespread availability of electronic clinical decision tools for HAI prevention by advocating for electronic health record vendors to offer, distribute, and evaluate customizable decision support tools for device placement, maintenance, and removal, and for culturing stewardship
- The better preparation of physicians and nurses in reducing CLABSI and CAUTI by advocating for a greater emphasis on HAI prevention in medical and nursing school curricula

I. Appendices

1. Details of the Program Description
2. Details of the Evaluation Design and Methodology
3. Details of the Implementation Results
4. Details of the Evaluation Results
5. Monthly Aggregate Rates and Ratios
6. Baseline Aggregate and National ICU Infection Rates
7. COVID-19 Stress on Program Implementation and ICU Infection Rates

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Appendix 1. Program Description Details

(See Section B)

Table of Contents

A. Program Reach

The Agency for Healthcare Research and Quality (AHRQ) ICU Safety Program was intended to have the largest reach possible in the United States. Overall, 832 units from 540 hospitals were recruited into the program, and 709 intensive care units (ICUs) across 46 States, the District of Columbia, and Puerto Rico participated fully in the program across six cohorts. Fourteen States participated in two cohorts, and seven States participated in three cohorts. Tables A-1 and A-2 detail which States and territories participated in one or more program cohorts.

Table A-1. AHRQ ICU Safety Program Reach: Number of Registered Cohorts by State, Cohorts 1 through 6

Number of Registered Cohorts	States/Territories
One cohort (n=22)	AL, AZ, CO, DE, DC, DE, IA, ID, IN, KS, MA, MD, ME, MI, MN, MO, MT, ND, NM, RI, SD, UT, WV
Two cohorts (n=14)	AR, FL, GA, NE, NJ, NY, OH, OR, PA, SC, TN, VA, WA, WI
Three or four cohorts (n=12)	CA, CT, IL, KY, LA, MS, NC, NH, NV, OK, PR, TX
Nonparticipating States (n=4)	AK, HI, VT, WY

Table A-2. AHRQ ICU Safety Program Reach: Number of Registered Units by State and Cohort, Cohorts 1 through 6

Cohort	States/Territories (number of units)
Cohort 1 (n=212)	AR (3), AZ (11), CA (13), FL (50), GA (23), KY (21), LA (1), MS (4), NC (1), NJ (22), NV (3), NY (10), OK (8), PR (3), SC (11), TX (28)
Cohort 2 (n=153)	AL (20), AR (3), CA (27), GA (15), KY (4), LA (8), MS (6), NC (10), NJ (18), NV (4), NY (17), OK (1), PR (1), SC (1), TX (18)
Cohort 3 (n=127)	DC (5), DE (1), IL (17), IN (12), KY (1), MD (13), MI (6), MN (2), OH (17), PA (18), VA (20), WI (7), WV (8)
Cohort 4 (n=118)	CO (3), CT (7), IA (2), ID (1), KS (10), MA (8), ME (1), MO (14), MS (6), MT (1), NC (20), ND (20), NE (3), NH (3), OH (10), OR (4), SD (4), TN (11), UT (1), WA (7)
Cohort 5 (n=160)	CA (17), CT (3), FL (39), IL (10), KY (7), LA (17), NE (6), NH (3), NM (6), NV (1), OK (7), OR (1), PR (12), TX (24), WA (5), WI (2)
Cohort 6 (n=62)	CT (14), IL (12), NH (1), PA (11), RI (3), TN (16), VA (5)

B. Program Curriculum, Tools, and Resources

This section describes in detail the curriculum, tools, and other resources used during the AHRQ ICU Safety Program described in Section B of the report. Please note that, although these components influenced the online toolkit, the AHRQ Toolkit for Preventing CLABSI and CAUTI is organized differently as described also in Section B.

Webinars (Onboarding and Virtual Learning Groups)

Onboarding 1: Program Overview and Building a CUSP Team

Building an effective team to support efforts to improve patient safety, while caring for patients, can be challenging. This webinar provides an overview of the AHRQ Safety Program for ICUs: Preventing CLABSI and CAUTI and provides strategies for building a diverse Comprehensive Unit based Safety Program (CUSP) team that includes physician and nurse champions to promote program implementation on the unit.

Onboarding 2: Engaging the Team and ICU Staff

Engaging all members of the ICU team to support patient safety improvement efforts can also be challenging. This webinar focuses on strategies the CUSP team can use to obtain feedback from all ICU staff to inform interventions to prevent central line–associated bloodstream infections (CLABSIs) and catheter associated urinary tract infections (CAUTIs).

Onboarding 3: Applying CUSP in the ICU Setting

When a CLABSI or CAUTI occurs, the team needs to uncover what happened and why. This webinar covers safe design principles, how the staff can identify and learn from problem areas or defects, and brainstorm solutions to correct them.

Onboarding 4: Using Data To Drive Change and Improve Patient Safety

Collecting and evaluating the right data to monitor progress in improving patient safety is critical to program success. This webinar will describe the appropriate data units should use to evaluate performance and how to share those data results within the unit and with key hospital stakeholders.

Onboarding 5: Preventing CLABSI and CAUTI Using a Tiered Approach With CUSP Principles

Key components of the AHRQ ICU Safety Program are the technical and adaptive aspects of CLABSI and CAUTI prevention described in the program's two-tiered approach to CLABSI and CAUTI prevention. This webinar will explain how to use the two tiers to prevent CLABSIs and CAUTIs.

Onboarding 6: Quality Improvement in Action

The final onboarding webinar reinforces what teams should focus on to develop an action plan based on their ICU Assessment results and other unit data (e.g., device utilization and infection rate data). It also features group brainstorming, writing an aim statement, and doing rapid cycle plan-do-study-act (PDSA) tests on action plan components.

VLG: Action Plan To Translate Research Into Practice

With all the data sources available, what information should the CUSP team focus on when creating its action plan? This webinar describes strategies other ICU teams have used to create their plan, how they overcame challenges in implementing it, and how they launched their first PDSA test.

VLG: Teamwork and Communication With Focus on TeamSTEPPS®

Effective teamwork and communication are a key component of infection prevention. With a focus on TeamSTEPPS® tools, this webinar showcases multiple units sharing examples of teamwork and communication strategies in their ICUs.

VLG: Senior Leadership Engagement and Buy-in

Senior leadership buy-in and active engagement in patient safety initiatives go a long way in promoting staff commitment and engagement in those efforts. This webinar discusses strategies to involve senior leadership in various aspects of the program, including how to write and present to senior leaders the business case for infection prevention.

VLG: Identifying and Addressing Defects

This virtual learning group (VLG) dives deeper into how to identify and address defects to decrease risk of patient harm. This webinar shares examples of defects that affect patient safety and recommends interventions to address them.

VLG: Multidisciplinary Rounding

Multidisciplinary rounding is a core activity in improving outcomes and promoting a culture of safety in the ICU. This webinar explains how to identify and engage a team that represents different care providers as well as senior leaders, frontline staff, and patients and family members.

VLG: Engaging Physicians in CLABSI and CAUTI Prevention in the ICU

This VLG discusses a multifaceted approach to actively engaging physicians in infection prevention and provides unit team brainstorming examples to achieve that.

VLG: Ask the Experts

Many ICU care providers think that all ICU patients require an indwelling urinary catheter (IUC) or should have these devices "just in case." Subject matter experts discuss strategies for avoiding central line and IUC placement when appropriate, how to implement technical and adaptive interventions to get to zero CLABSIs and CAUTIs, and strategies to improve patient safety culture.

VLG: Patient and Family Engagement

This webinar addresses how to empower patients and their families in infection prevention, and how to garner support from physicians and nurses to support patient and family engagement. Examples are provided on ways to educate patients and family members in preventing infections (e.g., using alternatives to IUCs when appropriate and calling out inadequate care providers' hand hygiene).

VLG: Celebrating Successes and Sustaining the Gains

Even while celebrating successes in quality improvement, the infection prevention work should never stop. This webinar focuses on how units can sustain the positive changes and other gains they made while in the program and reinforces the importance of celebrating successes when they occur in the unit to motivate continued improvement.

On-Demand Learning Modules

CLABSI Prevention—Disrupting the Lifecycle of a Central Venous Catheter Device: This course consists of four learning modules to enable participants to identify evidence-based key prevention strategies to reduce CLABSIs in the ICU setting, including strategies that promote implementation.

Central Venous Catheter Indications and Alternatives—Avoiding Placement and Determining Appropriateness

- Video Duration: 13 minutes.
- Recommended Audience: All staff who care for patients with central lines. Note: Include emergency department (ED) physicians and anesthesiologists.

- Description: This module looks at how to identify the clinical indications for central venous catheters (CVCs) and how to evaluate the use of device alternatives in an ICU, and it explores adaptive strategies to use when implementing new approaches to ensure devices are used only when necessary—including identifying champions to reinforce indications and alternatives and addressing staff attitudes and concerns about changing practices.

Central Venous Catheter Insertion Bundle

- Video Duration: 27 minutes.
- Recommended Audience: Anyone who has credential to insert a central line, those who assist with insertion, and personnel who teach this skill. NOTE: Include ED physicians, anesthesiologists and anesthesia techs, radiologists, radiology techs, peripherally inserted central catheter line insertion staff, et cetera depending on where CVCs are placed in the unit's patient population. Also includes simulation lab staff if CVC insertions are taught in that setting.
- Description: This module discusses how to know which supplies are essential for inserting a CVC, and both technical and adaptive strategies to ensure they are inserted aseptically such as standardizing the type and location of supplies needed for proper insertion, empowering staff to call attention to breaks in sterile procedures, and using teamwork and communication tools like CUSP and TeamSTEPPS to promote the consistent use of CVC insertion checklists.

Central Venous Catheter Maintenance

- Video Duration: 15 minutes.
- Recommended Audience: Anyone who changes CVC dressings or cares for patients with a catheter, anyone who educates on how to perform these functions, and those who oversee or manage staff who perform these functions. NOTE: Include simulation lab staff if facility has a sim lab and skills are taught there.
- Description: This module discusses how to recognize strategies and identify interventions to employ when caring for a patient with a CVC to prevent infection. Technical interventions discussed include incorporating prompts into existing electronic medical records and using prepackaged dressing change kits. Adaptive interventions covered include having champions provide "just in time" coaching and feedback to assess individual and unit compliance, and engaging staff with practice changes to foster their buy-in.

Central Venous Catheter Removal

- Video Duration: 13 minutes.
- Recommended Audience: Anyone who removes CVCs, educates staff members on how to perform this function, or oversees staff members who perform this function. Include simulation lab staff if this function is taught there.
- Description: This module explores how to evaluate when a CVC should be removed and discusses adaptive strategies to overcome challenges to prompt removal of unnecessary CVCs. These include engaging leadership to support policies that promote prompt removal of unnecessary CVCs and identifying CLABSI physician and nurse champions to help educate and maintain awareness of the issue.

CAUTI Prevention—Disrupting the Lifecycle of an Indwelling Urinary Catheter Device: This course consists of six learning modules to enable participants identify evidence-based key prevention strategies to reduce CAUTIs in the ICU setting, including strategies that promote implementation.

Avoiding Placement and Determining Appropriateness of Indwelling Urinary Catheters

- Video Duration: 29 minutes.
- Recommended Audience: All staff members who care for patients with IUCs. NOTE: Include ED and operating room (OR) staff and physicians since most IUCs are placed in the ED or the OR.
- Description: This module guides how to identify the clinical indications for IUCs and highlights strategies to use when implementing new approaches to ensure devices are used only when necessary. One key adaptive strategy is to engage staff and leadership such as having ICU nurses and physicians develop a shared mental model in which there is agreement on when IUCs are appropriate for measuring urine output.

Alternatives to Using Indwelling Urinary Catheters

- Video Duration: 22 minutes.
- Recommended Audience: All staff members who care for patients with IUCs. NOTE: Include ED staff since many IUCs are inserted there.
- Description: This module discusses how to identify and evaluate the use of IUC alternatives in an ICU and provides strategies when implementing new approaches to ensure devices are used only when necessary. Key technical strategies include stocking the right supplies and

alternatives, and key adaptive strategies include communicating effectively among team members, units, and departments and engaging staff to be a part of the decision making, testing, and purchasing of alternatives.

Indwelling Urinary Catheter Insertion Bundle

- Video Duration: 22 minutes.
- Recommended Audience: Anyone on the unit that inserts IUCs. NOTE: Include ED and OR staff who insert catheters, including physicians in the OR. If the facility has a simulation lab, include sim lab staff to ensure what is being taught there is consistent with current evidence-based best practice.
- Description: This module highlights the essential supplies for inserting an IUC and discusses strategies to ensure IUCs are inserted aseptically. Technical strategies such as stocking kits with the necessary supplies and making them easily accessible and ensuring there are adequate facilities for hand hygiene are discussed. Recommended adaptive strategies include mindfulness during catheter insertion and using or reviewing checklists prior to insertion—all of which require team education and buy-in to practice changes.

Indwelling Urinary Catheter Maintenance

- Video Duration: 16 minutes.
- Recommended Audience: Include all staff who care for patients with IUCs. NOTE: Consider radiology, cardiac catheterization lab, transport, OR, and ED staff also, depending on where unit patients travel or are cared for outside the ICU.
- Description: This module looks at how to recognize strategies and interventions to employ when caring for a patient with an IUC to prevent infection. It discusses technical strategies such as following evidence-based maintenance bundles and working with the ED, supply chain, and transport team on aspects of the bundle. Adaptive strategies that are covered include using nurse educators and champions to provide real-time feedback, recognizing and rewarding champions, and engaging staff to share stories and motivate each other.

Prompting Removal of Unnecessary Indwelling Urinary Catheters

- Video Duration: 19 minutes.
- Recommended Audience: All staff members who care for patients with IUCs.

- Description: This module outlines how to evaluate when a patient meets the criteria for IUC removal and looks at strategies to address challenges in removing unnecessary IUCs. Technical strategies covered include standardizing postoperative catheter removal for certain patients and requiring daily assessments of catheter need by physicians. Adaptive strategies discussed include empowering nurses to remove catheters without obtaining additional orders from the physician team and building a unit culture that fosters respect among nurses and physicians and recognizes the hazards of urinary catheters.

Urine Culturing Stewardship in the ICU Setting

- Video Duration: 14 minutes.
- Recommended Audience: registered nurses, licensed practical nurses, infection preventionists, any provider who orders urine cultures, quality staff, pathology lab staff involved in processing urinalyses and urine cultures, and clinical education staff.
- Description: This module addresses best practices for urine culturing stewardship: ordering urine cultures thoughtfully so they inform (not misinform) the care of individual patients. It reviews evidence-based rationale and practical approaches to education and implementation of such best practices. Technical strategies include auditing your unit's urine culturing practices, avoiding reflexive screening, and establishing agreed-upon protocols or algorithms to follow. Adaptive strategies include creating a unit culture of safety and discussing urine culturing stewardship, addressing staff attitudes toward change, and empowering staff members to speak up and share accountability for responsible urine culturing.

CUSP Team Training Videos

Having Difficult Conversations About Preventing Infections in the ICU (6 minutes)

Difficult conversations are sometimes necessary to ensure patient safety and prevent infections. This video provides examples of how to engage the entire team so people feel both safe and compelled to speak up to change the culture in an ICU.

Creating Team Buy-in To Work Toward Zero Preventable Infections in ICUs (4 minutes)

Every ICU has probably struggled in one way or another to get staff buy-in to make change last. This video explores practical ways to engage your team in regular, open, and patient-centered discussion of unit data and goals to keep your team motivated to improve patient safety.

Addressing Attitudes and Beliefs About Preventing Infections in ICUs (6 minutes)

Many ICU teams believe they are already doing everything necessary to protect their patients from infections and that getting to zero infections is impossible. This video teaches how to take the first steps in addressing these attitudes and beliefs to create a stronger culture of safety.

Increasing Ownership and Engagement at Multiple Levels To Prevent Infections in ICUs (6 minutes)

Increasing ownership and engagement among all hospital roles is essential to the sustainability of your infection prevention efforts. This video teaches several general and effective strategies to accomplish this by taking into account your unit's unique culture.

Empowering Nurses To Implement a Protocol for Urinary Catheter Removal (5 minutes)

Taking concrete steps to empower nurses is critical for preventing infections in the ICU. This video introduces strategies for implementing nurse-driven protocols to effectively decrease catheter days and decrease infection rates.

Speaking Up During Central Line Insertion To Prevent Infections (4 minutes)

All ICU staff members need to feel empowered to speak up when it comes to keeping the patient safe from infections. This may not be the culture in your ICU currently, but this video introduces practical approaches to get it there.

Audio Interviews With CUSP Experts

How To Have Difficult Conversations With Colleagues Around Infection Prevention Practices (18 minutes)

Pat Posa, R.N., B.S.N., M.S.A., Population Health Clinical Integrations Leader at St. Joseph Mercy Health System, provides examples of how to engage the entire team so people feel both safe and compelled to speak up to change the culture in an ICU.

How To Create Team Buy-in and Motivation To Get to Zero Infections (19 minutes)

Sam Watson, M.S.A., M.T. (ASCP), C.P.P.S., Senior Vice President of Patient Safety and Quality, and Executive Director at the Michigan Health & Hospital Association Keystone Center, presents clear

examples of how to effectively communicate about unit data and goals to keep your team motivated to improve patient safety with ICU teams, peer champions, and hospital leadership.

How To Address Attitudes and Beliefs Around Infection Prevention Strategies and Techniques (16 minutes)

David Thompson, M.S., D.N.Sc., Director of Patient Safety Education in the Department of Anesthesiology and Critical Care Medicine at Johns Hopkins Medicine, examines strategies to take the first steps in addressing attitudes and beliefs to create a stronger culture of safety.

How To Increase Ownership and Engagement at Multiple Levels To Prevent Infections in ICUs (17 minutes)

Anne Donovan, M.D., Assistant Clinical Professor, Associate Program Director, Critical Care Medicine Fellowship Program, University of California San Francisco, shares different ways to encourage staff members to consistently think about and engage with infection prevention processes, data usage, goal setting, and regular touch points with staff.

How To Empower Nurses To Effectively Implement a Nurse-Driven Protocol for Removing Urinary Catheters, Including How To Obtain Buy-in From Physicians (16 minutes)

Pat Posa, R.N., B.S.N., M.S.A., Population Health Clinical Integrations Leader at St. Joseph Mercy Health System, provides practical steps for implementing effective nurse-driven protocols to decrease catheter days and decrease infection rates.

How To Empower Staff To Speak Up To Stop a Central Line Insertion if They See a Breach in Aseptic Technique, Including How To Obtain Buy-in From Physicians (15 minutes)

Anne Donovan, M.D., Assistant Clinical Professor, Associate Program Director, Critical Care Medicine Fellowship Program, University of California San Francisco, explores practical strategies to encourage a collaborative interprofessional environment throughout the entire ICU.

Program Tools and Resources

Team Roster

This tool helps unit leads assemble a team of influential leaders and staff members necessary to drive successful implementation of the AHRQ Safety Program for ICUs: Preventing CLABSI and CAUTI.

Team Engagement Tip Sheet

To be shared with ICU team members, this tip sheet summarizes what these individuals can do to contribute to a collaborative effort for this program and beyond to enhance performance and patient safety.

Why I Care Poster Template

This template asks ICU team members to share why they care about patient safety. These comments can be displayed throughout the unit.

ICU Assessment Template

This assessment aims to help the team understand current healthcare-associated infection (HAI) prevention practices, policies, and procedures to tailor the educational program to meet your needs. This form should be completed by a team of individuals with strong knowledge of current clinical and safety practices in the ICU.

Action Plan Template

Working collaboratively, team members use this template to create an action plan to address gaps in preventing CLABSI and CAUTI in the unit. The plan includes one or more gaps to be addressed, the reasons for choosing them, a desired aim statement, and steps to strategize for improvement.

Staff Safety Assessment Tool

Assessing safety is an iterative process with no defined end. The purpose of this tool is to tap into frontline staff knowledge to find risks on your unit that affect patient safety. All healthcare providers and administrative staff in the unit can use this tool. It can be completed by any healthcare provider at any time and should be completed at least twice a year.

Team Checkup Tool

Participating units were requested to complete this tool evaluating three primary domains: (1) adoption of CUSP activities, (2) implementation of CLABSI and CAUTI reduction steps, and (3) progress barriers. Due to the data collection burden expressed by unit teams, the questions were incorporated into the

ICU Assessment that units completed at the program start. Additionally, State Leads (SLs) referred to these three domains when completing their State Lead Quarterly Report questions.

CLABSI/CAUTI Quizzes and Answer Keys

There are four quizzes for each of the CLABSI prevention modules and six quizzes for each of the CAUTI prevention modules. The answer keys are posted in separate documents and include explanations from subject matter experts who contributed to the development of the modules. Use these quizzes to conduct a quick knowledge assessment of your team or to engage teams in a lunch-and-learn session.

CLABSI/CAUTI Event Reporting Tool

Event reporting tools are available individually for CLABSI and CAUTI. These can guide your team through the initial investigation for a defect analysis. As a reminder, the event report tool should not be a stand-alone tool but used as part of the CUSP Learning from Defects materials.

Sustainability Storyboard Template and Guide

Display your ICU team accomplishments to your hospital senior executives, quality committees, board of directors, and surveyors using the template and guide. You can find the slide-by-slide display instructions in the guide.

Guide to Patient Safety (GPS)

Researchers at the University of Michigan developed a guide to help hospitals detect potential challenges and identify approaches to overcoming them. The National Program Team (NPT) subject matter experts and American Hospital Association (AHA) staff as part of site visit preparation used two GPS tools— one for CLABSI and one for CAUTI.

Data Exploration Tool

Containing State- and unit-level infection and device utilization rate information in a single online location, this tool facilitates coaching by AHA performance improvement coaches (PICs) to SLs, and by SLs, to their ICUs.

Making It Work Tip Sheets

Tip sheets were created to provide ICU teams with additional information on how to implement effective strategies in the following areas. The one- to three-page sheets provided how-to information for ICU teams to address specific issues that can pose challenges. They are designed to be portable and used at the bedside or nurses station. In addition to suggested strategies, conversation starters and reference materials such as case studies and tools are included.

- Assembling the CUSP Team
- Engaging Physicians in Preventing CLABSI and CAUTI
- Engaging Physician Champions in Preventing CLABSI and CAUTI
- Celebrating Successes and Supporting Spread
- Partnering With Patients and Families To Prevent CLABSI and CAUTI
- Overcoming the "Just in Case" Mindset
- Engaging Senior Leaders in Preventing Healthcare-Associated Infections (HAIs)
- Managing Urinary Retention and Catheterization in ICU Patients with Primary Neurologic Disorders
- Chlorhexidine Bathing and Perineal Cleaning
- Empowering Nurses To Implement Nurse-Driven Protocols for Reducing CAUTI in the ICU Setting
- Engaging Staff Beyond the CUSP Team
- Multidisciplinary Rounding for Patient Safety
- Spot Coaching To Support Behavior Change

C. Cohort-Specific Components

Table C-1. AHRQ ICU Safety: Cohort-Specific Components

Component	Subcomponents	Cohorts 1 and 2	Cohorts 3 and 4	Cohort 5	Cohort 6
Unit Recruitment and Registration	**Outreach**	CDC conducted outreach.	Same as Cohorts 1-2	**MODIFIED:** AHA conducted outreach with a CDC endorsement letter.	Same as Cohort 5

Component	Subcomponents	Cohorts 1 and 2	Cohorts 3 and 4	Cohort 5	Cohort 6
	Recruitment Criteria	Some non-PEIR ICUs (without a positive CAD) enrolled in the program.	**MODIFIED:** Only PEIR ICUs (with a positive CAD) could enroll in the program.	Same as Cohorts 3–4	Same as Cohorts 3–5
Cohort Kickoff Meetings for State Leads		SLs attended a 2-day meeting at AHA to learn in more detail about program goals, CUSP fundamentals, infection and device utilization data submission, and program deliverables and timeline.	Same as Cohorts 1–2	Same as Cohorts 1–4	Kickoff meetings were a virtual 2-hour meeting.
ICU Assessments	**ICU Assessments**	Baseline and postimplementation assessments were required.	**MODIFIED:** Only baseline ICU Assessment required; postimplementation assessment requirement dropped to allow teams to minimize data collection burden in response to low completion rates.	Same as Cohorts 3–4	Same as Cohorts 3–5
	Teamwork and Communication Form	Units asked to complete monthly a separate unit teamwork and communication form called the Team Checkup Tool.	**MODIFIED:** Incorporated Team Checkup Tool questions into the baseline ICU Assessment and State Lead Quarterly Reports	Same as Cohorts 3–4	Same as Cohorts 3–5
	ICU Assessment Crosswalk	None	**NEW:** Created ICU Assessment Crosswalk, which included links of applicable program and external resources to each assessment question	Same as Cohorts 3–4	Same as Cohorts 3–5

Component	Subcomponents	Cohorts 1 and 2	Cohorts 3 and 4	Cohort 5	Cohort 6
ICU Action Plans		None	**NEW:** ICUs had to create unit action plans based on their ICU assessment.	Same as Cohorts 3–4	**MODIFIED:** Units asked to verify or revise action plans after program pause due to COVID-19.
Case Studies		None	**NEW:** C3 SLs required to submit two case studies. This was reduced to one case study for C4.	**MODIFIED:** One case study per State was required.	Because of COVID-19, SLs were allowed to submit their units' presentations at virtual all-unit, closeout meetings as their case studies. (Three States submitted case studies, and two States submitted slide presentations.)
Site Visits		SLs required to visit 50% of participating ICUs.	SLs required to visit 30% of participating ICUs beginning with C4. **NEW:** SMEs now offered to attend site visits.	Same as Cohorts 3–4	**MODIFIED:** Due to COVID-19, a virtual site visit protocol was developed, and only one site visit per State was required. Some States had in-person site visits before the pandemic. SMEs attended some in-person and virtual site visits.

Component	Subcomponents	Cohorts 1 and 2	Cohorts 3 and 4	Cohort 5	Cohort 6
Educational Curriculum	**Onboarding Webinars**	A mix of live webinars and recorded modules	**MODIFIED:** Onboarding changed to consist of all live webinars.	**MODIFIED:** Tiered approaches now tied more explicitly to CUSP concepts.	**MODIFIED:** Condensed the number of onboarding webinars from six to five
	Virtual Learning Groups (VLGs)	Live webinars that featured ICU team presentations on program implementation successes and challenges	Same as Cohorts 1–2	Same as Cohorts 1–4, with the addition of an affinity group coaching call for neuro, neurosurgery, and trauma ICUs in March 2019. This live webinar was open to Cohorts 3–5.	**MODIFIED:** Four supplemental VLGs were proposed. First occurred, second changed to a coaching call. Third and fourth cancelled due to units' limited time during the pandemic. **NEW:** Due to COVID-19 time and staffing pressures, VLG Summaries were created with topic time markers.
	CLABSI and CAUTI Prevention On-Demand Learning Modules	Prerecorded content that ICUs could access as needed and at their convenience	Same as Cohorts 1–2	Same as Cohorts 1–4	Same as Cohorts 1–5
	CUSP Training Videos & Interviews With Experts	None	**NEW:** Developed at the end of C2, units could now access CUSP training videos and Interviews with Experts.	Same as Cohorts 3–4	These resources were highlighted in the onboarding webinars for Cohort 6.
	Statewide Meetings	SLs had to hold at least one in-person meeting for their units.	**MODIFIED:** This meeting was optional; however, several States did hold at least one meeting.	Same as Cohorts 3–4	Due to COVID-19 restrictions, in-person meetings did not occur. Some States held virtual closeout meetings instead.

Component	Subcomponents	Cohorts 1 and 2	Cohorts 3 and 4	Cohort 5	Cohort 6
Coaching Support	**SL Training**	SL coaching training was provided at kickoff meetings, during monthly check-ins with performance improvement coaches (PICs), and during cohort closeout meetings.	**MODIFIED:** C3 and C4 SLs took part in two coaching sessions led by an external coaching expert to promote more standardization of coaching methods by SLs.	**MODIFIED:** PICs provided more targeted coaching to SLs. In addition, monthly SLAC calls included ongoing coaching training.	Same as Cohort 5
			NEW: SLs completed a coaching self-assessment to enable PICs to target their coaching of individual SLs.	Same as Cohorts 3–4	Same as Cohorts 3–5
	State-based Clinical Mentors	State-based clinical mentors were funded to take part in each State.	**MODIFIED:** A few States continued to use a clinical mentor but were not funded. In addition, the NPT SMEs served as clinical mentors when requested by SLs.	Same as Cohorts 3–4	Same as Cohorts 3–5
State Lead Action Council Calls		PICs and AHA managers held monthly calls with SLs to troubleshoot issues and cover specific topics to support program implementation.	Same as Cohorts 1-2	Same as Cohorts 1–4	Same as Cohorts 1–5
Data Collection		Outcome Measures: CLABSI and CAUTI rates Process Measures: CVC and IUC utilization	**NEW:** Standardized Infection Rate and Standardized Utilization Ratio now collected and submitted quarterly.	Same as Cohorts 3–4	Same as Cohorts 3–5

Component	Subcomponents	Cohorts 1 and 2	Cohorts 3 and 4	Cohort 5	Cohort 6
Other Resources and Tools	**SharePoint Discussion Board**	Board allowed ICUs, SLs, NPT SMEs, and staff to post questions and answers and share best practices.	**MODIFIED:** Email Listserv® replaced SharePoint discussion board.	Same as Cohorts 3–4	Same as Cohorts 3–5
	CLABSI and CAUTI Guides to Patient Safety	Brief troubleshooting tools to help teams examine their practices.	Same as Cohorts 1–2	Same as Cohorts 1–4	Same as Cohorts 1–5
	Making It Work (MIW) Tip Sheets	None	**NEW**: MIW Tip Sheets, expanded on topics shared in VLGs.	**ADDITION:** Additional MIW Tip Sheets released.	**ADDITION:** Additional MIW Tip Sheets released.
	CLABSI and CAUTI Event Reporting Templates	None	**NEW**: CAUTI and CLABSI Event Report templates created to enhance CUSP learning from defects process.	Same as Cohorts 3–4	Shorter versions of the event reporting tools were released. Called CLABSI and CAUTI Learning from Defects Tool, they were designed to be used at the bedside by frontline staff.
	Data Exploration Tool	None	None	**NEW:** A single, online location with visually enhanced process and outcome data to facilitate coaching by PICs to SLs, and by SLs to their ICUs	Same as Cohort 5

Component	Subcomponents	Cohorts 1 and 2	Cohorts 3 and 4	Cohort 5	Cohort 6
State Lead Closeout Meeting		SLs attended a 2-day meeting at AHA to share lessons learned and to provide added feedback about the program. In addition, coaching training was provided to assist their units to sustain their gains.	**Modified:** Coaching training by outside experts was provided.	Same as Cohorts 3–4	Due to COVID-19 restrictions, the final SLAC call served as the closeout meeting. SLs shared lessons learned and provided feedback about the program; however, no coaching training was provided because of time limitations.

AHA = American Hospital Association; C2 = Cohort 2; C3 = Cohort 3; C4 = Cohort 4; CAD = cumulative attributable difference; CAUTI = catheter-associated urinary tract infection; CDC = Centers for Disease Control and Prevention; CLABSI = central line–associated blood stream infection; COVID-19 = coronavirus disease 2019; CUSP = Comprehensive Unit-based Safety Program; CVC = central venous catheter; ICU = intensive care unit; IUC = indwelling urinary catheter; MIW = Making It Work; PEIR = persistently elevated infection rate; SL = State Lead; SLAC = State Lead Action Council; SME =subject matter expert; VLG = virtual learning group

Appendix 2. Details of Evaluation Design and Methodology

(See Section C)

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A. CAD Values for ICUs Included in the Analysis

The Cumulative Attributable Difference (CAD) represents the number of infections a unit has to prevent in order to meet the standardized infection rate (SIR) goals set forth by the U.S. Department of Health and Human Services in the National Action Plan to Prevent Health Care-Associated Infections: Road Map to Elimination (HAI Action Plan). The SIR targets are 0.5 for central line–associated blood stream infection (CLABSI) and 0.75 for catheter-associated urinary tract infection (CAUTI) by the year 2020, using 2015 as the baseline. The formula for the CAD is:

$$\text{Observed \# HAIs} - (\text{Predicted \# HAIs} \times \text{SIR goal})$$

Table A-1 shows the aggregate CAD values during the baseline period of the study. For Cohorts 1 and 2, we used the 12 months prior to intervention as baseline (February 2015 to January 2016 for Cohort 1 and October 2015 to September 2016 for Cohort 2). For Cohorts 3 through 6, because the SIRs were submitted in aggregate every calendar quarter and the predicted number of infections is needed to calculate the CAD, we used the most recent four calendar quarters prior to the start of intervention as baseline (April 2017 to March 2018 for Cohort 3, July 2017 to June 2018 for Cohort 4, January 2019 to December 2019 for Cohort 5, and October 2018 to September 2019 for Cohort 6). For Cohorts 3 through 5, we excluded quarters that overlapped between the preintervention and postintervention periods.

Although units had to provide verification of a positive CAD in their most recent 12 months of available data at the time of recruitment, not all units had an aggregate positive CAD for the project baseline period in either CLABSI or CAUTI. Table A-1 shows the number of units that had positive and negative aggregate CADs for CLABSI and/or CAUTI during the project's baseline period. Of the 658 units included in the analytic sample for CLABSI, 625 had CAD values present, and, of these, 32.5 percent (203) had a negative CAD. Of the 664 units included in the analytic sample for CAUTI, 630 had nonmissing CAD values, and, of these, 35.7 percent (225) had a negative CAD. Analysis findings on differences in program effects by subgroups based on CAD are in the report.

Table A-1. CAD values (positive and negative) during "baseline" period

Utilization Sample	Cohort	Positive CAD	Negative CAD	Total
CLABSI or Central Line Utilization Sample	Cohort 1	97 (70.8%)	40 (29.2%)	137 (100.0%)
	Cohort 2	76 (74.5%)	26 (25.5%)	102 (100.0%)
	Cohort 3	78 (65.5%)	41 (34.5%)	119 (100.0%)
	Cohort 4	59 (58.4%)	42 (41.6%)	101 (100.0%)
	Cohort 5	74 (63.2%)	43 (36.8%)	115 (100.0%)
	Cohort 6	38 (77.6%)	11 (22.4%)	49 (100.0%)
	Overall	422 (67.5%)	203 (32.5%)	625* (100.0%)
CAUTI or Urinary Catheter Utilization Sample	Cohort 1	91 (66.4%)	46 (33.6%)	137 (100.0%)
	Cohort 2	64 (62.1%)	39 (37.9%)	103 (100.0%)
	Cohort 3	84 (70.0%)	36 (30.0%)	120 (100.0%)
	Cohort 4	70 (68.0%)	33 (32.0%)	103 (100.0%)
	Cohort 5	71 (60.2%)	47 (39.8%)	118 (100.0%)
	Cohort 6	25 (51.0%)	24 (49.0%)	49 (100.0%)
	Overall	405 (64.3%)	225 (35.7%)	630* (100.0%)

B. Data Collection and Measures

For all cohorts, American Hospital Association (AHA) tracked participation of all units in the program's educational components (e.g., onboarding, on-demand modules, VLGs). Table B-1 summarizes the data collection measures and schedule, and a brief description of the measures follows.

Table B-1. Data Collection Schedule for Cohorts 1 to 6[1]

Measure Types	Measures	Cohorts on Which Measure Was Used	Frequency of Data Collection	Data Collected
Clinical Outcome Measures	NHSN CLABSI and CAUTI rates Population CLABSI and CAUTI rates	1 to 6	Monthly	• Number of CLABSIs • Number of central line days • Number of CAUTIs • Number of indwelling urinary catheter days • Number of patient days
Clinical Process Measures	Central line utilization ratio Indwelling urinary catheter utilization ratio	1 to 6	Monthly	• Number of central line days • Number of indwelling urinary catheter days • Number of patient days
Implementation Measures	Participation in program educational components	1 to 6	Varies, at the time program educational components are offered	• Attendance in onboarding webinars and VLGs; downloading of on-demand education modules

Measure Types	Measures	Cohorts on Which Measure Was Used	Frequency of Data Collection	Data Collected
	State Lead Quarterly Report (SLQR)[2]	3 to 6	Quarterly	• Adoption of CUSP elements • Challenges and successes for ICUs
	ICU Action Plan[3]	3 to 6	Beginning of program	• Gaps that units identified and planned to address during program implementation, each unit's infection focus • General infection prevention strengths and gaps
	ICU Assessment	1 to 6	Beginning and end of program for Cohorts 1 and 2; beginning of program only for Cohorts 3 to 6	• Infection prevention/safety practices and policies • Teamwork and communication • Patient Safety Culture
	Site Visit Report[4]	1 to 6	30 days after visit	• Hospital infection practices • Units' strengths and barriers for implementation
	Team Checkup Tool[5]	1 and 2	Monthly	• Progress on and barriers to program implementation

AHA = American Hospital Association; CAUTI = catheter-associated urinary tract infection; CLABSI = central line–associated bloodstream infection; CUSP = Comprehensive Unit-based Safety Program; ICU = intensive care unit; NHSN = National Healthcare Safety Network; SL = State Lead; SLQR = State Lead Quarterly Report; VLG = virtual learning group

[1] ICUs were expected to provide monthly clinical outcome and process data during the intervention and, retrospectively, for the 12 months prior to intervention. Implementation and practice measures were collected during the intervention.
[2] In Cohorts 1 and 2, State Leads (SLs) submitted monthly reports. Beginning with Cohort 3, SLs submitted the SLQR to allow more time for SLs to observe unit-level change.
[3] ICU Action Plans were collected beginning with Cohort 3. Units from these cohorts were expected to complete the ICU Action Plan after reviewing their ICU Assessment results. Cohorts 1 and 2 units were also encouraged during the onboarding process to develop action plans to assist with program implementation; however, these plans were not collected.
[4] Site Visit Reports were also conducted for Cohorts 1 and 2; the reports created by the State and unit leads following the site visit was in the form of an action plan.
[5] Team Checkup Tool was used only for Cohorts 1 and 2. Beginning in Cohort 3, questions on this tool were incorporated into the ICU Assessment and SLQR. SLs answered these questions based on their monthly check-in calls with unit leads.
Source: AHA's compilation

Clinical Outcome and Clinical Process Measures

The primary clinical outcome measures for this program were monthly NHSN CLABSI and CAUTI rates and population CLABSI and CAUTI rates. The data collection for these measures capitalized on Centers for Disease Control and Prevention (CDC) NHSN, to which program participants were already reporting data. In most cases, data from participating ICUs were available to AHA via an NHSN group established for this program. Each ICU was asked to join the AHA NHSN group and confer rights to its NHSN data. This rights conferral process constituted a data use agreement between the ICU and AHA. AHA collected ICU-level aggregate monthly counts of CLABSIs, CAUTIs, central line days, urinary catheter days, and

patient days using this secure NHSN group. Based on these data, NHSN rates were calculated using CDC's NHSN methodology (Dudeck, et al., 2011) as follows:

1. ***NHSN CLABSI rate*** was calculated by dividing the total number of CLABSI or CLABSI episodes within a given a month by the total number of central line days within the same time period, then multiplying by 1,000:

$$NHSN\ CLABSI\ Rate = \frac{CLABSI\ Episodes}{Central\ Line\ Days} \times 1{,}000$$

2. ***NHSN CAUTI rate*** was calculated by dividing the total number of CAUTI or CAUTI episodes within a given a month by the total number of catheter days within the same time period, then multiplying by 1,000:

$$NHSN\ CAUTI\ Rate = \frac{CAUTI\ Episodes}{Catheter\ Days} \times 1{,}000$$

As many quality improvement (QI) interventions (including the AHRQ ICU Safety Program) target reduction in device utilization, population CLABSI and CAUTI rates were also measured as they are standardized by the number of patient days. The latter is more stable over time than the number of device utilization days and, hence, allows the population rates to reflect reductions in CLABSI and CAUTI episodes due to reductions in utilization (Fakih, et al. 2012).[1]

3. ***Population CLABSI rate*** was calculated by dividing the total number of CLABSI episodes within a given month by the total number of patient days within the same time period, then multiplying by 10,000.

$$Population\ CLABSI\ Rate = \frac{CLABSI\ Episodes}{Patient\ Days} \times 10{,}000$$

4. ***Population CAUTI rate*** was calculated by dividing the total number of CAUTI episodes within a given month by the total number of patient days within the same time period, then multiplying by 10,000.

$$Population\ CAUTI\ Rate = \frac{CAUTI\ Episodes}{Patient\ Days} \times 10{,}000$$

[1] The downside of the population rates is that they tend to underestimate the CLABSI and CAUTI rates because their denominators (the number of patient days) pertain to all patients, including those who did not get the device and so were not at risk of developing these infections.

The clinical process measures were central line utilization and urinary catheter utilization ratio:

5. ***Central line utilization ratio*** was calculated by dividing the total number of central line days within a month by the total number of patient days within the same time period, then multiplying by 100:

$$Central\ Line\ Utilization\ Ratio = \frac{Central\ Line\ Days}{Patient\ Days} \times 100$$

   This ratio more closely assesses the relationship between central line use and patient volume. Because many CLABSI interventions are also focused on decreasing the number of central line days, this measure assesses if a reduction in central line days is the result of a decrease in utilization (i.e., ratio decreases with time) or a decrease in patient volume (i.e., ratio remains relatively constant).

6. ***Urinary catheter utilization ratio*** was calculated by dividing the total number of catheter days within a given month by the total number of patient days within the same time period, then multiplying by 100:

$$Urinary\ Catheter\ Utilization\ Ratio = \frac{Catheter\ Days}{Patient\ Days} \times 100$$

   This ratio assesses the relationship between catheter use and patient volume. Because many CAUTI interventions are also focused on decreasing the number of catheter days, this measure assesses if a reduction in catheter days is the result of a decrease in utilization (i.e., ratio decreases with time) or a decrease in patient volume (i.e., ratio remains relatively constant).

Note that, based on the above definitions, these measures are related as follows:

- $Population\ CLABSI\ rate\ =\ (NHSN\ CLABSI\ rate \times Central\ line\ utilization\ ratio)/10$
- $Population\ CAUTI\ rate\ =\ (NHSN\ CAUTI\ rate \times Urinary\ catheter\ utilization\ ratio)/10$

Overall Participation Levels

As noted in report Section C (Evaluation Design and Methodology) in the Final Report, ICUs were categorized as having a low, moderate, or substantial level of participation based on the units' participation in the program components. Because program components were substantially different between Cohorts 1 and 2 and Cohorts 3 to 6, the criteria for level of participation were defined

differently for these two sets of cohorts,[2] as shown in Tables B-2 and Table B-3. For Cohorts 1 and 2, participation level was assigned based on ICU Assessments, Team Checkup Tools (TCTs), on-demand modules, VLGs, and three specific onboarding webinars which, respectively, focused on building an implementation team, designing a plan to get to zero, and using QI to get to zero. For Cohorts 3 to 6, participation levels were assigned based on onboarding webinars, on-demand modules, and VLGs that focused on topics common across the four cohorts (such as the use of action plans to translate research into practice (TRIP), and engaging physicians in CLABSI and CAUTI prevention) or topics specific to the needs of a cohort (such as preventing CLABSI and CAUTI during a pandemic in the case of Cohort 6). The ratings were then summed,[3] and each ICU was assigned a participation level based on its total score as follows:[4] for Cohorts 1 and 2: 0–6 points = Minimal, 7–10 points = Moderate, and 11–13 points = Substantial; for Cohorts 3 to 6: 0–4 points = Minimal, 5–7 points = Moderate, and 8–9 points = Substantial.

[2] As noted in Section G of the report, there were differences in the criteria used to classify Cohorts 1 and 2 units and Cohorts 3 to 6 units into minimal, moderate, and substantial participation levels, so observed differences in the distribution of participation levels across cohorts may be due in part to the differences in criteria used.

[3] AHA, the National Program Team (NPT), and AHRQ agreed that all the educational components included in the criteria are important and found no compelling reason to give more weight to one over another. Therefore, each component was given equal weight when summing the component-specific ratings into a total score.

[4] Cutoff scores for classifying program participation into minimal, moderate, and substantial levels were established after AHA, the NPT, and AHRQ examined the distributions of participation data from the various program components rather than setting them a priori. As shown above, cutoff scores differed across cohort groups, and, as noted in Section G of the report, the rating method has not been validated.

Table B-2. Criteria for Assigning Units' Participation Ratings: Cohorts 1 and 2

Program Component	Participation	Rating
ICU Assessment	Did not submit	0
	Submitted	2
TCT	Did not submit	0
	Submitted	2
VLGs	0 VLGs	0
	1–2 VLGs	1
	3–4 VLGs	2
	5 or more VLGS	3
CLABSI and CAUTI On-Demand Modules	0 of 9 modules	0
	1–2 of 9 modules	1
	3–5 of 9 modules	2
	6 or more of 9 modules	3
Onboarding Webinars 1) Building an Implementation Team 2) Using QI To Get to Zero 3) Design a Plan To Get to Zero	0 webinars	0
	Viewed 1 webinar	2
	Viewed 2 webinars (one must have been webinar #1)	3

ICU = intensive care unit; QI = quality improvement; TCT = Team Checkup Tool; VLG = virtual learning group

Notes: A unit was given a rating for its participation in each program component. The ratings were then summed across program components, and a participation level was assigned to each unit as follows: minimal=0–6 points, moderate=7–10 points, or substantial=11–13 points.

Table B-3. Criteria for Assigning Units' Participation Ratings: Cohorts 3 Through 6

Educational Offering	Participation	Rating
On-Demand modules	Viewed 1 or 2 or fewer out of 10 on-demand modules	1
	Viewed 3–4 out of 10 on-demand modules	2
	Viewed at least 5 out of 10 on-demand modules	3
Onboarding Webinars[1]	Viewed fewer than half of onboarding webinars Cohort 3: 1 out of 3 webinars Cohorts 4 and 5: 1–2 out of 6 webinars Cohort 6: 1–2 out of 5 webinars	1
	Viewed the following onboarding webinars Cohort 3: 2 out of 3 webinars Cohorts 4 and 5: 3–4 out of 6 webinars Cohort 6: 3–4 out of 5 webinars	2
	Viewed the following onboarding webinars Cohort 3: all 3 webinars Cohorts 4 and 5: 5–6 webinars Cohort 6: 5 out of 5 webinars	3
VLGs[2] Four Cohort 3 VLGs Three Cohort 4 VLGs	Participated in one of the VLGs (by cohort)	1
	Participated in two of the VLGs (by cohort)	2
	Participated in three or more of the VLGs (by cohort)	3

AHA = American Hospital Association; CAUTI = catheter-associated urinary tract infection; CLABSI = central line–associated bloodstream infection; CUSP = Comprehensive Unit-based Safety Program; ICU = intensive care unit; TRIP = translate research into practice; VLG = virtual learning group

Notes: A unit was given a rating for each educational offering. The ratings were summed to arrive at a total score for each unit. The unit was then assigned a low, moderate, or substantial participation level based on the total score as follows: minimal=0–4 points, moderate=5–7 points, or substantial=8–9 points.
Source: AHA's analysis based on participation data.

[1] There were four onboarding webinars for Cohort 3, but one of them provided only a program overview so was not included in the ratings.
[2] Cohort 3 VLGs included: "Action Plan To Translate Research to Practice," "Preventing CLABSI and CAUTI Using a Tiered Approach," "Teamwork and Communication," "Engaging Physicians in CLABSI and CAUTI Prevention in the ICU." Cohort 4 VLGs included: "Action Plan To Translate Research to Practice," "Teamwork and Communication," "Engaging Physicians in CLABSI and CAUTI Prevention in the ICU," "Identifying and Addressing Defects." Cohort 5 VLGs included: "Action Plan to TRIP," "Identifying and Addressing Defects," "Engaging Physicians in CLABSI and CAUTI Prevention." Cohort 6 VLGs included: "Action Plan To Translate Research into Practice," "Resuming the ICU Safety Program: Resiliency, CUSP and Action Plan," "Teamwork and Communication Using CUSP and TeamSTEPPS," Preventing CLABSI & CAUTI During a Pandemic…What's Tried and True Is New Again: Technical and Socio-adaptive Strategies."

CUSP Adoption Composite and Subdomain Scores

An overall composite measure of each participating ICU's adoption of Comprehensive Unit-based Safety Program (CUSP) elements was calculated based on SLs' responses to the 11 "yes/no" questions from the State Lead Quarterly Report (SLQR) (Table B-4). Specifically, for each ICU, the percentage of "Yes" responses to the 11 questions was calculated for each quarter. These quarterly "percent yes" scores

were then averaged across all quarters to generate an overall composite score for each unit. Similar to the approach used for participation data, AHA used this composite measure to classify each ICU as having a low, moderate, or substantial degree of CUSP adoption as follows: 0 percent to 70 percent = Low, >70 percent to 85 percent = Moderate, and >85 percent = Substantial.

Table B-4. CUSP Elements and Subdomains as Measured Through 11 Questions from the State Lead Quarterly Reports (SLQRs)

Question	CUSP Element: In the Past Quarter, Did the Unit Do the Following?	Subdomain
1	Met as a CUSP team to review progress toward action plan goals?	Goals
2	Worked toward meeting their action plan goals?	Goals
3	Piloted an intervention using tests of change cycles? (e.g., Plan Do Study Act (PDSA) cycle)	Testing
4	Met with hospital senior leadership?	Leader support
5	Conducted safety rounds with senior leadership?	Leader support
6	Met with leaders outside of team meetings?	Leader support
7	Engaged a physician champion for support?	Champion
8	Engaged a nurse champion for support?	Champion
9	Shared CLABSI and/or CAUTI data with frontline staff?	Data
10	Posted data about days since last infection?	Data
11	Conducted a defect analysis? (e.g., Root Cause Analysis)	Testing

CAUTI = catheter-associated urinary tract infection; CLABSI = central line–associated blood stream infection; CUSP = Comprehensive Unit-based Safety Program; PDSA = plan-do-study-act; SLQR = State Lead Quarterly Report

Source: State Lead Quarterly Report

To better understand the adoption of various aspects of CUSP, the 11 questions were further categorized into 5 subdomains: Goals, Testing, Leader Support, Champion, and Data. A composite score was created for each subdomain using the same procedure as the overall CUSP composite score.

Figure B-4 shows the average subdomain and overall composite scores for each cohort and for the combined Cohorts 3 to 6 sample. Appendix 3, Table B-1 provides the corresponding descriptive statistics on these scores.

C. Analytic Samples

Table C-1 summarizes recruitment and retention rates, overall and by cohort. Overall retention rate was 85.3 percent.[5] Cohort-specific retention rates were relatively high but varied across cohorts (see Table C-1). From highest to lowest, the retention rates were 97.6 percent for Cohort 3, 89.8 percent for Cohort

[5] Audit units were units that did not meet the program eligibility criteria of having a positive CAD for CLABSI and/or CAUTI but were allowed to participate because they had an eligible participating unit from the same hospital. In addition, five eligible units from Cohort 5 were marked as audit for not completing the ICU Action Plan. Audit units were not included in the evaluation.

4, 84.4 percent for Cohort 1, 81.3 percent for Cohort 5,[6] 80.6 percent for Cohort 6, and 79.1 percent for Cohort 2 (Table C-1).

Analysis of the timing of withdrawals shows that, overall, the majority of the 122 total withdrawals occurred during the beginning (42.6%) or middle (41.0%) of the intervention period. However, as with the retention rate, the timing also varied across cohorts.

The most frequently cited reasons for withdrawal also varied across cohorts. For Cohorts 1 and 2, these were competing priorities with other QI initiatives, lack of a team to focus on the program, insufficient human resources, and "other" reasons.[6] Cohorts 3 and 4, on the other hand, most frequently cited limited ownership and involvement at the senior executive, unit management, or the ICU staff level. Based on the information from SL interviews, units who withdrew had lack of buy-in for the project or suffered system shocks due to executive-level or team leadership turnover. In Cohorts 5 and 6, the most common reasons were limited ownership from senior executives and ICU leadership and insufficient staffing or high turnover.

Table C-1. Recruitment and Retention, Overall and by Cohort

Cohort	Registered Hospitals	Registered Units	Withdrawn Units	Active Units[1]	Retention Rate[2]	Auditing Units	Participating Units	Evaluation Units[3]
Cohort 1	132	212	33	178	84.4%	4	174	165
Cohort 2	88	153	32	121	79.1%	1	120	106
Cohort 3	87	127	3	124	97.6%	1	123	123
Cohort 4	86	118	12	106	89.8%	0	106	106
Cohort 5	110	160	30	130	81.3%	11	119	118
Cohort 6	37	62	12	50	80.6%	1	49	49
Overall	540	832	122	709	85.3%	18	691	667

[1] Active Units = Auditing Units + Participating Units
[2] Retention Rate = Active Units / Registered Units
[3] Evaluation units include participating units that had outcome data in at least 3 months of the preintervention period and at least 3 months of the intervention period.

Analysis of the timing of withdrawals shows that, overall, the majority of the 122 total withdrawals occurred during the beginning (42.6%) or middle (41.0%) of the intervention period. However, as with

[6] "Other" reasons included: organizational restructuring staff and leadership turnover or shortages, significant and sustained improvement in CLABSI/CAUTI, and unit merging with another participating unit.

the retention rate, the timing also varied across cohorts (see Appendix 2, Table C-1 for details as well as the reasons cited for withdrawal).

The most frequently cited reasons for withdrawal also varied across cohorts. For Cohorts 1 and 2, these were competing priorities with other QI initiatives, lack of a team to focus on the program, insufficient human resources, and "other" reasons. Cohorts 3 and 4, on the other hand, most frequently cited limited ownership and involvement at the senior executive, unit management, or the ICU staff level. Based on the information from SL interviews, units who withdrew had lack of buy-in for the project or suffered system shocks due to executive-level or team leadership turnover. In Cohorts 5 and 6, the most common reasons were limited ownership from senior executives and ICU leadership and insufficient staffing/high turnover.

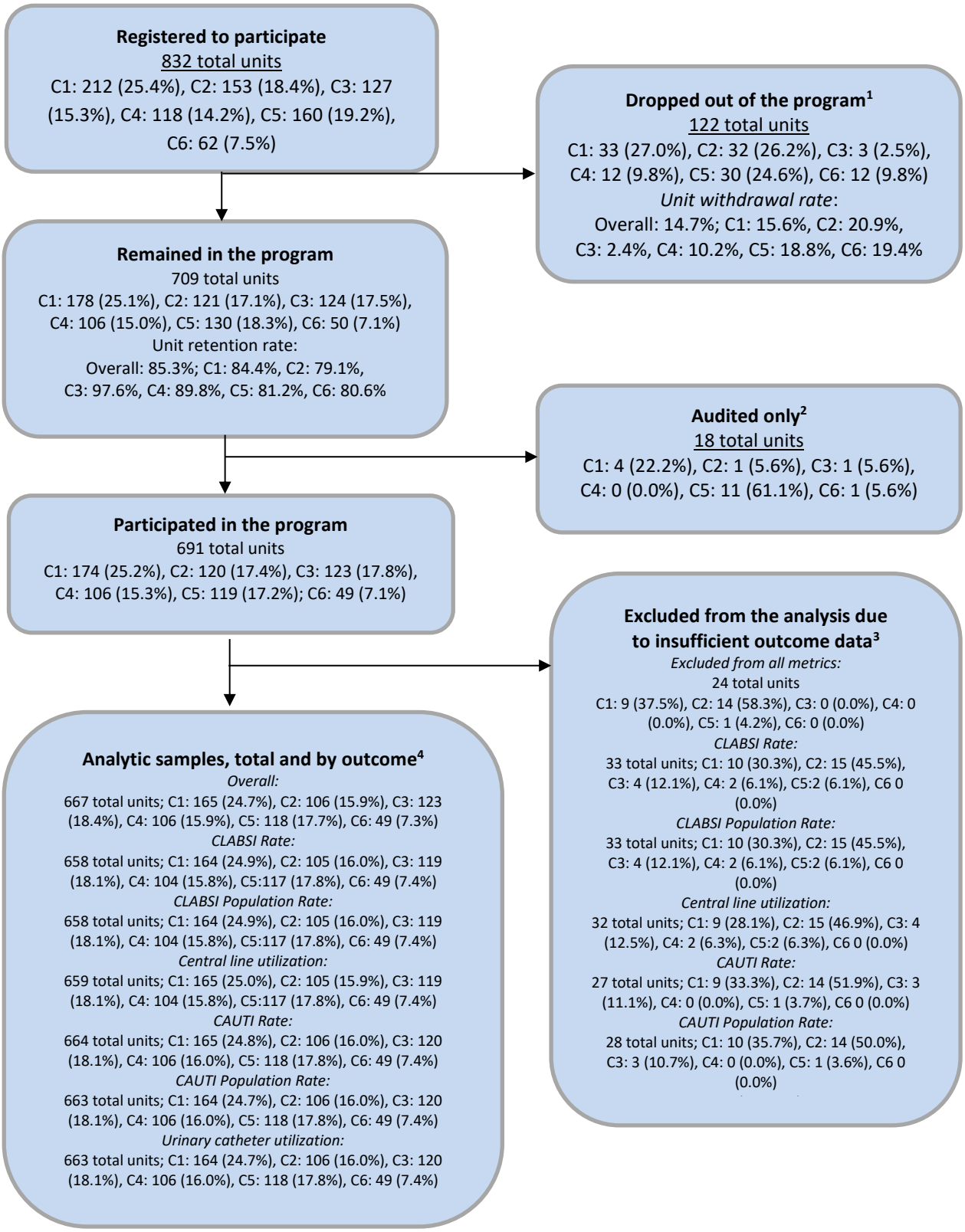
Table C-2. Timing of Withdrawals (Program Month), Overall and By Cohort

Cohort	Beginning/Onboarding (Months 1 to 4)	Middle/Maintenance (Months 5 to 8)	End of Cohort/Sustainability (Months 9 to 12)	Total Withdrawals
Cohort 1	11 (33.3%)	13 (39.4%)	9 (27.3%)	33 (100%)
Cohort 2	11 (34.4%)	20 (62.5%)	1 (3.1%)	32 (100%)
Cohort 3	1 (33.3%)	0 (0.0%)	2 (66.7%)	3 (100%)
Cohort 4	5 (41.7%)	2 (1.7%)	5 (41.7%)	12 (100%)
Cohort 5	14 (46.7%)	13 (43.3%)	3 (10.0%)	30 (100%)
Cohort 6	10 (83.3%)	2 (16.7%)	0 (0.0%)	12 (100%)
Overall	52 (42.6%)	50 (41.0%)	20 (16.4%)	122 (100%)

AHA = American Hospital Association

Notes: Withdrawals are from data collected through April 30, 2021, which includes all program months for Cohorts 1 to 6.
Source: AHA's calculations based on registration and participation data collected by AHA

Figure C-1. Analytic File Construction for Each Outcome (Cohorts 1 to 6): NHSN CLABSI and CAUTI Rates, Population CLABSI and CAUTI Rates, Urinary Catheter Utilization Ratio, and Central Line Utilization Ratio[1]



AHA = American Hospital Association; C1 = Cohort 1; C2 = Cohort 2; C3 = Cohort 3; C4 = Cohort 4; C5 = Cohort 5; C6 = Cohort 6; CAD = cumulative attributable difference; CAUTI = catheter-associated urinary tract infection; CLABSI = central line–associated bloodstream infection; HIIN = Hospital Improvement Innovation Network; NHSN = National Healthcare Safety Network

Source: AHA's analysis based on registration, participation, and submission data collected by AHA

[1] The number of withdrawals reported here are as of data collected through April 30, 2021, which encompasses the full intervention period for C1 through C6.
[2] "Audited only" means that the unit participated in the program but did not meet the program eligibility criterion of having a positive CAD for CLABSI and/or CAUTI during the most recent 12 months of data available during the identification phase of the recruitment (see section on Recruitment). Five units in Cohorts 1 and 2 audited the program. In Cohorts 3 to 5, a unit could audit if it had an eligible unit from the same hospital participating in the program. Five eligible units from Cohort 5 were changed to an audit status for not completing a key program element, the ICU Action Plan. Four units from Puerto Rico were marked as audit because some of the Puerto Rican hospitals do not submit data to NHSN. AHA was unable to calculate their CAD to determine eligibility; historical AHA HIIN data was used to calculate the CAD for program eligibility.
[3] For each outcome measure, the analyses were limited to active, nonaudit units with at least 3 months of valid (non-0/0) outcome data in the preintervention period and at least 3 months of valid (non-0/0) outcome data in the intervention period.
[4] Of the 691 active, nonaudit units that counted as participating, 667 met criteria for inclusion into at least 1 of the analytic samples.

Sample Characteristics

Table C-3. Characteristics of ICUs Included in Evaluation, by Cohort and Overall (Percentage of Units)

Characteristics	Subgroups	Cohort 1	Cohort 2	Cohort 3	Cohort 4	Cohort 5	Cohort 6	Overall
ICU Characteristics	Number of units	165	106	123	106	118	49	667
Number of beds[1]	Mean (SD)	17.6 (8.2)	14.0 (6.1)	16.3 (6.7)	16.0 (7.4)	15.9 (8.1)	18.8 (8.2)	16.3 (7.6)
	Median (Range)	16.0 (6 to 62)	12.0 (4 to 33)	16.0 (4 to 36)	14.5 (5 to 42)	14.0 (4 to 39)	16.0 (8 to 40)	15.0 (4 to 62)
	Small (1–5 beds)	0.0	1.9	1.6	0.9	1.7	0.0	1.1
	Medium (6–15 beds)	41.7	60.0	48.0	51.9	53.4	40.8	49.4
	Large (16–30 beds)	50.3	36.2	48.8	41.5	36.4	46.9	43.7
	Very Large (>30 beds)	8.0	1.9	1.6	5.7	8.5	12.2	5.9
NHSN Location Type[2]	Medical/Surgical Critical Care	79.9	76.4	68.3	74.5	74.6	71.4	74.8

	Medical/ Surgical	48.2	38.7	49.6	48.1	57.6	51.0	48.8
	Medical	20.1	25.5	11.4	17.9	11.9	16.3	17.3
	Surgical	11.6	12.3	5.7	8.5	5.1	4.1	8.4
	Oncology Medical-Surgical	0.0	0.0	1.6	0.0	0.0	0.0	0.3
	Cardio/Cardiothoracic Critical Care	10.4	15.1	18.7	17.9	15.3	14.3	15.0
	Surgical Cardiothoracic	6.7	8.5	13.0	8.5	6.8	8.2	8.6
	Medical Cardiac	3.7	6.6	5.7	9.4	8.5	6.1	6.5
	Neurological/ Neurosurgery Critical Care	3.7	3.8	7.3	3.8	7.6	14.3	5.9
	Neurosurgical	2.4	2.8	5.7	2.8	4.2	10.2	4.1
	Neurologic	1.2	0.9	1.6	0.9	3.4	4.1	1.8
	Burn/Trauma Critical Care	6.1	4.7	5.7	3.8	2.5	0.0	4.4
	Trauma	3.7	2.8	3.3	1.9	2.5	0.0	2.7
	Burn	2.4	1.9	2.4	1.9	0.0	0.0	1.7

AHA = American Hospital Association; ICU = intensive care unit; NHSN = National Healthcare Safety Network; SD = standard deviation

[1] Three units (two from Cohort 1 and one from Cohort 2) did not provide their bed size.

[2] The categorization of ICU location types follows the definitions provided by NHSN. One unit from Cohort 1 did not provide its ICU location type.

Notes: Information on unit bed-size and ICU location type was provided by participants upon registration for Cohorts 3 to 5.

Source: AHA's analysis based on registration data collected by AHA

Table C-4. Characteristics of Hospitals Included in Evaluation, by Cohort and Overall (Percentage of Units)

Characteristics	Subgroup	Cohort 1	Cohort 2	Cohort 3	Cohort 4	Cohort 5	Cohort 6	Overall
Hospital Characteristics	Number of hospitals	109	63	84	76	84	27	435*
Number of Beds	Mean (SD)	411.9 (410.7)	286.9 (186.2)	323.5 (213.1)	327.8 (237.0)	424.5 (411.9)	413.1 (343.5)	365.4 (325.2)
	Median (Range)	305.0 (35 to 2,700)	223.0 (47 to 929)	276.5 (64 to 1,031)	256.0 (52 to 1,291)	303.5 (30 to 2,875)	288.0 (91 to 1,455)	283.0 (30 to 2,875)
	Small (<100 beds)	10.1	9.5	9.5	9.2	11.9	3.7	9.7
	Medium (100–299 beds)	53.2	69.8	66.7	60.5	48.8	59.3	59.5
	Large (300+ beds)	36.7	20.6	23.8	30.3	39.3	37.0	30.8
Teaching Status	Teaching	71.6	57.1	77.4	73.7	76.2	77.8	72.0
	Nonteaching	28.4	42.9	22.6	26.3	23.8	22.2	28.0
Urbanicity	Rural	15.6	15.9	13.1	11.8	6.0	3.7	11.7

	Urban	84.4	84.1	86.9	88.2	94.0	96.3	88.3
Ownership Status	For-profit	21.1	20.6	9.5	10.5	20.2	7.4	15.9
	Government	20.2	22.2	9.5	17.1	11.9	0.0	14.9
	Nonprofit	58.7	57.1	81.0	72.4	67.9	92.6	69.2

AHA = American Hospital Association; NHSN = National Healthcare Safety Network; SD = standard deviation

Notes: Percentages for hospital characteristics are based on the total number hospitals included in the evaluation (as opposed to units).

Source: For Cohorts 1 and 2, AHA's analysis is based on data from the 2016 AHA annual survey. For Cohorts 3, 4, and 5, it is based on the 2018 AHA Annual Survey. For Cohort 6, it is based on the 2019 AHA Annual Survey. In the case of one Cohort 3 hospital and one Cohort 5 hospital where AHA data were not available, the 2018 NHSN survey was used.

* The total number of hospitals does not equal the sum of the hospitals from each cohort because eight hospitals were in more than one cohort.

Appendix 3. Details of Implementation Results

(See Section D)

Table of Contents

A. Participation by Program Component and Overall Participation Levels

This section of the appendix summarizes unit participation in various program components, organized according to the set of cohorts for which these program components were applicable, as follows:

1. All cohorts (Cohorts 1 to 6)
2. Cohorts 1 and 2 only
3. Cohorts 3 to 6 only

In addition, this section also describes the criteria used to classify units into participation levels (low, moderate, substantial). Because the program components differed between Cohorts 1 and 2 and Cohorts 3 to 6, different criteria were used for these two sets of cohorts.

Participation by Program Component

Program Components Applicable to Cohorts 1 through 6

Table A-1. Percentage of Units' Submission for ICU Assessments and Site Visits, Overall and by Cohort

Quarter	Cohort 1 (n=165)	Cohort 2 (n=106)	Cohort 3 (n=123)	Cohort 4 (n=106)	Cohort 5 (n=118)	Cohort 6 (n=49)	Overall (n=667)
ICU Assessments	154 (93.3%)	91 (85.8%)	123 (100.0%)	106 (100.0%)	118 (100.0%)	49 (100.0%)	641 (96.1%)
Site Visits	64 (38.8%)	47 (44.3%)	69 (56.1%)	55 (51.9%)	65 (55.1%)	11 (22.4%)	311 (46.6%)

ICU = intensive care unit

Table A-2. Percentage of Site Visits that Occurred in the Beginning, Middle, and End of the Implementation Period, by Cohort

Sample	Beginning/Onboarding (Months 1 to 4)	Middle/Maintenance (Months 5 to8)	End of Cohort/Sustainability (Months 9 to 12)	Total Site Visits
Cohort 1	4 (6.6%)	34 (55.7%)	23 (37.7%)	61 (100.0%)
Cohort 2	9 (19.2%)	28 (59.6%)	10 (21.3%)	47 (100.0%)
Cohort 3	6 (9.1%)	41 (62.1%)	19 (28.8%)	66 (100.0%)
Cohort 4	13 (23.6%)	19 (34.6%)	23 (41.8%)	55 (100.0%)
Cohort 5	36 (55.4%)	23 (35.4%)	6 (9.2%)	65 (100.0%)
Cohort 6	4 (40.0%)	4 (40.0%)	2 (20.0%)	10 (100.0%)
Overall	72 (23.7%)	149 (49.0%)	83 (27.3%)	304 (100.0%)

Notes: One Cohort 5 unit had a site visit in baseline month 12. Its site visit is counted in the "Beginning/Onboarding (Months 1 to 4)" category.

This table excludes the following site visits:

- Seven site visits that occurred outside of the 12-month intervention period in month 13: 3 in Cohort 1, 3 in Cohort 3, 1 in Cohort 6.
- Two Cohort 3 units did not submit a site visit date in their site visit report; the site visit date used is an approximation based on the date when the State lead submitted the report.
- Four Cohort 5 Puerto Rico units had multiple site visits. The date of the first site visit conducted was used in this analysis.

Program Components Applicable to Cohorts 1 and 2 Only

Table A-3. Percentage Participation in Onboarding and Other Webinars, Overall and by Cohort

	Webinars	Cohort 1 (n=165)	Cohort 2 (n=106)	Overall (n=271)
Onboarding Webinars	Using Quality Improvement To Get to Zero	134 (81.2%)	30 (28.3%)	164 (60.5%)
	Building an Implementation Team	136 (82.4%)	71 (67.0%)	207 (76.4%)
	ICU Curriculum Overview	86 (52.1%)	0 (0.0%)	86 (31.7%)
	Data I: The Power of Measuring Results	81 (49.1%)	14 (13.2%)	95 (35.1%)
	Data II: A 3-Step Measurement Plan	77 (46.7%)	0 (0.0%)	77 (28.4%)
	Data III: Using Data To Drive Change: Communications and Transparency	65 (39.4%)	0 (0.0%)	65 (24.0%)
Additional Webinars*	Design a Plan To Get to Zero: Using a tiered approach to translate evidence-based practice into care	91 (55.2%)	78 (73.6%)	169 (62.4%)

ICU = intensive care unit

*This webinar was included in the participation criteria for Cohorts 1 and 2.

Table A-4. Percentage Categories for VLG Viewership, Overall and by Cohort*

Live or recorded VLG: Percentage of VLGs attended or viewed	Cohort 1 (n=156)	Cohort 2 (n=106)	Overall (n=271)
0%	23 (13.9%)	2 (1.9%)	25 (9.2%)
>0% to <50%	76 (46.1%)	74 (69.8%)	150 (55.3%)
≥50% to 100%	66 (40.0%)	30 (28.3%)	96 (35.4%)

AHA = American Hospital Association; ICU = intensive care unit; VLG = virtual learning group

* VLGs for Cohorts 1 and 2 did not have specific titles, because each month AHA featured an hour-long presentation from an ICU team displaying how it implemented the program in its hospital. All participants were asked to share program successes and challenges and ask questions of each other. VLGs were an opportunity for peer-to-peer learning.

Table A-5. Percentage Participation in CLABSI On-Demand Modules, Overall and by Cohort

CLABSI On-demand Modules	Cohort 1 (n=156)	Cohort 2 (n=106)	Overall (n=271)
CVC 101: Avoiding Placement of CVC: Indications and Alternatives	58 (35.2%)	25 (23.5%)	83 (30.6%)
CVC 201: Central Venous Catheter Insertion Bundle	52 (31.5%)	23 (21.7%)	75 (27.7%)
CVC 301: Central Venous Catheter Maintenance	36 (21.8%)	19 (17.9%)	55 (20.3%)
CVC 401: Central Venous Catheter Removal	33 (20.0%)	18 (17.0%)	51 (18.8%)

CLABSI = central line–associated bloodstream infection; CVC = central venous catheter

Table A-6. Percentage Participation Categories in CLABSI Module Viewership, Overall and by Cohort

CLABSI Modules: Percentage of CLABSI modules viewership	Cohort 1 (n=156)	Cohort 2 (n=106)	Overall (n=271)
0%	104 (63.0%)	78 (73.6%)	182 (67.2%)
>0% to <50%	10 (6.1%)	7 (6.6%)	17 (6.3%)
≥50% to 100%	51 (30.9%)	21 (19.8%)	72 (26.6%)

CLABSI = central line–associated bloodstream infection

Table A-7. Percentage Participation in CAUTI On-Demand Modules, Overall and by Cohort

CAUTI On-Demand Modules	Cohort 1 (n=156)	Cohort 2 (n=106)	Overall (n=271)
IUC 101: Indwelling Urinary Catheter Indications	85 (51.5%)	44 (41.5%)	129 (47.6%)
IUC 102: Alternatives to Indwelling Urinary Catheters	76 (46.1%)	25 (23.5%)	101 (37.3%)
IUC 201: Indwelling Urinary Catheter Insertion Bundle	50 (30.3%)	20 (18.6%)	70 (25.8%)
IUC 301: Maintaining Awareness and Proper Care of IUCs in Place	42 (25.5%)	27 (25.7%)	69 (25.5%)
IUC 401: Prompting Removal of Unnecessary Indwelling Urinary Catheters	34 (26.1%)	26 (24.5%)	60 (22.1%)

CAUTI = catheter-associated urinary tract infection; IUC = indwelling urinary catheter

Table A-8. Percentage Participation Categories in CAUTI Module Viewership, Overall and by Cohort

CAUTI Modules: Percentage of CAUTI Modules Viewership	Cohort 1 (n=156)	Cohort 2 (n=106)	Overall (n=271)
0%	69 (41.8%)	58 (54.7%)	127 (46.9%)
>0% to <50%	46 (27.9%)	21 (19.8%)	67 (24.7%)
≥50% to 100%	50 (30.3%)	27 (25.5%)	77 (28.4%)

CAUTI = catheter-associated urinary tract infection

Program Components Applicable to Cohorts 3, 4, 5, and 6 Only

Table A-9. Percentage Participation in Onboarding Webinars, Overall and by Cohort

Onboarding Webinars	Cohort 3 (n=123)	Cohort 4 (n=106)	Cohort 5 (n=118)	Cohort 6 (n=49)	Overall (n=396)
Program Overview	110 (89.4%)	N/A	N/A	N/A	N/A
Building an Engaged CUSP Team	98 (79.7%)	82 (77.4%)	98 (83.1%)	49 (100.0%)	327 (82.6%)
Engaging the CUSP Team and ICU Staff	N/A	85 (80.2%)	81 (68.6%)	47 (95.9%)	N/A
Using Data to Drive Change	103 (83.7%)	86 (81.1%)	87 (73.7%)	47 (95.9%)	323 (81.6%)
Apply CUSP in the ICU Setting	N/A	79 (74.5%)	78 (66.1%)	N/A	N/A
Quality Improvement in Action	95 (77.2%)	87 (82.1%)	78 (66.1%)	47 (95.9%)	307 (77.5%)
Preventing CLABSI and CAUTI Using a Tiered Approach With CUSP Principles	N/A	87 (82.1%)	83 (70.3%)	45 (91.8%)	N/A

CAUTI = catheter-associated urinary tract infection; CLABSI = central line–associated bloodstream infection; CUSP = Comprehensive Unit-based Safety Program; ICU = intensive care unit

Table A-10. Percentage Participation in Virtual Learning Group (VLG), Overall and by Cohort

Live or Recorded VLG	Cohort 3 (n=123)	Cohort 4 (n=106)	Cohort 5 (n=118)	Cohort 6 (n=49)	Overall (n=396)
Action Plan to Translate Research into Practice	93 (75.6%)	70 (66.0%)	76 (64.4%)	33 (67.3%)	272 (68.7%)
Preventing CLABSI and CAUTI Using a Tiered Approach With CUSP Principles	95 (77.2%)	N/A	N/A	N/A	N/A
Using Safe Design Principles To Identify and Learn From Defects	14 (11.4%)	35 (33.0%)	72 (61.0%)	35 (71.4%)	156 (39.4%)
Sustaining the Gains and Spreading What Works	69 (56.1%)	23 (21.7%)	49 (41.5%)	N/A	N/A
Engaging Physicians in CLABSI and CAUTI Prevention in the ICU	63 (51.2%)	59 (55.7%)	57 (48.3%)	21 (42.9%)	200 (50.5%)
Using Patient Safety Culture Survey Results To Drive Change and Improve Safety	60 (48.8%)	58 (54.7%)	57 (48.3%)	N/A	N/A
Ask the Experts	58 (47.2%)	52 (49.1%)	68 (57.6%)	N/A	N/A
Senior Executive Rounding	50 (40.7%)	42 (39.6%)	53 (44.9%)	N/A	N/A
Teamwork and Communication	52 (42.3%)	35 (33.0%)	N/A	41 (83.7%)	N/A
Patient and Family Engagement	36 (29.3%)	26 (24.5%)	46 (39.0%)	20 (40.8%)	128 (32.3%)
Celebrating Successes	34 (27.6%)	20 (18.9%)	40 (33.9%)	21 (42.9%)	115 (29.0%)
Resuming the ICU Safety Program: Resiliency, CUSP, and Action Plan	N/A	N/A	N/A	30 (61.2%)	N/A
Preventing CLABSI & CAUTI During a Pandemic… What's Tried and True Is New Again: Technical and Socio-adaptive Strategies	N/A	N/A	N/A	32 (65.3%)	N/A
Senior Leadership Engagement and Buy-in	N/A	N/A	N/A	29 (59.2%)	N/A

CAUTI = catheter-associated urinary tract infection; CLABSI = central line–associated bloodstream infection; CUSP = Comprehensive Unit-based Safety Program; ICU = intensive care unit; VLG = virtual learning group

Table A-11. Percentage Categories for VLG Viewership, Overall and by Cohort

Live or Recorded VLG: Percentage of VLGs attended/viewed	Cohort 3 (n=123)	Cohort 4 (n=106)	Cohort 5 (n=118)	Cohort 6 (n=49)	Overall (n=396)
0%	8 (6.5%)	11 (10.4%)	17 (14.4%)	4 (8.2%)	40 (10.1%)
>0% to <50%	56 (45.5%)	63 (59.4%)	45 (38.1%)	14 (28.6%)	178 (44.9%)
≥50% to 100%	59 (48.0%)	32 (30.2%)	56 (47.5%)	31 (63.3%)	178 (44.9%)

VLG = virtual learning group

Table A-12. Percentage Participation in CLABSI On-Demand Modules, Overall and by Cohort

CLABSI On-Demand Modules	Cohort 3 (n=123)	Cohort 4 (n=106)	Cohort 5 (n=118)	Cohort 6 (n=49)	Overall (n=396)
CVC 101: Central Venous Catheter Indications and Alternatives	34 (27.6%)	32 (30.2%)	33 (28.0%)	19 (38.8%)	118 (29.8%)
CVC 201: Central Venous Catheter Insertion Bundle	33 (26.8%)	27 (25.5%)	27 (22.9%)	9 (18.4%)	96 (24.2%)
CVC 301: Central Venous Catheter Maintenance	32 (26.0%)	32 (30.2%)	26 (22.0%)	13 (26.5%)	103 (26.0%)
CVC 401: Central Venous Catheter Removal	35 (28.5%)	30 (28.3%)	20 (16.9%)	10 (20.4%)	95 (24.0%)

CLABSI = central line–associated bloodstream infection

Table A-13. Percentage Participation Categories in CLABSI Module Viewership, Overall and by Cohort

CLABSI Modules: Percentage of CLABSI Modules Viewership	Cohort 3 (n=123)	Cohort 4 (n=106)	Cohort 5 (n=118)	Cohort 6 (n=49)	Overall (n=396)
0%	77 (62.6%)	55 (51.9%)	77 (65.3%)	24 (49.0%)	233 (58.8%)
>0% to <50%	11 (8.9%)	19 (17.9%)	15 (12.7%)	14 (28.6%)	59 (14.9%)
≥50% to 100%	35 (28.5%)	32 (30.2%)	26 (22.0%)	11 (22.4%)	104 (26.3%)

Note: CLABSI = central line–associated bloodstream infection

Table A-14. Percentage Participation in CAUTI On-Demand Modules, Overall and by Cohort

CAUTI On-Demand Modules	Cohort 3 (n=123)	Cohort 4 (n=106)	Cohort 5 (n=118)	Cohort 6 (n=49)	Overall (n=396)
IUC 101: Avoiding Placement and Determining Appropriateness of Indwelling Urinary Catheters	66 (53.7%)	54 (50.9%)	22 (18.6%)	24 (49.0%)	166 (41.9%)
IUC 102: Alternatives to Indwelling Urinary Catheters	49 (39.8%)	36 (34.0%)	18 (15.3%)	9 (18.4%)	112 (28.3%)
IUC 201: Indwelling Urinary Catheter Insertion Bundle	37 (30.1%)	30 (28.3%)	15 (12.7%)	8 (16.3%)	90 (22.7%)
IUC 301: Indwelling Urinary Catheter Maintenance	42 (34.1%)	36 (34.0%)	15 (12.7%)	7 (14.3%)	100 (25.3%)
IUC 401: Prompting Removal of Unnecessary Indwelling Urinary Catheters	37 (30.1%)	37 (34.9%)	25 (21.2%)	10 (20.4%)	109 (27.5%)
UCS 101: Urine Culturing Stewardship in the ICU Setting	43 (35.0%)	33 (31.1%)	28 (23.7%)	11 (22.4%)	115 (29.0%)

CAUTI = catheter-associated urinary tract infection; ICU = intensive care unit

Table A-15. Percentage Participation Categories in CAUTI Module Viewership, Overall and by Cohort

CAUTI Modules: Percentage of CAUTI Modules Viewership	Cohort 3 (n=123)	Cohort 4 (n=106)	Cohort 5 (n= 118)	Cohort 6 (n=49)	Overall (n=396)
0%	36 (29.3%)	42 (39.6%)	75 (63.6%)	24 (49.0%)	177 (44.7%)
>0% to <50%	43 (35.0%)	26 (24.5%)	25 (21.2%)	13 (26.5%)	107 (27.0%)
≥50% to 100%	44 (35.8%)	38 (35.8%)	18 (15.3%)	12 (24.5%)	112 (28.3%)

CAUTI = catheter-associated urinary tract infection

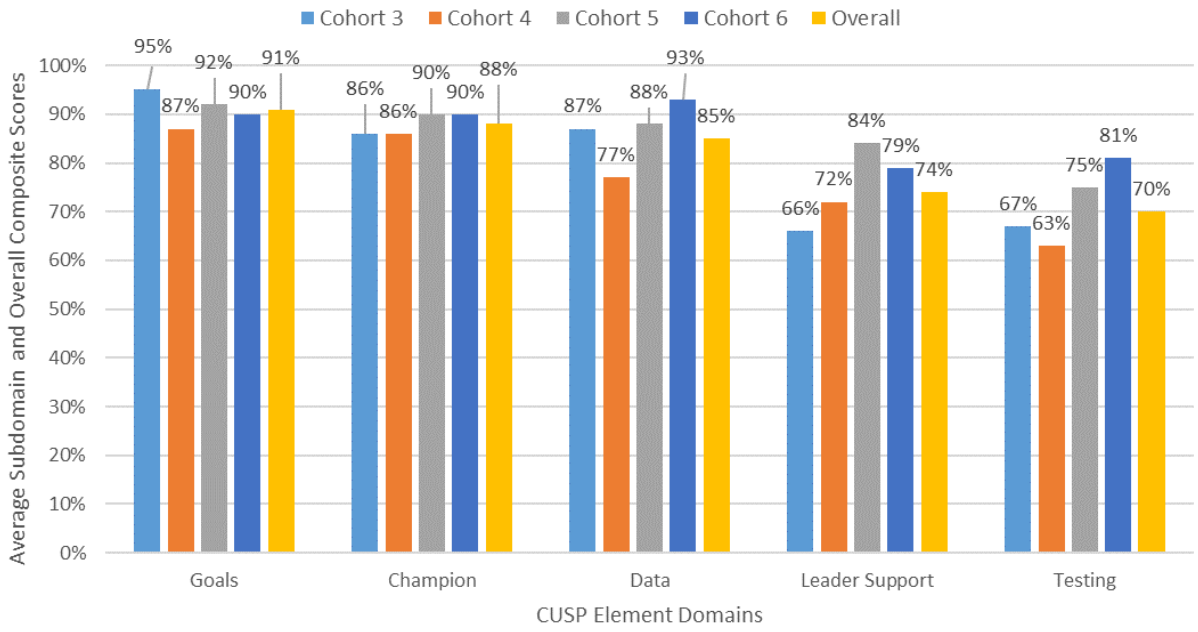
Table A-16. Percentage of Units for Which State Leads Submitted State Lead Quarterly Reports (SLQR), and Case Studies, Overall and by Cohort

Quarter	Cohort 3 (n=123)	Cohort 4 (n=106)	Cohort 5 (n=118)	Cohort 6 (n=49)	Overall (n=396)
SLQR Quarter 1	122 (99.2%)	99 (93.4%)	100 (84.7%)	46 (93.9%)	367 (92.7%)
SLQR Quarter 2	123 (100.0%)	88 (83.0%)	115 (97.5%)	49 (100.0%)	375 (94.7%)
SLQR Quarter 3	119 (96.7%)	78 (73.6%)	115 (97.5%)	49 (100.0%)	361 (91.2%)
SLQR Quarter 4	121 (98.4%)	104 (98.1%)	115 (97.5%)	45 (91.8%)	385 (97.2%)
Case Studies	24 (19.5%)	15 (14.2%)	23 (19.5%)	6 (12.2%)	68 (17.2%)

SLQR = State Lead Quarterly Report

B. Adoption of CUSP (Cohorts 3 to 6 only)

Figure B-1. Average Subdomain and Overall CUSP Composite Scores, by Cohort and Overall (N=346 units; C3: 123 units; C4: 106 units; C5: 117 units; C6: 49 units)



C3 = Cohort 3; C4 = Cohort 4; C5 = Cohort 5; C6 = Cohort 6; CUSP = Comprehensive Unit-based Safety Program

CUSP Adoption Composite and Subdomain Scores

Table B-1. CUSP Adoption Composite and Subdomain Scores

Cohort	Descriptive Statistics	Composite Score	Working Toward Goals Subdomain	Champion Subdomain	Data Driven Subdomain	Leader Support Subdomain	Testing Change/ Roots Subdomain
Cohort 3	N	123	123	123	123	123	123
	Mean (SD)	78.8 (17.5)	94.8 (10.6)	86.5 (19.4)	87.3 (16.8)	65.6 (29.2)	66.6 (30.5)
	Median (Range)	81.8 (38.6 to 100.0)	100.0 (50.0 to 100.0)	100.0 (25.0 to 100.0)	100.0 (37.5 to 100.0)	66.7 (0.0 to 100.0)	75.0 (0.0 to 100.0)
Cohort 4	N	106	106	106	106	106	106
	Mean (SD)	76.5 (15.9)	87.4 (23.8)	85.9 (18.2)	77.0 (24.5)	71.5 (25.4)	63.4 (23.8)
	Median (Range)	81.8 (13.6 to 100.0)	100.0 (0.0 to 100.0)	87.5 (25.0 to 100.0)	87.5 (0.0 to 100.0)	75.0 (16.7 to 100.0)	62.5 (0.0 to 100.0)
Cohort 5	N	118	118	118	118	118	118
	Mean (SD)	85.4 (17.1)	91.7 (16.4)	89.9 (19.4)	87.7 (19.6)	83.8 (21.7)	74.6 (26.5)
	Median (Range)	93.2 (22.7 to 100.0)	100.0 (25.0 to 100.0)	100.0 (0.0 to 100.0)	100.0 (12.5 to 100.0)	91.7 (0.0 to 100.0)	75.0 (0.0 to 100.0)
Cohort 6	N	49	49	49	49	49	49
	Mean (SD)	85.9 (17.1)	90.1 (19.4)	89.8 (16.9)	93.2 (12.1)	78.9 (28.4)	80.9 (24.0)
	Median (Range)	93.2 (22.7 to 100.0)	100.0 (12.5 to 100.0)	100.0 (37.5 to 100.0)	100.0 (50.0 to 100.0)	91.7 (8.3 to 100.0)	87.5 (12.5 to 100.0)
Overall	N	396	396	396	396	396	396
	Mean (SD)	81.0 (17.4)	91.3 (17.9)	87.8 (18.8)	85.4 (20.2)	74.2 (27.0)	69.9 (27.4)
	Median (Range)	84.1 (13.6 to 100.0)	100.0 (0.0 to 100.0)	100.0 (0.0 to 100.0)	100.0 (0.0 to 100.0)	83.3 (0.0 to 100.0)	75.0 (0.0 to 100.0)

AHA = American Hospital Association; CUSP = Comprehensive Unit-based Safety Program; SD = standard deviation; SLQR = State Lead Quarterly Report

Notes: For many subdomains, the median is equal to 100. When this occurs, it is because at least half of the units have a subdomain score of 100.
Source: AHA's analysis based on data from four State Lead Quarterly Reports (SLQRs) for Cohorts 3 through 6

C. Unit and Hospital Characteristics by Program Participation and by CUSP Adoption

Table C-1. Unit and Hospital Characteristics by Program Participation and by CUSP Adoption

Characteristics	Subgroups	Cohorts 1 to 6: Overall	Low Participation (C1- C6)	Moderate Participation (C1-C6)	Substantial Participation (C1-C6)	Cohorts 3 to 6: Overall	Low CUSP Adoption (C3-C6)	Moderate CUSP Adoption (C3- C6)	Substantial CUSP Adoption (C3-C-6)
ICU Characteristic	Number of units	667	186	283	198	394	90	111	193
Number of beds[1]	Mean (SD) [Range]	16.3 (7.6) [4 to 62]	15.2 (7.0) [5 to 39]	16.0 (7.5) [4 to 44]	17.9†‡ (8.1) [6 to 62]	16.4 (7.6) [4 to 42]	15.2 (7.9) [4 to 42]	17.0 (7.5) [6 to 40]	16.6 (7.5) [4 to 37]
	Overall test of differences across the three groups	p=0.002 *	N/A	N/A	N/A	p=0.218	N/A	N/A	N/A
	Small to Medium (1–15 beds)	335 (50.5%)	108 (58.7%)	149 (52.8%)	78† (39.4%)	202 (51.3%)	53 (58.9%)	51 (45.9%)	98 (50.8%)
	Large (16–30 beds)	290 (43.7%)	69 (37.5%)	115 (40.8%)	106†‡ (53.5%)	168 (42.6%)	33 (36.7%)	52 (46.8%)	83 (43.0%)
	Very Large (>30 beds)	39 (5.9%)	7 (3.8%)	18 (6.4%)	14 (7.1%)	24 (6.1%)	4 (4.4%)	8 (7.2%)	12 (6.2%)
	Overall test of differences across the three groups	p=0.003 *	N/A	N/A	N/A	p=0.479	N/A	N/A	N/A
NHSN Location Type[3]	Medical Surgical	498 (74.8%)	136 (73.1%)	218 (77.0%)	144 (73.1%)	284 (72.1%)	70 (77.8%)	81 (73.0%)	133 (68.9%)
	Cardio/ Cardiothoracic	100 (15.0%)	28 (15.1%)	37 (13.1%)	35 (17.8%)	67 (17.0%)	14 (15.6%)	20 (18.0%)	33 (17.1%)
	Neurological/ Neurosurgical	39 (5.9%)	13 (7.0%)	17 (6.0%)	9 (4.6%)	29 (7.4%)	4 (4.4%)	8 (7.2%)	17 (8.8%)
	Burn/Trauma	29 (4.4%)	9 (4.8%)	11 (3.9%)	9 (4.6%)	14 (3.5%)	2 (2.2%)	2 (1.8%)	10 (5.2%)
	Overall test of differences across the three groups	p=0.773	N/A	N/A	N/A	p=0.505	N/A	N/A	N/A
Hospital Bed Size[4]	Small (<100 beds)	46 (6.9%)	14 (7.5%)	21 (7.4%)	11 (5.6%)	29 (7.4%)	12 (13.3%)	8 (7.2%)	9† (4.7%)
	Medium (100–299 beds)	330 (49.5%)	85 (45.7%)	150 (53.0%)	95 (48.0%)	191 (48.5%)	55 (61.1%)	49† (44.1%)	87† (45.1%)
	Large (300+ beds)	291 (43.6%)	87 (46.8%)	112 (39.6%)	92 (46.5%)	174 (44.2%)	23 (25.6%)	54† (48.6%)	97†‡ (50.3%)

Characteristics	Subgroups	Cohorts 1 to 6: Overall	Low Participation (C1- C6)	Moderate Participation (C1-C6)	Substantial Participation (C1-C6)	Cohorts 3 to 6: Overall	Low CUSP Adoption (C3-C6)	Moderate CUSP Adoption (C3- C6)	Substantial CUSP Adoption (C3-C-6)
	Overall test of differences across the three groups	p=0.416	N/A	N/A	N/A	p= 0.001*	N/A	N/A	N/A
Hospital Teaching Status	Teaching	525 (78.7%)	152 (29.0%)	212 (40.4%)	161 (30.7%)	320 (81.2%)	64 (71.1%)	90 (81.1%)	166† (86.0%)
	Nonteaching	142 (21.3%)	34 (23.9%)	71 (50.0%)	37 (26.1%)	74 (18.8%)	26 (28.9%)	21 (18.9%)	27† (14.0%)
	Overall test of differences across the three groups	p=0.120	N/A	N/A	N/A	p= 0.011*	N/A	N/A	N/A
Urbanicity	Urban	610 (91.5%)	173 (93.0%)	260 (91.9%)	177 (89.4%)	365 (92.6%)	76 (84.4%)	102 (91.9%)	187† (96.9%)
	Rural	57 (8.5%)	13 (7.0%)	23 (8.1%)	21 (10.6%)	29 (7.4%)	14 (15.6%)	9 (8.1%)	6† (3.1%)
	Overall test of differences across the three groups	p=0.424	N/A	N/A	N/A	p= 0.001*	N/A	N/A	N/A
Ownership Status	For-profit	94 (14.1%)	32 (17.2%)	46 (16.3%)	16†‡ (8.1%)	48 (12.2%)	10 (11.1%)	6 (5.4%)	32‡ (16.6%)
	Government	117 (17.5%)	31 (16.7%)	45 (15.9%)	41 (20.7%)	44 (11.2%)	14 (31.8%)	15 (13.5%)	15 (7.8%)
	Non-government/ Nonprofit	456 (68.4%)	123 (66.1%)	192 (67.8%)	141 (71.2%)	302 (76.6%)	66 (73.3%)	90 (81.1%)	146 (75.7%)
	Overall test of differences across the three groups	p=0.054	N/A	N/A	N/A	p= 0.018*	N/A	N/A	N/A

AHA = American Hospital Association; C1= Cohort 1; C2= Cohort 2; C3= Cohort 3; C4= Cohort 4; C5= Cohort 5; C6= Cohort 6; CUSP = Comprehensive Unit-based Safety Program; ICU = intensive care unit; NHSN = National Healthcare Safety Network; SD = standard deviation; SLQR = State Lead Quarterly Report

* The overall test of the null hypothesis that all three participation groups have the same mean or distribution in the specified ICU or hospital characteristic is statistically significant at the 0.05 level. Note that when the overall test is not statistically significant, no further tests were conducted to compare the three groups at specific categories (e.g., small, medium, large) of a characteristic (e.g., hospital bed size).

† The moderate or substantial education participation or CUSP adoption level was significantly different from the low level at the 0.05 level.

‡ The substantial education participation or CUSP adoption level was significantly different from the moderate level at the 0.05 level.

[1] Three units (two from Cohort 1 and one from Cohort 2) did not provide a bed-size.

[2] Two units from Cohort 5 did not submit an SLQR.

[3] One unit from Cohort 4 changed NHSN location type from a neurosurgical to a surgical unit during the baseline period of its cohort. One unit from Cohort 1 did not provide its location type. Each of the four categories of location type shown above are made up of multiple location types: medical surgical includes medical, medical/surgical, surgical, and oncology medical/surgical units; cardio/cardiothoracic includes surgical cardiothoracic and medical cardiac units; neurological/neurosurgical includes neurological and neurosurgical units; and burn/trauma includes burn and trauma units.

[4] Data on hospital characteristics came from the 2016 AHA annual survey for Cohorts 1 and 2; the 2018 AHA Annual Survey for Cohorts 3, 4, and 5; and the 2019 AHA Annual Survey for Cohort 6. In the case of one Cohort 3 hospital and one Cohort 5 hospital where AHA data were not available, data from the 2018 NHSN survey were used. Participants upon registration provided data on unit bed-size and ICU location type.

D. Infection Focus

Infection Focus Distribution

Data on infection focus were collected as follows: In Cohorts 1 and 2, intensive care units (ICUs) were asked at the beginning of the program to report whether they intended to focus their intervention efforts on central line–associated blood stream infection (CLABSI), catheter-associated urinary tract infection (CAUTI), or both.[1] The focus was either declared by the ICU in its ICU Assessment or collected and reported by the State leads. In Cohorts 3 through 6, American Hospital Association (AHA) determined whether a unit's infection focus was CLABSI, CAUTI, or both CLABSI and CAUTI based on their responses to two questions in their Action Plans.[2]

Table D-1 shows the distribution of infection focus. Across all cohorts, slightly more than half (50.2%) of units stated they would focus on both CLABSI and CAUTI (Table D-1), about a quarter (25.5%) on CAUTI only, and 16.6 percent on CLABSI only. However, an overall chi-square test showed that infection focus differed across cohorts (p-value < 0.001). Table D-2 indicates which pairs of cohorts had statistically significant differences in the distribution of infection focus. These differences are described next.

While the distribution of infection focus was similar between Cohorts 1 and 2, these two cohorts differed from the other cohorts in that they had greater percentages of units (79.1% and 85.7%, respectively) that indicated a focus on both CLABSI and CAUTI than any of the other four cohorts (which had between 34.9% and 44.1%). Infection focus did not differ significantly across Cohorts 3 to 5, but, compared with Cohort 6, Cohort 4 had a smaller percentage of units with a CLABSI focus (17.9% vs. 36.7%), a greater percentage with a CAUTI focus (47.2% vs 20.4%), and a smaller percentage with both

[1] Infection focus for Cohorts 1 and 2 units was also collected in the follow up ICU assessment, to capture any changes in infection focus that occurred while participating in the program. Eleven ICUs in Cohort 1 and four ICUs in Cohort 2 reported different infection foci at the end of the intervention period. These changes are not reflected in the focus reported in Table E-4.
[2] The coded responses to the following two questions were cross-tabulated, and the results were used to categorize infection focus: Question 1, an open-ended question that asked about a unit's "Identified Gap," was coded for keywords that indicated a specific focus on CLABSI and/or CAUTI. Two AHA staff members along with clinical AHA staff oversight qualitatively coded the Action Plans to ensure the keywords pointed to the correct infection focus. Question 6: "Take Steps to Strategize for Improvement – Tools or Resources to Use (webinars, guides, checklists, TeamSTEPPS, CUSP toolkit, etc. Please be specific, select all that apply)," a multiple-choice question, was parsed by examining which infection-based education the unit would focus on participating in during the intervention period. The options were CLABSI and/or CAUTI and other tools.

CLABSI and CAUTI focus (34.9% vs. 42.9%). CLABSI was the least common focus in the overall sample and across all cohorts except Cohort 6 (whose least common focus was CAUTI).

Table D-1. Distribution of Infection Focus, Overall and by Cohort

Cohort	Number of Units	CLABSI	CAUTI	Both CLABSI and CAUTI
Cohort 1	129	11 (8.5%)	16 (12.4%)	102 (79.1%)
Cohort 2	91	6 (6.6%)	7 (7.7%)	78 (85.7%)
Cohort 3	123	31 (25.2%)	47 (38.2%)	45 (36.6%)
Cohort 4	106	19 (17.9%)	50 (47.2%)	37 (34.9%)
Cohort 5	118	26 (22.0%)	40 (33.9%)	52 (44.1%)
Cohort 6	49	18 (36.7%)	10 (20.4%)	21 (42.9%)
Overall	616	111 (18.0%)	170 (27.6%)	335 (54.4%)

AHA = American Hospital Association; CAUTI = catheter-associated urinary tract infection; CLABSI = central line–associated blood stream infection; COVID19 = coronavirus disease 2019; ICU = intensive care unit

Note: Some units (36 and 15 units, respectively) in Cohorts 1 and 2 had missing infection focus because units did not report it in their ICU Assessments or through their State leads. No units had missing infection focus in Cohorts 3 to 6 because all units completed their Action Plans. Due to the COVID-19 pandemic, Cohort 6 units experienced a 5-month gap period. Upon reentry to the program, Cohort 6 units voluntarily completed a new ICU Action Plan. Three of the Cohort 6 units changed their infection focus: two units changed from CAUTI focus to both CLABSI and CAUTI focus, and one unit changed from CLABSI focus to CAUTI focus. These three units were considered as having both CLABSI and CAUTI focus.
Source: AHA's analysis based on data collected through ICU Assessments or State leads (Cohorts 1 and 2), and unit Action Plans (Cohorts 3 to 6)

Table D-2. p-values for Testing Whether the Distribution of Infection Focus Differed Between Pairs of Cohorts

p-values	Cohort 2	Cohort 3	Cohort 4	Cohort 5	Cohort 6
Cohort 1	0.432	0.000*	0.000*	0.000*	0.000*
Cohort 2	–	0.000*	0.000*	0.000*	0.000*
Cohort 3	–	–	0.286	0.496	0.069
Cohort 4	–	–	–	0.129	0.003*
Cohort 5	–	–	–	–	0.084

Note: The overall chi-square statistic of association between infection focus and cohort is statistically significant: $p<0.000$.
* The distributions of infection focus are statistically significantly different between the two cohorts at the 0.05 level.

Appendix 4. Details of Evaluation Results

(See Section E)

Table of Contents

A. Primary Aim: Cohorts 1 to 6, Cohorts 1 to 5, and Cohort 6 Samples

Cohorts 1 to 6 Sample

NHSN CLABSI Rate: Cohorts 1 to 6

Table A-1. Estimated Program Effects on NHSN CLABSI Rates: Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes from the Unadjusted and Adjusted Models for Cohorts 1 to 6

	Unadjusted Model			Adjusted Model		
Effect	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**
Rate change (slope) during preintervention period	0.985 (0.974 to 0.996)	-1.5 (-2.6 to -0.4)	0.008*	0.985 (0.974 to 0.997)	-1.5 (-2.6 to -0.3)	0.013*
Rate change (slope) during intervention period	0.980 (0.967 to 0.993)	-2.0 (-3.3 to -0.7)	0.004*	0.980 (0.966 to 0.994)	-2.0 (-3.4 to -0.6)	0.005*
Difference in rate of change (slope): intervention vs. preintervention period (ref)	0.995 (0.973 to 1.017)	-0.5 (-2.7 to 1.7)	0.633	0.994 (0.972 to 1.017)	-0.6 (-2.8 to 1.7)	0.620

CI = confidence intervals; CLABSI = central line–associated bloodstream infection; IRR = incidence rate ratios; NHSN = National Healthcare Safety Network

Notes: Sample sizes: Unadjusted Model: N = 658 units (Cohort 1: 164; Cohort 2: 105; Cohort 3: 119; Cohort 4: 104; Cohort 5: 117; Cohort 6: 49). Adjusted Model: N = 612 units (Cohort 1: 127; Cohort 2: 90; Cohort 3: 119; Cohort 4: 104; Cohort 5: 117; Cohort 6: 49).

* Statistically significant at α = 0.05Population CLABSI Rate: Cohorts 1 to 6

Table A-2. Estimated Program Effects on Population CLABSI: Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted and Adjusted Models for Cohorts 1 to 6

	Unadjusted Model			Adjusted Model		
Effect	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**
Rate change (slope) during preintervention period	0.981 (0.970 to 0.992)	-1.9 (-3.0 to -0.8)	0.001*	0.981 (0.970 to 0.992)	-1.9 (-3.0 to -0.8)	0.001*
Rate change (slope) during intervention period	0.979 (0.965 to 0.992)	-2.1 (-3.5 to -0.8)	0.002*	0.979 (0.965 to 0.993)	-2.1 (-3.5 to -0.7)	0.003*
Difference in rate of change (slope): intervention vs. preintervention period (ref)	0.998 (0.976 to 1.021)	-0.2 (-2.4 to 2.1)	0.868	0.998 (0.975 to 1.021)	-0.2 (-2.5 to 2.1)	0.852

CI = confidence intervals; CLABSI = central line–associated bloodstream infection; IRR = incidence rate ratios

Notes: Sample sizes: Unadjusted Model: N = 658 units (Cohort 1: 164; Cohort 2: 105; Cohort 3: 119; Cohort 4: 104; Cohort 5: 117; Cohort 6: 49). Adjusted Model: N = 606 units (Cohort 1: 127; Cohort 2: 90; Cohort 3: 119; Cohort 4: 104; Cohort 5: 117; Cohort 6: 49).

* Statistically significant at the 0.05 level

Central Line Utilization: Cohorts 1 to 6

Table A-3. Estimated Program Effects on Central Line Utilization: Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted and Adjusted Models for Cohorts 1 to 6

	Unadjusted Model			Adjusted Model		
Effect	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**
Rate change (slope) during preintervention period	0.995 (0.994 to 0.996)	-0.5 (-0.6 to -0.4)	0.000*	0.995 (0.994 to 0.997)	-0.5 (-0.6 to -0.3)	0.000*
Rate change (slope) during intervention period	0.999 (0.997 to 1.000)	-0.1 (-0.3 to -0.0)	0.014*	0.999 (0.997 to 1.000)	-0.1 (-0.3 to -0.0)	0.035*
Difference in rate of change (slope): intervention vs. preintervention period (ref)	1.003 (1.001 to 1.005)	0.3 (0.1 to 0.5)	0.001*	1.003 (1.001 to 1.005)	0.3 (0.1 to 0.5)	0.002*

CI = confidence intervals; IRR = incidence rate ratios

Notes: Sample sizes: Unadjusted Model: N = 659 units (Cohort 1: 165; Cohort 2: 105; Cohort 3: 119; Cohort 4: 104; Cohort 5: 117; Cohort 6: 49). Adjusted Model: N = 607 units (Cohort 1: 128; Cohort 2: 90; Cohort 3: 119; Cohort 4: 104; Cohort 5: 117; Cohort 6: 49).

* Statistically significant at the 0.05 level

NHSN CAUTI Rate: Cohorts 1 to 6

Table A-4. Estimated Program Effects on NHSN CAUTI Rates: Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted and Adjusted Models for Cohorts 1 to 6

	Unadjusted Model			Adjusted Model		
Effect	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**
Rate change (slope) during preintervention period	0.979 (0.970 to 0.988)	-2.1 (-3.0 to -1.2)	0.000*	0.978 (0.969 to 0.987)	-2.2 (-3.1 to -1.3)	0.000*
Rate change (slope) during intervention period	0.981 (0.970 to 0.992)	-1.9 (-3.0 to -0.8)	0.001*	0.979 (0.968 to 0.991)	-2.1 (-3.2 to -0.9)	0.001*
Difference in rate of change (slope): intervention vs. preintervention period (ref)	1.002 (0.984 to 1.020)	0.2 (-1.6 to 2.0)	0.831	1.001 (0.982 to 1.021)	0.1 (-1.8 to 2.1)	0.894

CAUTI = catheter-associated urinary tract infection; CI = confidence intervals; IRR = incidence rate ratios; NHSN = National Healthcare Safety Network

Notes: Sample sizes: Unadjusted Model: N = 664 units (Cohort 1: 165; Cohort 2: 106; Cohort 3: 120; Cohort 4: 106; Cohort 5: 118; Cohort 6: 49). Adjusted Model: N = 612 units (Cohort 1: 128; Cohort 2: 91; Cohort 3: 120; Cohort 4: 106; Cohort 5: 118; Cohort 6: 49).

* Statistically significant at the 0.05 level

Population CAUTI Rate: Cohorts 1 to 6

Table A-5. Estimated Program Effects on Population CAUTI Rates: Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted and Adjusted Models for Cohorts 1 to 6

	Unadjusted Model			Adjusted Model		
Effect	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**
Rate change (slope) during preintervention period	0.973 (0.964 to 0.982)	-2.7 (-3.6 to -1.8)	0.000*	0.972 (0.963 to 0.981)	-2.8 (-3.7 to -1.9)	0.000*
Rate change (slope) during intervention period	0.976 (0.965 to 0.987)	-2.4 (-3.5 to -1.3)	0.000*	0.975 (0.963 to 0.987)	-2.5 (-3.7 to -1.3)	0.000*
Difference in rate of change (slope): intervention vs. preintervention period (ref)	1.003 (0.985 to 1.022)	0.3 (-1.5 to 2.2)	0.724	1.003 (0.984 to 1.023)	0.3 (-1.6 to 2.3)	0.760

CAUTI = catheter-associated urinary tract infection; CI = confidence intervals; IRR = incidence rate ratios

Notes: Sample sizes: Unadjusted Model: N = 663 units (Cohort 1: 164; Cohort 2: 106; Cohort 3: 120; Cohort 4: 106; Cohort 5: 118; Cohort 6: 49). Adjusted Model: N = 612 units (Cohort 1: 128; Cohort 2: 91; Cohort 3: 120; Cohort 4: 106; Cohort 5: 118; Cohort 6: 49).

* Statistically significant at the 0.05 level

Indwelling Urinary Catheter Utilization: Cohorts 1 to 6

Table A-6. Estimated Program Effects on Urinary Catheter Utilization Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted and Adjusted Models for Cohorts 1 to 6

	Unadjusted Model			Adjusted Model		
Effect	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**
Rate change (slope) during preintervention period	0.993 (0.992 to 0.994)	-0.7 (-0.8 to -0.6)	0.000*	0.993 (0.993 to 0.994)	-0.7 (-0.7 to -0.6)	0.000*
Rate change (slope) during intervention period	0.996 (0.995 to 0.997)	-0.4 (-0.5 to -0.3)	0.000*	0.996 (0.995 to 0.997)	-0.4 (-0.5 to -0.3)	0.000*
Difference in rate of change (slope): intervention vs. preintervention period (ref)	1.002 (1.001 to 1.004)	0.2 (0.1 to 0.4)	0.006*	1.002 (1.001 to 1.004)	0.2 (0.1 to 0.4)	0.007*

CI = confidence intervals; IRR = incidence rate ratios

Notes: Sample sizes: Unadjusted Model: N = 663 units (Cohort 1: 164; Cohort 2: 106; Cohort 3: 120; Cohort 4: 106; Cohort 5: 118; Cohort 6: 49). Adjusted Model: N = 612 units (Cohort 1: 128; Cohort 2: 91; Cohort 3: 120; Cohort 4: 106; Cohort 5: 118; Cohort 6: 49).

* Statistically significant at the 0.05 level

Cohorts 1 to 5 Sample

NHSN CLABSI Rate: Cohorts 1 to 5

Table A-7. Estimated Program Effects on NHSN CLABSI Rates: Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted and Adjusted Models for Cohorts 1 to 5

	Unadjusted Model			Adjusted Model		
Effect	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**
Rate change (slope) during preintervention period	0.986 (0.974 to 0.997)	-1.4 (-2.6 to -0.3)	0.016*	0.986 (0.974 to 0.998)	-1.4 (-2.6 to -0.2)	0.024*
Rate change (slope) during intervention period	0.975 (0.961 to 0.990)	-2.5 (-3.9 to -1.0)	0.001*	0.975 (0.960 to 0.990)	-2.5 (-4.0 to -1.0)	0.001*
Difference in rate of change (slope): intervention vs. preintervention period (ref)	0.989 (0.967 to 1.013)	-1.1 (-3.3 to 1.3)	0.371	0.989 (0.965 to 1.013)	-1.1 (-3.5 to 1.3)	0.362

CI = confidence intervals; CLABSI = central line–associated blood stream infection; IRR = incidence rate ratios; NHSN = National Healthcare Safety Network

Notes: Sample sizes: Unadjusted Model: N = 609 units (Cohort 1: 164; Cohort 2: 105; Cohort 3: 119; Cohort 4: 104; Cohort 5: 117). Adjusted Model: N = 563 units (Cohort 1: 127; Cohort 2: 90; Cohort 3: 119; Cohort 4: 104; Cohort 5: 117).

* Statistically significant at the 0.05 level

Population CLABSI Rate: Cohorts 1 to 5

Table A-8. Estimated Program Effects on Population CLABSI: Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted and Adjusted Models for Cohorts 1 to 5

	Unadjusted Model			Adjusted Model		
Effect	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**
Rate change (slope) during preintervention period	0.982 (0.970 to 0.993)	-1.8 (-3.0 to -0.7)	0.002*	0.982 (0.970 to 0.994)	-1.8 (-3.0 to -0.6)	0.003*
Rate change (slope) during intervention period	0.973 (0.958 to 0.987)	-2.7 (-4.2 to -1.3)	0.000*	0.972 (0.957 to 0.987)	-2.8 (-4.3 to -1.3)	0.000*
Difference in rate of change (slope): intervention vs. preintervention period (ref)	0.991 (0.968 to 1.014)	-0.9 (-3.2 to 1.4)	0.442	0.990 (0.966 to 1.015)	-1.0 (-3.4 to 1.5)	0.422

CI = confidence intervals; CLABSI = central line–associated blood stream infection; IRR = incidence rate ratios
Notes: Sample sizes: Unadjusted Model: N = 609 units (Cohort 1: 164; Cohort 2: 105; Cohort 3: 119; Cohort 4: 104; Cohort 5: 117). Adjusted Model: N = 557 units (Cohort 1: 127; Cohort 2: 90; Cohort 3: 119; Cohort 4: 104; Cohort 5: 117).
* Statistically significant at the 0.05 level

Central Line Utilization: Cohorts 1 to 5

Table A-9. Estimated Program Effects on Central Line Utilization: Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted and Adjusted Models for Cohorts 1 to 5

	Unadjusted Model			Adjusted Model		
Effect	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**
Rate change (slope) during preintervention period	0.996 (0.995 to 0.997)	-0.4 (-0.5 to -0.3)	0.000*	0.996 (0.995 to 0.997)	-0.4 (-0.5 to -0.3)	0.000*
Rate change (slope) during intervention period	0.997 (0.996 to 0.998)	-0.3 (-0.4 to -0.2)	0.000*	0.997 (0.996 to 0.998)	-0.3 (-0.4 to -0.2)	0.000*
Difference in rate of change (slope): intervention vs. preintervention period (ref)	1.001 (0.999 to 1.003)	0.1 (-0.1 to 0.3)	0.234	1.001 (0.999 to 1.003)	0.1 (-0.1 to 0.3)	0.338

CI = confidence intervals; IRR = incidence rate ratios

Notes: Sample sizes: Unadjusted Model: N = 610 units (Cohort 1: 165; Cohort 2: 105; Cohort 3: 119; Cohort 4: 104; Cohort 5: 117). Adjusted Model: N = 558 units (Cohort 1: 128; Cohort 2: 90; Cohort 3: 119; Cohort 4: 104; Cohort 5: 117).

* Statistically significant at the 0.05 level

NHSN CAUTI Rate: Cohorts 1 to 5

Table A-10. Estimated Program Effects on NHSN CAUTI Rates: Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted and Adjusted Models for Cohorts 1 to 5

	Unadjusted Model			Adjusted Model		
Effect	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**
Rate change (slope) during preintervention period	0.981 (0.972 to 0.990)	-1.9 (-2.8 to -1.0)	0.000*	0.980 (0.970 to 0.989)	-2.0 (-3.0 to -1.1)	0.000*
Rate change (slope) during intervention period	0.979 (0.968 to 0.991)	-2.1 (-3.2 to -0.9)	0.000*	0.977 (0.964 to 0.989)	-2.3 (-3.6 to -1.1)	0.000*
Difference in rate of change (slope): intervention vs. preintervention period (ref)	0.998 (0.979 to 1.017)	-0.2 (-2.1 to 1.7)	0.849	0.997 (0.977 to 1.017)	-0.3 (-2.3 to 1.7)	0.742

CAUTI = catheter-associated urinary tract infection; CI = confidence intervals; IRR = incidence rate ratios; NHSN = National Healthcare Safety Network

Notes: Sample sizes: Unadjusted Model: N = 615 units (Cohort 1: 165; Cohort 2: 106; Cohort 3: 120; Cohort 4: 106; Cohort 5: 118). Adjusted Model: N = 563 units (Cohort 1: 128; Cohort 2: 91; Cohort 3: 120; Cohort 4: 106; Cohort 5: 118).

* Statistically significant at the 0.05 level

Population CAUTI Rate: Cohorts 1 to 5

Table A-11. Estimated Program Effects on Population CAUTI Rates: Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted and Adjusted Models for Cohorts 1 to 5

	Unadjusted Model			Adjusted Model		
Effect	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**
Rate change (slope) during preintervention period	0.975 (0.966 to 0.984)	-2.5 (-3.4 to -1.6)	0.000*	0.974 (0.964 to 0.983)	-2.6 (-3.6 to -1.7)	0.000*
Rate change (slope) during intervention period	0.973 (0.961 to 0.984)	-2.7 (-3.9 to -1.6)	0.000*	0.970 (0.958 to 0.983)	-3.0 (-4.2 to -1.7)	0.000*
Difference in rate of change (slope): intervention vs. preintervention period (ref)	0.998 (0.979 to 1.017)	-0.2 (-2.1 to 1.7)	0.822	0.997 (0.977 to 1.017)	-0.3 (-2.3 to 1.7)	0.739

CAUTI = catheter-associated urinary tract infection; CI = confidence intervals; IRR = incidence rate ratios
Notes: Sample sizes: Unadjusted Model: N = 614 units (Cohort 1: 164; Cohort 2: 106; Cohort 3: 120; Cohort 4: 106; Cohort 5: 118). Adjusted Model: N = 563 units (Cohort 1: 128; Cohort 2: 91; Cohort 3: 120; Cohort 4: 106; Cohort 5: 118).
* Statistically significant at the 0.05 level

Indwelling Urinary Catheter Utilization: Cohorts 1 to 5

Table A-12. Estimated Program Effects on Urinary Catheter Utilization Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted and Adjusted Models for Cohorts 1 to 5

	Unadjusted Model			Adjusted Model		
Effect	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**
Rate change (slope) during preintervention period	0.993 (0.993 to 0.994)	-0.7 (-0.7 to -0.6)	0.000*	0.994 (0.993 to 0.994)	-0.6 (-0.7 to -0.6)	0.000*
Rate change (slope) during intervention period	0.994 (0.993 to 0.995)	-0.6 (-0.7 to -0.5)	0.000*	0.994 (0.993 to 0.995)	-0.6 (-0.7 to -0.5)	0.000*
Difference in rate of change (slope): intervention vs. preintervention period (ref)	1.001 (0.999 to 1.002)	0.1 (-0.1 to 0.2)	0.417	1.001 (0.999 to 1.002)	0.1 (-0.1 to 0.2)	0.501

CI = confidence intervals; IRR = incidence rate ratios
Notes: Sample sizes: Unadjusted Model: N = 614 units (Cohort 1: 164; Cohort 2: 106; Cohort 3: 120; Cohort 4: 106; Cohort 5: 118). Adjusted Model: N = 563 units (Cohort 1: 128; Cohort 2: 91; Cohort 3: 120; Cohort 4: 106; Cohort 5: 118).
* Statistically significant at the 0.05 level

Cohort 6 Sample

NHSN CLABSI Rate: Cohort 6

Table A-13. Estimated Program Effects on NHSN CLABSI Rates: Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted and Adjusted Models for Cohort 6

	Unadjusted Model			Adjusted Model		
Effect	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**
Rate change (slope) during preintervention period	0.980 (0.944 to 1.017)	-2.0 (-5.6 to 1.7)	0.287	0.980 (0.944 to 1.017)	-2.0 (-5.6 to 1.7)	0.279
Rate change (slope) during intervention period	1.013 (0.972 to 1.056)	1.3 (-2.8 to 5.6)	0.533	1.013 (0.972 to 1.056)	1.3 (-2.8 to 5.6)	0.537
Difference in rate of change (slope): intervention vs. preintervention period (ref)	1.034 (0.963 to 1.110)	3.4 (-3.7 to 11.0)	0.357	1.034 (0.963 to 1.110)	3.4 (-3.7 to 11.0)	0.353

CI = confidence intervals; CLABSI = central line–associated blood stream infection; IRR = incidence rate ratios; NHSN = National Healthcare Safety Network

Population CLABSI Rate: Cohort 6

Table A-14. Estimated Program Effects on Population CLABSI: Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted and Adjusted Models for Cohort 6

	Unadjusted Model			Adjusted Model		
Effect	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**
Rate change (slope) during preintervention period	0.973 (0.937 to 1.010)	-2.7 (-6.3 to 1.0)	0.153	0.973 (0.938 to 1.010)	-2.7 (-6.2 to 1.0)	0.157
Rate change (slope) during intervention period	1.027 (0.985 to 1.070)	2.7 (-1.5 to 7.0)	0.212	1.027 (0.985 to 1.070)	2.7 (-1.5 to 7.0)	0.209
Difference in rate of change (slope): intervention vs. preintervention period (ref)	1.055 (0.983 to 1.133)	5.5 (-1.7 to 13.3)	0.140	1.055 (0.983 to 1.133)	5.5 (-1.7 to 13.3)	0.141

CI = confidence intervals; CLABSI = central line–associated bloodstream infection; IRR = incidence rate ratios
Notes: Sample sizes: Unadjusted Model: N = 49 units (Cohort 6: 49). Adjusted Model: N = 49 units (Cohort 6: 49).

Central Line Utilization: Cohort 6

Table A-15. Estimated Program Effects on Central Line Utilization: Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted and Adjusted Models for Cohort 6

	Unadjusted Model			Adjusted Model		
Effect	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**
Rate change (slope) during preintervention period	0.992 (0.988 to 0.996)	-0.8 (-1.2 to -0.4)	0.000*	0.992 (0.988 to 0.996)	-0.8 (-1.2 to -0.4)	0.000*
Rate change (slope) during intervention period	1.017 (1.013 to 1.021)	1.7 (1.3 to 2.1)	0.000*	1.017 (1.013 to 1.021)	1.7 (1.3 to 2.1)	0.000*
Difference in rate of change (slope): intervention vs. preintervention period (ref)	1.025 (1.018 to 1.032)	2.5 (1.8 to 3.2)	0.000*	1.025 (1.018 to 1.032)	2.5 (1.8 to 3.2)	0.000*

CI = confidence intervals; IRR = incidence rate ratios

Notes: Sample sizes: Unadjusted Model: N = 49 units (Cohort 6: 49).Adjusted Model: N = 49 units (Cohort 6: 49).

* Statistically significant at the 0.05 level

NHSN CAUTI Rate: Cohort 6

Table A-16. Estimated Program Effects on NHSN CAUTI Rates: Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted and Adjusted Models for Cohort 6

	Unadjusted Model			Adjusted Model		
Effect	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**
Rate change (slope) during preintervention period	0.958 (0.926 to 0.992)	-4.2 (-7.4 to -0.8)	0.015*	0.956 (0.924 to 0.990)	-4.4 (-7.6 to -1.0)	0.011*
Rate change (slope) during intervention period	1.009 (0.968 to 1.051)	0.9 (-3.2 to 5.1)	0.683	1.009 (0.969 to 1.051)	0.9 (-3.1 to 5.1)	0.657
Difference in rate of change (slope): intervention vs. preintervention period (ref)	1.053 (0.983 to 1.127)	5.3 (-1.7 to 12.7)	0.140	1.055 (0.986 to 1.130)	5.5 (-1.4 to 13.0)	0.121

CAUTI = catheter-associated urinary tract infection; CI = confidence intervals; IRR = incidence rate ratios; NHSN = National Healthcare Safety Network

Notes: Sample sizes: Unadjusted Model: N = 49 units (Cohort 6: 49). Adjusted Model: N = 49 units (Cohort 6: 49).

* Statistically significant at the 0.05 level

Population CAUTI Rate: Cohort 6

Table A-17. Estimated Program Effects on Population CAUTI Rates: Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted and Adjusted Models for Cohort 6

	Unadjusted Model			Adjusted Model		
Effect	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**
Rate change (slope) during preintervention period	0.950 (0.917 to 0.984)	-5.0 (-8.3 to -1.6)	0.004*	0.949 (0.916 to 0.982)	-5.1 (-8.4 to -1.8)	0.003*
Rate change (slope) during intervention period	1.020 (0.979 to 1.062)	2.0 (-2.1 to 6.2)	0.350	1.020 (0.979 to 1.063)	2.0 (-2.1 to 6.3)	0.349
Difference in rate of change (slope): intervention vs. preintervention period (ref)	1.074 (1.002 to 1.150)	7.4 (0.2 to 15.0)	0.043*	1.075 (1.004 to 1.151)	7.5 (0.4 to 15.1)	0.039*

CAUTI = catheter-associated urinary tract infection; CI = confidence intervals; IRR = incidence rate ratios
Notes: Sample sizes: Unadjusted Model: N = 49 units (Cohort 6: 49). Adjusted Model: N = 49 units (Cohort 6: 49).
* Statistically significant at the 0.05 level

Indwelling Urinary Catheter Utilization: Cohort 6

Table A-18. Estimated Program Effects on Urinary Catheter Utilization Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted and Adjusted Models for Cohort 6

	Unadjusted Model			Adjusted Model		
Effect	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**	**IRR (95% CI)**	**Percent Change (95% CI)**	**p-value**
Rate change (slope) during preintervention period	0.992 (0.989 to 0.995)	-0.8 (-1.1 to -0.5)	0.000*	0.992 (0.989 to 0.995)	-0.8 (-1.1 to -0.5)	0.000*
Rate change (slope) during intervention period	1.012 (1.008 to 1.015)	1.2 (0.8 to 1.5)	0.000*	1.012 (1.008 to 1.015)	1.2 (0.8 to 1.5)	0.000*
Difference in rate of change (slope): intervention vs. preintervention period (ref)	1.020 (1.014 to 1.026)	2.0 (1.4 to 2.6)	0.000*	1.020 (1.014 to 1.026)	2.0 (1.4 to 2.6)	0.000*

CAUTI = catheter-associated urinary tract infection; CI = confidence intervals; IRR = incidence rate ratios
Notes: Sample sizes: Unadjusted Model: N = 49 units (Cohort 6: 49), Adjusted Model: N = 49 units (Cohort 6: 49)
* Statistically significant at the 0.05 level

B. Secondary Aims: Cohorts 1 to 6 Sample

What is the nature of the statistically significant within-subgroup and differential effects?

To facilitate understanding of the nature of the estimated within-subgroup and differential effects summarized in Section E, trend lines are plotted in Figures B-1 to B-5. For each graph, statistically significant preintervention to intervention changes in slopes (within-subgroup effects) are depicted using red trend lines, while non–statistically significant within-subgroup effects ("null effects") are shown in blue trend lines. For each outcome (or row of graphs), subgroups connected by the same colored horizontal bar do *not* have statistically significant pairwise differences in effects (that is, no pairwise differential effects), while subgroups not connected by the same colored bar have differential effects. **There were a total of 54 within-subgroup effects tested across all four outcomes, of which 18 (35%) emerged as statistically significant**: 10 within-subgroup effects characterized by a slower decline during the intervention period compared with the preintervention period, 7 by a reversal in trend from decreasing during preintervention to increasing during intervention, and 1 by an increasing trend during both periods but a slower increase during the intervention period. The remaining 34 within-subgroup effects were characterized by decreasing trends that remained the same during both periods. **The summary below will focus on the 10 statistically significant differential effects noted in report Section**

E, Figure E-2, noting as needed which within-subgroup effects are statistically significant. The estimates of the statistically significant differential effects are given below in the form of R-IRR (ratio of IRRs).[1] The complete set of results is given in Section B, Appendix 4.

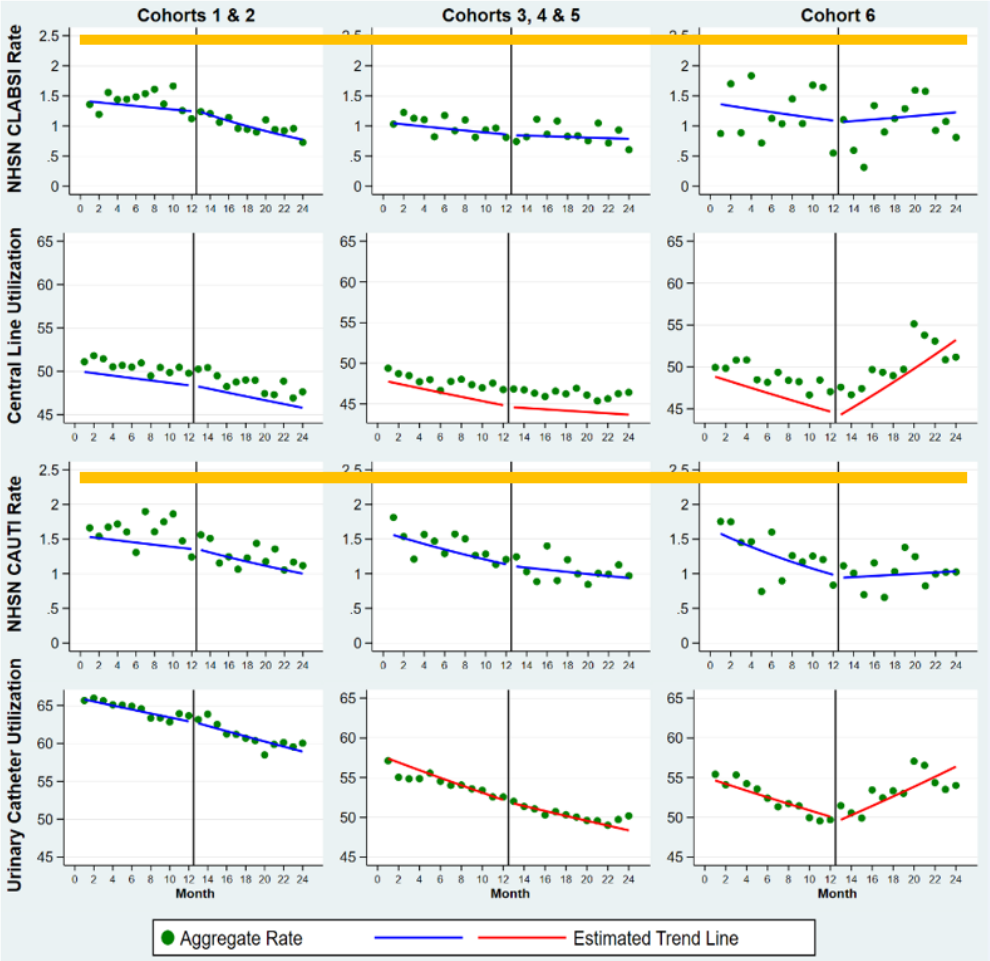
Differential Effect by Cohort

By cohort group (Figure B-1):

The effects on device utilization differed between each pair of the three cohort groups. The nature of these differential effects was similar for central line and urinary catheter utilization, with the program having a "null" effect in Cohorts 1 and 2, and having undesirable effects on Cohorts 3, 4, and 5 and Cohort 6. Specifically, whereas Cohorts 1 and 2 utilization decreased at similar rates during the preintervention and intervention periods, Cohorts 3, 4, and 5 utilization decreased at a slower rate during the intervention period compared with the preintervention period (Cohorts 3, 4, and 5 vs. Cohorts 1 and 2: central line utilization – **R-IRR=1.006, CI: 1.002 to 1.010, p=0.007**; urinary catheter utilization – **R-IRR=1.004, CI: 1.001 to 1.007, p=0.021**), and Cohort 6 had a shift in trend from decreasing during the preintervention to increasing during the intervention (Cohort 6 vs. Cohorts 1 and 2: central line utilization – **R-IRR=0.1.021, CI: 1.013 to 1.029, p<0.001**; urinary catheter utilization – **R-IRR=0.1.021, CI: 1.013 to 1.029, p<0.001**). When comparing Cohort 6 to Cohorts 3, 4, and 5, the difference in effects was also statistically significant (Cohort 6 vs. Cohorts 3, 4, and 5: central line utilization – **R-IRR=1.027, CI: 1.019 to 1.035, p<0.001**; urinary catheter utilization – **R-IRR=1.017, CI: 1.011 to 1.023, p<0.001**).

[1] Strictly speaking, the differential effect is a ratio of the R-IRRs between two subgroups (e.g., the R-IRR for the moderate participation group divided by the R-IRR for the low participation group). However, rather than introduce another notation (e.g., RR-IRR) to refer to the ratio of two R-IRRs, for simplicity, the differential effect is simply denoted by R-IRR.

Figure B-1. Aggregate Infection Rates, Device Utilization Ratios, and Estimated Trend Lines From the Unadjusted Model for Cohorts 1 to 6, by Cohort Group



CAUTI = catheter-associated urinary tract infection; CLABSI = central line–associated bloodstream infection; NHSN = National Healthcare Safety Network

Notes: For each outcome (or row of graphs), subgroups connected by a gold bar at the top of the row did *not* have statistically significant pairwise differences in effects (that is, no pairwise differential effects). For each graph, red trend lines depict a statistically significant preintervention to intervention change in slopes (or effect), while blue trend lines indicate a non–statistically significant effect. Months to the left of the vertical black line (months 1 to 12) represent the preintervention period, and months to the right (months 13 to 24) represent the intervention period. Sample sizes: NHSN CLABSI: N = 658 units (Cohorts 1 & 2: 269; Cohorts 3, 4, & 5: 340; Cohort 6: 49); Central Line Utilization: N = 659 units (Cohorts 1 & 2: 270; Cohorts 3, 4, & 5: 340; Cohort 6: 49). Sample sizes for NHSN CAUTI Sample: N = 664 units (Cohorts 1 & 2: 271; Cohorts 3, 4, & 5: 344; Cohort 6: 49). Sample sizes for Urinary Catheter Utilization Sample: N = 663 units (Cohorts 1 & 2: 270; Cohorts 3, 4, & 5: 344; Cohort 6: 49).

NHSN CLABSI Rate (Cohorts 1 to 6)

Table B-1. Estimated Program Effects on NHSN CLABSI Rates, by Cohort Groups (Cohorts 1 and 2, Cohorts 3, 4, and 5, Cohort 6): Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted Model for Cohorts 1 to 6

Effect	IRR (95% CI)	Percent Change (95% CI)	p-value
Difference in rate change (slope): intervention vs. preintervention period (ref) for Cohorts 1 & 2	0.969 (0.938 to 1.001)	-3.1 (-6.2 to 0.1)	0.059
Difference in rate change (slope): intervention vs. preintervention period (ref) for Cohorts 3 & 4 & 5	1.011 (0.978 to 1.046)	1.1 (-2.2 to 4.6)	0.515
Difference in rate change (slope): intervention vs. preintervention period (ref) for Cohort 6	1.033 (0.963 to 1.108)	3.3 (-3.7 to 10.8)	0.362
Difference in differences in rate of change (slope): Cohorts 3 & 4 & 5 vs. Cohorts 1 & 2 (ref)	1.043 (0.996 to 1.093)	4.3 (-0.4 to 9.3)	0.075
Difference in differences in rate of change (slope): Cohort 6 vs. Cohorts 1 & 2 (ref)	1.066 (0.987 to 1.152)	6.6 (-1.3 to 15.2)	0.105
Difference in differences in rate of change (slope): Cohort 6 vs. Cohorts 3 & 4 & 5 (ref)	1.022 (0.945 to 1.104)	2.2 (-5.5 to 10.4)	0.590

CI = confidence intervals; CLABSI = central line–associated bloodstream infection; IRR = incidence rate ratios; NHSN = National Healthcare Safety Network

Sample size: N = 658 units (Cohorts 1 & 2: 269; Cohorts 3,4, & 5: 340; Cohort 6: 49)

Central Line Utilization (Cohorts 1 to 6)

Table B-2. Estimated Program Effects on Central Line Utilization, by Cohort Groups (Cohorts 1 and 2, Cohorts 3, 4, and 5, Cohort 6): Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted Model for Cohorts 1 to 6

Effect	IRR (95% CI)	Percent Change (95% CI)	p-value
Difference in rate change (slope): intervention vs. preintervention period (ref) for Cohorts 1 & 2	0.998 (0.995 to 1.001)	-0.2 (-0.5 to 0.1)	0.223
Difference in rate change (slope): intervention vs. preintervention period (ref) for Cohorts 3 & 4 & 5	1.004 (1.001 to 1.007)	0.4 (0.1 to 0.7)	0.007*
Difference in rate change (slope): intervention vs. preintervention period (ref) for Cohort 6	1.025 (1.018 to 1.032)	2.5 (1.8 to 3.2)	0.000*
Difference in differences in rate of change (slope): Cohorts 3 & 4 & 5 vs. Cohorts 1 & 2 (ref)	1.006 (1.002 to 1.010)	0.6 (0.2 to 1.0)	0.007*
Difference in differences in rate of change (slope): Cohort 6 vs. Cohorts 1 & 2 (ref)	1.027 (1.019 to 1.035)	2.7 (1.9 to 3.5)	0.000*
Difference in differences in rate of change (slope): Cohort 6 vs. Cohorts 3 & 4 & 5 (ref)	1.021 (1.013 to 1.029)	2.1 (1.3 to 2.9)	0.000*

CI = confidence intervals; IRR = incidence rate ratios

* Statistically significant at $\alpha = 0.05$

Sample size: N = 659 units (Cohorts 1 & 2: 270; Cohorts 3,4, & 5: 340; Cohort 5: 49)

NHSN CAUTI Rate (Cohorts 1 to 6)

Table B-3. Estimated Program Effects on NHSN CAUTI Rates, by Cohort Groups (Cohorts 1 and 2, Cohorts 3, 4, and 5, Cohort 6): Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted Model for Cohorts 1 to 6

Effect	IRR (95% CI)	Percent Change (95% CI)	p-value
Difference in rate change (slope): intervention vs. preintervention period (ref) for Cohorts 1 & 2	0.985 (0.959 to 1.010)	-1.5 (-4.1 to 1.0)	0.238
Difference in rate change (slope): intervention vs. preintervention period (ref) for Cohorts 3 & 4 & 5	1.014 (0.986 to 1.042)	1.4 (-1.4 to 4.2)	0.326
Difference in rate change (slope): intervention vs. preintervention period (ref) for Cohort 6	1.053 (0.984 to 1.126)	5.3 (-1.6 to 12.6)	0.136
Difference in differences in rate of change (slope): Cohorts 3 & 4 & 5 vs. Cohorts 1 & 2 (ref)	1.030 (0.992 to 1.070)	3.0 (-0.8 to 7.0)	0.128
Difference in differences in rate of change (slope): Cohort 6 vs. Cohorts 1 & 2 (ref)	1.069 (0.995 to 1.149)	6.9 (-0.5 to 14.9)	0.069
Difference in differences in rate of change (slope): Cohort 6 vs. Cohorts 3 & 4 & 5 (ref)	1.038 (0.965 to 1.116)	3.8 (-3.5 to 11.6)	0.315

CAUTI = catheter-associated urinary tract infection; CI = confidence intervals; IRR = incidence rate ratios; NHSN = National Healthcare Safety Network

Sample size: N = 664 units (Cohorts 1 & 2: 271; Cohorts 3,4, & 5: 344; Cohort 6: 49)

Indwelling Urinary Catheter Utilization (Cohorts 1 to 6)

Table B-4. Estimated Program Effects on Urinary Catheter Utilization, by Cohort Groups (Cohorts 1 and 2, Cohorts 3, 4, and 5, Cohort 6): Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted Model for Cohorts 1 to 6

Effect	IRR (95% CI)	Percent Change (95% CI)	p-value
Difference in rate change (slope): intervention vs. preintervention period (ref) for Cohorts 1 & 2	0.998 (0.996 to 1.001)	-0.2 (-0.4 to 0.1)	0.241
Difference in rate change (slope): intervention vs. preintervention period (ref) for Cohorts 3 & 4 & 5	1.003 (1.000 to 1.005)	0.3 (0.0 to 0.5)	0.033*
Difference in rate change (slope): intervention vs. preintervention period (ref) for Cohort 6	1.020 (1.014 to 1.026)	2.0 (1.4 to 2.6)	0.000*
Difference in differences in rate of change (slope): Cohorts 3 & 4 & 5 vs. Cohorts 1 & 2 (ref)	1.004 (1.001 to 1.007)	0.4 (0.1 to 0.7)	0.021*
Difference in differences in rate of change (slope): Cohort 6 vs. Cohorts 1 & 2 (ref)	1.021 (1.015 to 1.028)	2.1 (1.5 to 2.8)	0.000*
Difference in differences in rate of change (slope): Cohort 6 vs. Cohorts 3 & 4 & 5 (ref)	1.017 (1.011 to 1.023)	1.7 (1.1 to 2.3)	0.000*

CI = confidence intervals; IRR = incidence rate ratios

*Statistically significant at $\alpha = 0.05$

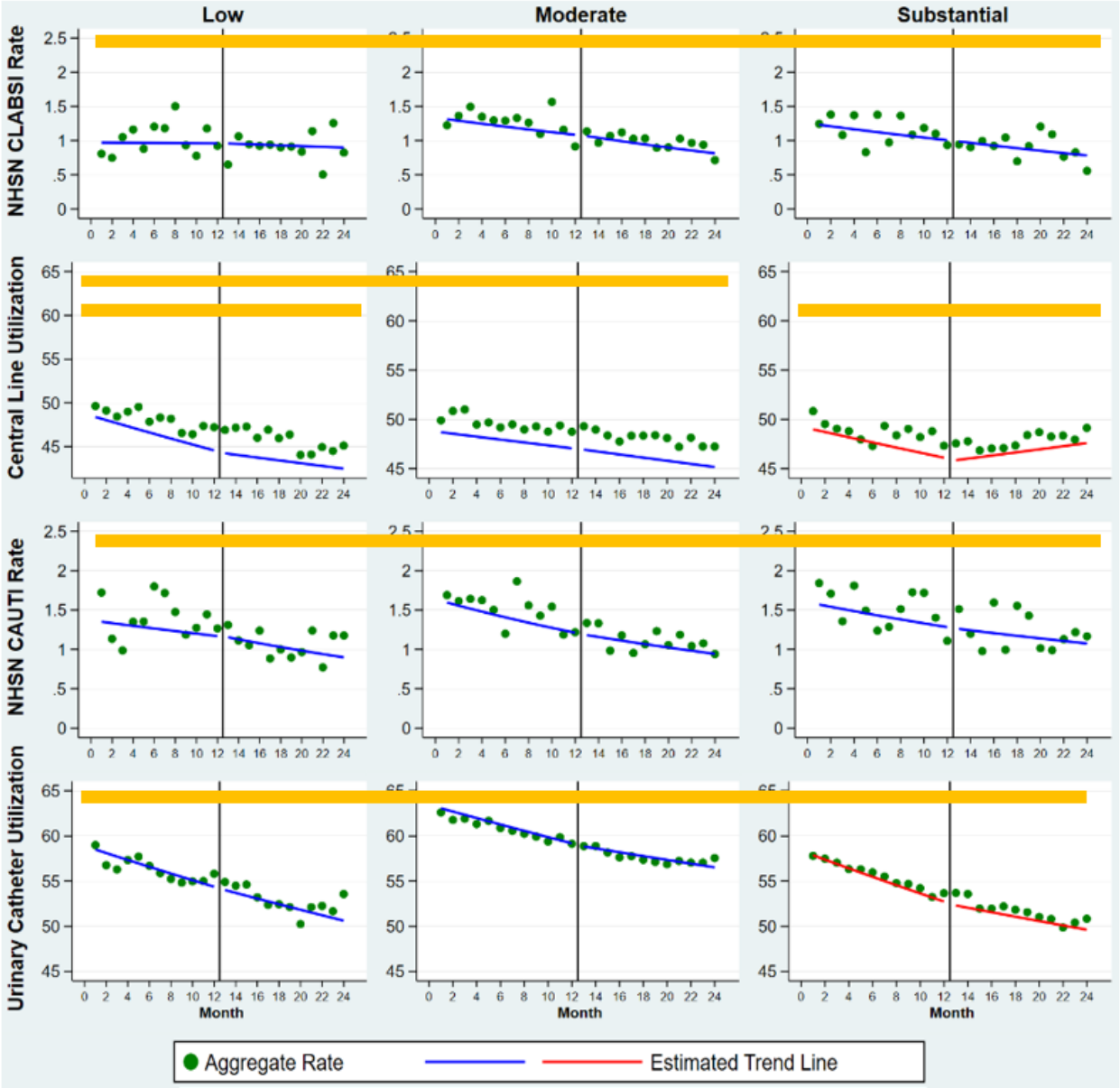
Sample size: N = 663 units (Cohorts 1 & 2: 270; Cohorts 3, 4, & 5: 344; Cohort 6: 49)

Differential Effect by Participation Level (Cohorts 1 to 6)

By participation level (Figure B-2):

The effect on central line utilization differed **(IRR=1.009, CI: 1.005 to 1.014, p<0.000)** between the substantial participation group (whose trend flipped from decreasing during the preintervention period to increasing during the intervention period) and the moderate participation group (whose trend was decreasing at similar rates during both periods), but no differential effects were found between the low and moderate groups or between the low and substantial groups.

Figure B-2. Aggregate Infection Rates, Device Utilization Ratios, and Estimated Trend Lines From the Unadjusted Model for Cohorts 1 to 6, by Participation Level



CAUTI = catheter-associated urinary tract infection; CLABSI = central line–associated bloodstream infection; NHSN = National Healthcare Safety Network

Notes: For each outcome (or row of graphs), subgroups connected by a gold bar at the top of the row did *not* have statistically significant pairwise differences in effects (that is, no pairwise differential effects). For each graph, red trend lines depict a statistically significant preintervention to intervention change in slopes (or effect), while blue trend lines indicate a non–statistically significant effect. Months to the left of the vertical black line (months 1 to 12) represent the preintervention period, and months to the right (months 13 to 24) represent the intervention period. Sample sizes for NHSN CLABSI Sample: N = 658 units (Low: 144; Moderate: 329; Substantial: 185). Sample sizes for Central Line Utilization Sample: N = 659 units (Low: 144; Moderate: 330; Substantial: 185). Sample sizes for NHSN CAUTI Sample: N = 664 units (Low: 144; Moderate: 335; Substantial: 185). Sample sizes for Urinary Catheter Utilization Sample: N = 663 units (Low: 144; Moderate: 334; Substantial: 185).

NHSN CLABSI Rate (Cohorts 1 to 6)

Table B-5. Estimated Program Effects on NHSN CLABSI Rates, by Participation Level (Low, Moderate, Substantial): Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted Model for Cohorts 1 to 6

Effect	IRR (95% CI)	Percent Change (95% CI)	p-value
Difference in rate change (slope): intervention vs. preintervention period (ref) for Low Participation	0.995 (0.943 to 1.050)	-0.5 (-5.7 to 5.0)	0.860
Difference in rate change (slope): intervention vs. preintervention period (ref) for Moderate Participation	0.993 (0.963 to 1.023)	-0.7 (-3.7 to 2.3)	0.642
Difference in rate change (slope): intervention vs. preintervention period (ref) for Substantial Participation	0.997 (0.958 to 1.039)	-0.3 (-4.2 to 3.9)	0.898
Difference in differences in rate of change (slope): Moderate vs. Low (ref)	0.998 (0.938 to 1.061)	-0.2 (-6.2 to 6.1)	0.940
Difference in differences in rate of change (slope): Substantial vs. Low (ref)	1.002 (0.937 to 1.072)	0.2 (-6.3 to 7.2)	0.950
Difference in differences in rate of change (slope): Substantial vs. Moderate	1.005 (0.955 to 1.057)	0.5 (-4.5 to 5.7)	0.862

CI = confidence intervals; CLABSI = central line–associated bloodstream infection; IRR = incidence rate ratios; NHSN = National Healthcare Safety Network

Sample size: N = 658 units (Low: 144; Moderate: 329; Substantial: 185)

Central Line Utilization (Cohorts 1 to 6)

Table B-6. Estimated Program Effects on Central Line Utilization, by Participation Level (Low, Moderate, Substantial): Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted Model for Cohorts 1 to 6

Effect	IRR (95% CI)	Percent Change (95% CI)	p-value
Difference in rate change (slope): intervention vs. preintervention period (ref) for Low Participation	1.004 (0.999 to 1.008)	0.4 (-0.1 to 0.8)	0.086
Difference in rate change (slope): intervention vs. preintervention period (ref) for Moderate Participation	1.000 (0.997 to 1.002)	-0.0 (-0.3 to 0.2)	0.789
Difference in rate change (slope): intervention vs. preintervention period (ref) for Substantial Participation	1.009 (1.005 to 1.013)	0.9 (0.5 to 1.3)	0.000*
Difference in differences in rate of change (slope): Moderate vs. Low (ref)	0.996 (0.991 to 1.001)	-0.4 (-0.9 to 0.1)	0.112
Difference in differences in rate of change (slope): Substantial vs. Low (ref)	1.005 (0.999 to 1.011)	0.5 (-0.1 to 1.1)	0.082
Difference in differences in rate of change (slope): Substantial vs. Moderate	1.009 (1.005 to 1.014)	0.9 (0.5 to 1.4)	0.000*

CI = confidence intervals; IRR = incidence rate ratios

* Statistically significant at α = 0.05

Sample size: N = 659 units (Low: 144; Moderate: 330; Substantial: 185)

NHSN CAUTI Rate (Cohorts 1 to 6)

Table B-7. Estimated Program Effects on NHSN CAUTI Rates, by Participation Level (Low, Moderate, Substantial): Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted Model for Cohorts 1 to 6

Effect	IRR (95% CI)	Percent Change (95% CI)	p-value
Difference in rate change (slope): intervention vs. preintervention period (ref) for Low Participation	0.991 (0.948 to 1.035)	-0.9 (-5.2 to 3.5)	0.671
Difference in rate change (slope): intervention vs. preintervention period (ref) for Moderate Participation	1.004 (0.980 to 1.030)	0.4 (-2.0 to 3.0)	0.726
Difference in rate change (slope): intervention vs. preintervention period (ref) for Substantial Participation	1.004 (0.971 to 1.038)	0.4 (-2.9 to 3.8)	0.816
Difference in differences in rate of change (slope): Moderate vs. Low (ref)	1.014 (0.964 to 1.067)	1.4 (-3.6 to 6.7)	0.587
Difference in differences in rate of change (slope): Substantial vs. Low (ref)	1.014 (0.959 to 1.071)	1.4 (-4.1 to 7.1)	0.631
Difference in differences in rate of change (slope): Substantial vs. Moderate	0.999 (0.959 to 1.042)	-0.1 (-4.1 to 4.2)	0.980

CAUTI = catheter-associated urinary tract infection; CI = confidence intervals; IRR = incidence rate ratios; NHSN = National Healthcare Safety Network

Sample size: N = 664 units (Low: 144; Moderate: 335; Substantial: 185)

Indwelling Urinary Catheter Utilization (Cohorts 1 to 6)

Table B-8. Estimated Program Effects on Urinary Catheter Utilization, by Participation Level (Low, Moderate, Substantial): Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted Model for Cohorts 1 to 6

Effect	IRR (95% CI)	Percent Change (95% CI)	p-value
Difference in rate change (slope): intervention vs. preintervention period (ref) for Low Participation	1.001 (0.997 to 1.004)	0.1 (-0.3 to 0.4)	0.686
Difference in rate change (slope): intervention vs. preintervention period (ref) for Moderate Participation	1.002 (1.000 to 1.004)	0.2 (-0.0 to 0.4)	0.069
Difference in rate change (slope): intervention vs. preintervention period (ref) for Substantial Participation	1.004 (1.001 to 1.007)	0.4 (0.1 to 0.7)	0.021*
Difference in differences in rate of change (slope): Moderate vs. Low (ref)	1.001 (0.997 to 1.006)	0.1 (-0.3 to 0.6)	0.526
Difference in differences in rate of change (slope): Substantial vs. Low (ref)	1.003 (0.998 to 1.008)	0.3 (-0.2 to 0.8)	0.232
Difference in differences in rate of change (slope): Substantial vs. Moderate	1.002 (0.998 to 1.005)	0.2 (-0.2 to 0.5)	0.440

CI = confidence intervals; IRR = incidence rate ratios

* Statistically significant at $\alpha = 0.05$

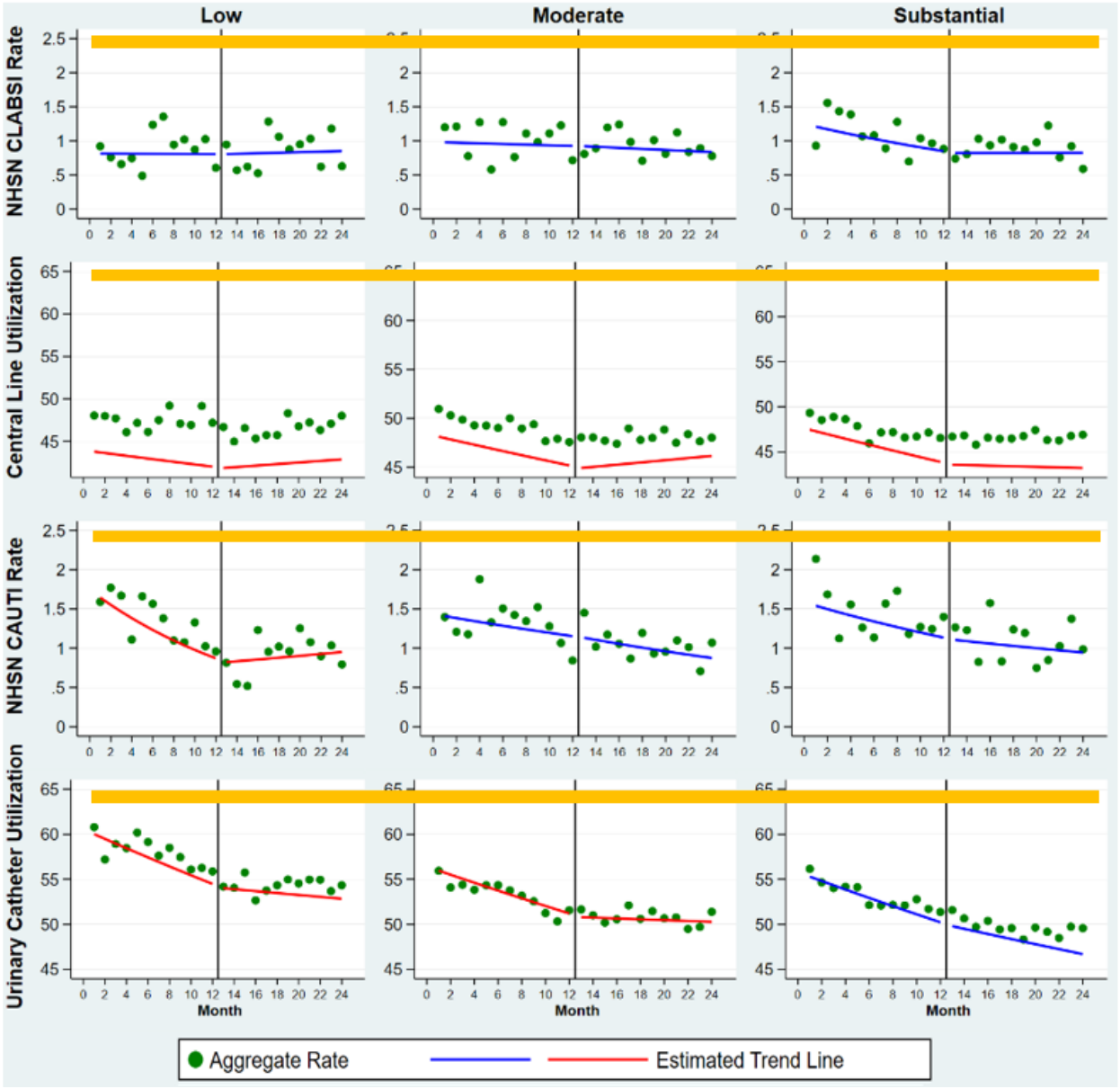
Sample size: N = 663 units (Low: 144; Moderate: 334; Substantial: 185)

Differential Effect by CUSP Adoption

By CUSP adoption level (Figure B-3):

There were no variations in program effects by Comprehensive Unitbased Safety Program (CUSP) adoption level for any of the four outcomes, suggesting that the overall effect on each of these outcomes held regardless of the level of adoption of CUSP principles. Despite the absence of differential effects, 6 of the 12 within-subgroup effects shown in Figure E-5 were statistically significant, and these pertain to catheter-associated urinary tract infection (CAUTI) rates, central line utilization, and urinary catheter utilization. These significant effects were characterized by either a slower decline during the intervention period, or a preintervention to intervention reversal from a decreasing trend to an increasing trend.

Figure B-3. Aggregate Infection Rates, Device Utilization Ratios, and Estimated Trend Lines From the Unadjusted Model for Cohorts 1 to 6, by CUSP Adoption Level



CAUTI = catheter-associated urinary tract infection; CLABSI = central line–associated bloodstream infection; CUSP = Comprehensive Unitbased Safety Program; NHSN = National Healthcare Safety Network

Notes: For each outcome (or row of graphs), subgroups connected by a gold bar at the top of the row did *not* have statistically significant pairwise differences in effects (that is, no pairwise differential effects). For each graph, red trend lines depict a statistically significant preintervention to intervention change in slopes (or effect), while blue trend lines indicate a non–statistically significant effect. Months to the left of the vertical black line (months 1 to 12) represent the preintervention period, and months to the right (months 13 to 24) represent the intervention period. Sample size for Central Line Utilization: N = 387 units (Low: 90; Moderate: 109; Substantial: 188). Sample Size for NHSN CAUTI Sample: N = 391 units (Low: 90; Moderate: 110; Substantial: 191). Sample size for Urinary Catheter Utilization Sample: N = 391 units (Low: 90; Moderate: 110; Substantial: 191).

NHSN CLABSI Rate (Cohorts 3 to 6)

Table B-9. Estimated Program Effects on NHSN CLABSI Rates, by CUSP Adoption Level (Low, Moderate, Substantial): Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted Model for Cohorts 3 to 6

Effect	IRR (95% CI)	Percent Change (95% CI)	p-value
Difference in rate change (slope): intervention vs. preintervention period (ref) for Low CUSP Adoption	1.006 (0.936 to 1.081)	0.6 (-6.4 to 8.1)	0.879
Difference in rate change (slope): intervention vs. preintervention period (ref) for Moderate CUSP Adoption	0.996 (0.943 to 1.052)	-0.4 (-5.7 to 5.2)	0.893
Difference in rate change (slope): intervention vs. preintervention period (ref) for Substantial CUSP Adoption	1.033 (0.990 to 1.077)	3.3 (-1.0 to 7.7)	0.132
Difference in differences in rate of change (slope): Moderate vs. Low (ref)	0.991 (0.905 to 1.085)	-0.9 (-9.5 to 8.5)	0.839
Difference in differences in rate of change (slope): Substantial vs. Low (ref)	1.027 (0.945 to 1.117)	2.7 (-5.5 to 11.7)	0.530
Difference in differences in rate of change (slope): Substantial vs. Moderate	1.037 (0.968 to 1.111)	3.7 (-3.2 to 11.1)	0.305

CI = confidence intervals; CLABSI = central line–associated bloodstream infection; CUSP = Comprehensive Unitbased Safety Program; IRR = incidence rate ratios; NHSN = National Healthcare Safety Network
Sample size: N = 387 units (Low: 90; Moderate: 109; Substantial 188)

Central Line Utilization (Cohorts 3 to 6)

Table B-10. Estimated Program Effects on Central Line Utilization, by CUSP Adoption Level (Low, Moderate, Substantial): Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted Model for Cohorts 3 to 6

Effect	IRR (95% CI)	Percent Change (95% CI)	p-value
Difference in rate change (slope): intervention vs. preintervention period (ref) for Low CUSP Adoption	1.006 (1.000 to 1.011)	0.6 (0.0 to 1.1)	0.034*
Difference in rate change (slope): intervention vs. preintervention period (ref) for Moderate CUSP Adoption	1.008 (1.003 to 1.013)	0.8 (0.3 to 1.3)	0.001*
Difference in rate change (slope): intervention vs. preintervention period (ref) for Substantial CUSP Adoption	1.006 (1.003 to 1.010)	0.6 (0.3 to 1.0)	0.001*
Difference in differences in rate of change (slope): Moderate vs. Low (ref)	1.002 (0.995 to 1.010)	0.2 (-0.5 to 1.0)	0.539
Difference in differences in rate of change (slope): Substantial vs. Low (ref)	1.000 (0.994 to 1.007)	0.0 (-0.6 to 0.7)	0.897
Difference in differences in rate of change (slope): Substantial vs. Moderate	0.998 (0.992 to 1.004)	-0.2 (-0.8 to 0.4)	0.547

CI = confidence intervals; CUSP = Comprehensive Unitbased Safety Program; IRR = incidence rate ratios

* Statistically significant at α = 0.05

Sample size: N = 387 units (Low: 90; Moderate: 109; Substantial 188)

NHSN CAUTI Rate (Cohorts 3 to 6)

Table B-11. Estimated Program Effects on NHSN CAUTI Rates, by CUSP Adoption Level (Low, Moderate, Substantial): Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted Model for Cohorts 3 to 6

Effect	IRR (95% CI)	Percent Change (95% CI)	p-value
Difference in rate change (slope): intervention vs. preintervention period (ref) for Low CUSP Adoption	1.073 (1.012 to 1.139)	7.3 (1.2 to 13.9)	0.019*
Difference in rate change (slope): intervention vs. preintervention period (ref) for Moderate CUSP Adoption	0.995 (0.948 to 1.044)	-0.5 (-5.2 to 4.4)	0.830
Difference in rate change (slope): intervention vs. preintervention period (ref) for Substantial CUSP Adoption	1.014 (0.978 to 1.051)	1.4 (-2.2 to 5.1)	0.458
Difference in differences in rate of change (slope): Moderate vs. Low (ref)	0.927 (0.858 to 1.000)	-7.3 (-14.2 to 0.0)	0.051
Difference in differences in rate of change (slope): Substantial vs. Low (ref)	0.944 (0.881 to 1.012)	-5.6 (-11.9 to 1.2)	0.104
Difference in differences in rate of change (slope): Substantial vs. Moderate	1.019 (0.959 to 1.082)	1.9 (-4.1 to 8.2)	0.540

CAUTI = catheter-associated urinary tract infection; CI = confidence intervals; CUSP = Comprehensive Unitbased Safety Program; IRR = incidence rate ratios; NHSN = National Healthcare Safety Network

* Statistically significant at $\alpha = 0.05$

Sample size: N = 391 units (Low: 90; Moderate: 110; Substantial 191)

Indwelling Urinary Catheter Utilization (Cohorts 3 to 6)

Table B-12. Estimated Program Effects on Urinary Catheter Utilization, by CUSP Adoption Level (Low, Moderate, Substantial): Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted Model for Cohorts 3 to 6

Effect	IRR (95% CI)	Percent Change (95% CI)	p-value
Difference in rate change (slope): intervention vs. preintervention period (ref) for Low CUSP Adoption	1.007 (1.002 to 1.012)	0.7 (0.2 to 1.2)	0.006*
Difference in rate change (slope): intervention vs. preintervention period (ref) for Moderate CUSP Adoption	1.007 (1.003 to 1.011)	0.7 (0.3 to 1.1)	0.001*
Difference in rate change (slope): intervention vs. preintervention period (ref) for Substantial CUSP Adoption	1.003 (1.000 to 1.006)	0.3 (-0.0 to 0.6)	0.080
Difference in differences in rate of change (slope): Moderate vs. Low (ref)	1.000 (0.994 to 1.007)	0.0 (-0.6 to 0.7)	0.919
Difference in differences in rate of change (slope): Substantial vs. Low (ref)	0.996 (0.990 to 1.002)	-0.4 (-1.0 to 0.2)	0.185
Difference in differences in rate of change (slope): Substantial vs. Moderate	0.996 (0.990 to 1.001)	-0.4 (-1.0 to 0.1)	0.117

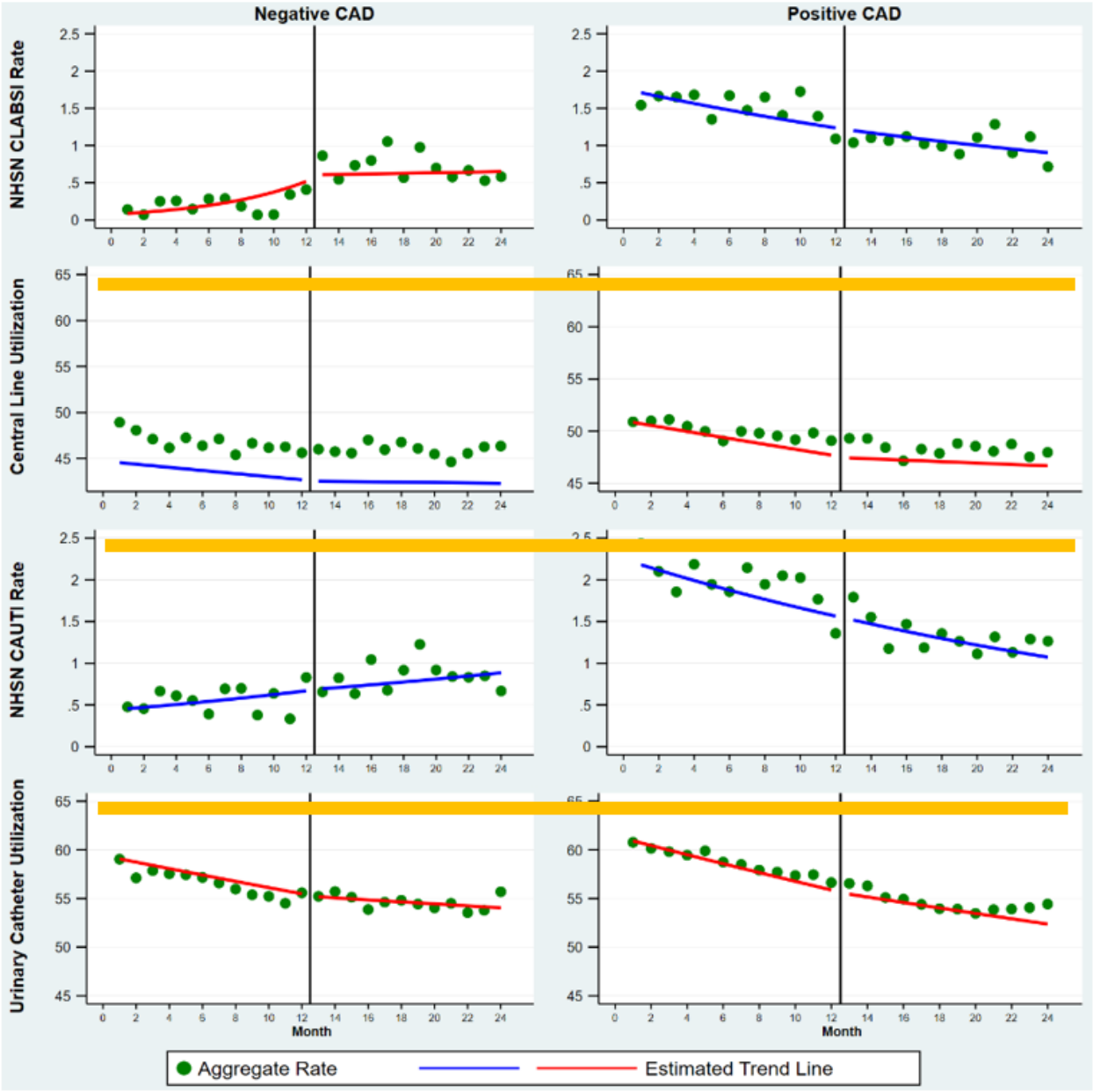
CI = confidence intervals; CUSP = Comprehensive Unitbased Safety Program; IRR = incidence rate ratios
* Statistically significant at α = 0.05
Sample size: N = 391 units (Low: 90; Moderate: 110; Substantial 191)

Differential Effect by Cumulative Attributable Difference (CAD)

By preintervention CAD (Figure B-4):

The only statistically significant differential effect **(R-IRR=1.174, CI: 1.089 to 1.266, p<0.001)** that emerged was for central line–associated blood stream infection (CLABSI) rate, where units with a positive cumulative attributable difference (CAD) had a *slower rate of decline* during the intervention period compared with the preintervention period (an unfavorable effect) while the negative CAD group had *slower rate of increase* during the intervention period (a favorable effect). This difference in effects, however, may be due to regression to the mean. As Figure B-4 below shows, there appears to be regression to the mean in infection rates (but not in device utilization). That is, for both CLABSI and CAUTI rates, units that had negative CADs during the preintervention period tended to "regress" toward higher rates during the intervention period, while those with positive CAD during the preintervention period tended to "regress" toward lower rates during intervention.

Figure B-4. Aggregate Infection Rates, Device Utilization Ratios, and Estimated Trend Lines From the Unadjusted Model for Cohorts 1 to 6, by CAD Value (Negative or Positive)



CAD = cumulative attributable difference; CAUTI = catheter-associated urinary tract infection; CLABSI = central line–associated bloodstream infection; NHSN = National Healthcare Safety Network

Notes: For each outcome (or row of graphs), subgroups connected by a gold bar at the top of the row did *not* have statistically significant pairwise differences in effects (that is, no pairwise differential effects). Within each graph, red trend lines depict a statistically significant preintervention to intervention change in slopes (or effect), while blue trend lines indicate a non–statistically significant effect. Months to the left of the vertical black line (months 1 to 12) represent the preintervention period, and months to the right (months 13 to 24) represent the intervention period. Sample size for NHSN CLABSI Sample: N = 625 units (Negative CAD: 203; Positive CAD: 422). Sample size for Central Line Utilization Sample: N = 626 units (Negative CAD: 204; Positive CAD: 422). Sample size for NHSN CAUTI Sample: N = 630 units (Negative CAD: 225; Positive CAD: 405). Sample size for Urinary Catheter Utilization Sample: N = 630 units (Negative CAD: 225; Positive CAD: 405).

NHSN CLABSI Rate (Cohorts 1 to 6)

Table B-13. Estimated Program Effects on NHSN CLABSI Rates, by Cumulative Attributable Difference (CAD) (Positive or Negative): Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted Model for Cohorts 1 to 6

Effect	IRR (95% CI)	Percent Change (95% CI)	p-value
Difference in rate change (slope): intervention vs. preintervention period (ref) for Negative CAD	0.855 (0.796 to 0.918)	-14.5 (-20.4 to -8.2)	0.000*
Difference in rate change (slope): intervention vs. preintervention period (ref) for Positive CAD	1.004 (0.979 to 1.028)	0.4 (-2.1 to 2.8)	0.775
Difference in differences in rate of change (slope): Positive vs. Negative (ref)	1.174 (1.089 to 1.266)	17.4 (8.9 to 26.6)	0.000*

CAD = cumulative attributable difference; CI = confidence intervals; CLABSI = central line–associated bloodstream infection; IRR = incidence rate ratios; NHSN = National Healthcare Safety Network

* Statistically significant at α = 0.05

Sample size: N = 625 units (Positive CAD: 203; Negative CAD: 422)

Central Line Utilization (Cohorts 1 to 6)

Table B-14. Estimated Program Effects on Central Line Utilization, by Cumulative Attributable Difference (CAD) (Positive or Negative): Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted Model for Cohorts 1 to 6

Effect	IRR (95% CI)	Percent Change (95% CI)	p-value
Difference in rate change (slope): intervention vs. preintervention period (ref) for Negative CAD	1.003 (1.000 to 1.007)	0.3 (0.0 to 0.7)	0.066
Difference in rate change (slope): intervention vs. preintervention period (ref) for Positive CAD	1.004 (1.002 to 1.007)	0.4 (0.2 to 0.7)	0.001*
Difference in differences in rate of change (slope): Positive vs. Negative (ref)	1.001 (0.997 to 1.005)	0.1 (-0.3 to 0.5)	0.691

CAD = cumulative attributable difference; CI = confidence intervals; IRR = incidence rate ratios

* Statistically significant at α = 0.05

Sample size: N = 625 units (Positive CAD: 203; Negative CAD: 422)

NHSN CAUTI Rate (Cohorts 1 to 6)

Table B-15. Estimated Program Effects on NHSN CAUTI Rates, by Cumulative Attributable Difference (CAD) (Positive or Negative): Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted Model for Cohorts 1 to 6

Effect	IRR (95% CI)	Percent Change (95% CI)	p-value
Difference in rate change (slope): intervention vs. preintervention period (ref) for Negative CAD	0.987 (0.945 to 1.031)	-1.3 (-5.5 to 3.1)	0.555
Difference in rate change (slope): intervention vs. preintervention period (ref) for Positive CAD	0.999 (0.978 to 1.019)	-0.1 (-2.2 to 1.9)	0.893

Difference in differences in rate of change (slope): Positive vs. Negative (ref)	1.012 (0.964 to 1.061)	1.2 (-3.6 to 6.1)	0.635

CAD = cumulative attributable difference; CAUTI = catheter-associated urinary tract infection; CI = confidence intervals; IRR = incidence rate ratios; NHSN = National Healthcare Safety Network
Sample size: N = 630 units (Positive CAD: 225; Negative CAD: 405)

Indwelling Urinary Catheter Utilization (Cohorts 1 to 6)

Table B-16. Estimated program effects on urinary catheter utilization, by cumulative attributable difference (CAD) (positive or negative): incidence rate ratios (IRR) and associated confidence intervals (CI) and percent changes from the unadjusted model for cohorts 1 to 6

Effect	IRR (95% CI)	Percent Change (95% CI)	p-value
Difference in rate change (slope): intervention vs. preintervention period (ref) for Negative CAD	1.004 (1.001 to 1.007)	0.4 (0.1 to 0.7)	0.009*
Difference in rate change (slope): intervention vs. preintervention period (ref) for Positive CAD	1.003 (1.001 to 1.005)	0.3 (0.1 to 0.5)	0.012*
Difference in differences in rate of change (slope): Positive vs. Negative (ref)	0.999 (0.995 to 1.002)	-0.1 (-0.5 to 0.2)	0.529

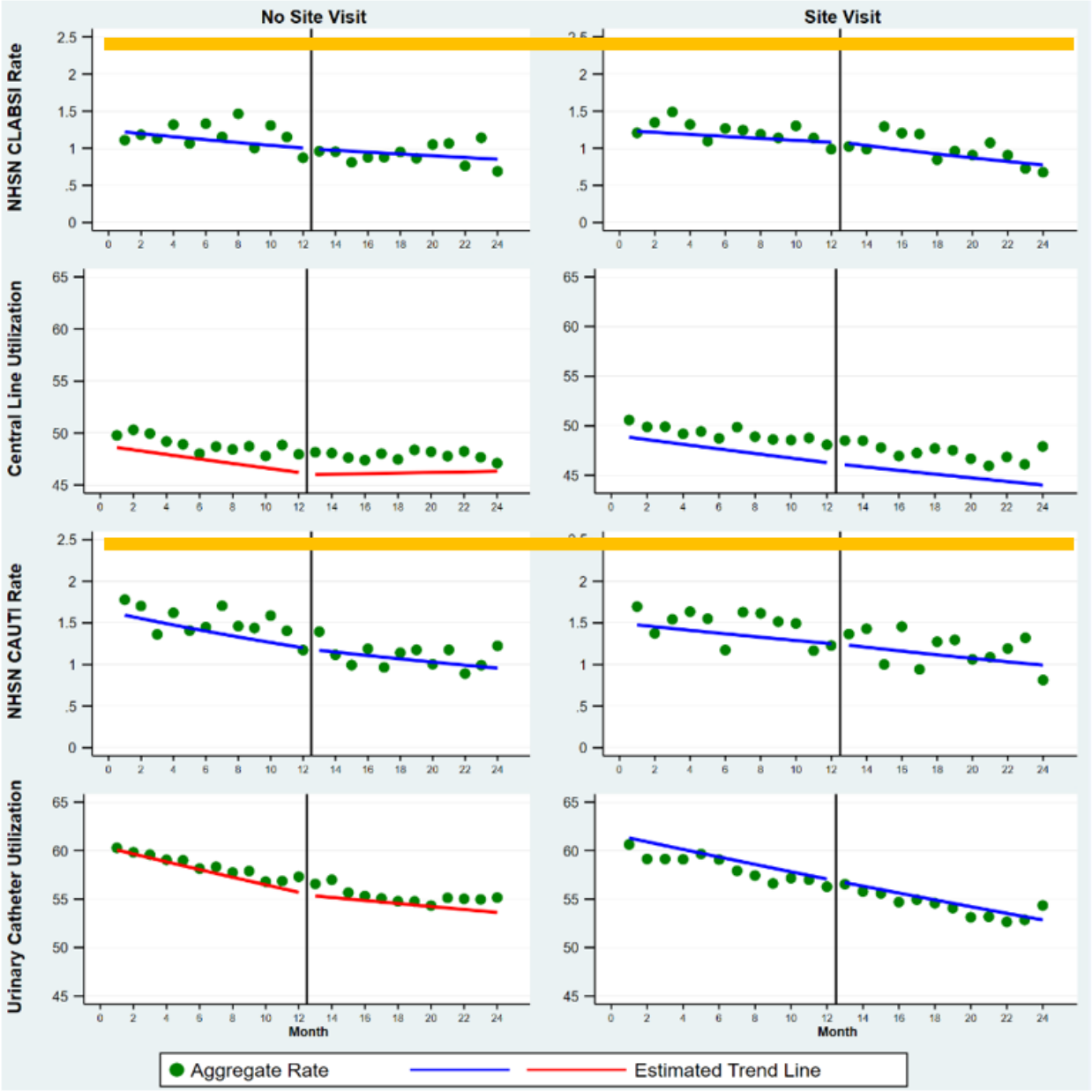
CAD = cumulative attributable difference; CI = confidence intervals; IRR = incidence rate ratios
* Statistically significant at α = 0.05
Sample size: N = 630 units (Positive CAD: 225; Negative CAD: 405)

Differential Effect by Site Visit (Cohorts 1 to 6)

By site visit (Figure B-5):

Program effects on device utilization varied by site visit status and seem to support the benefits of a site visit. For central line utilization **(R-IRR=0.996, CI: 0.992 to 1.000, p=0.035)**, both the site visit group and the no-site visit group had declining device utilization ratios during the preintervention period, but while units with a site visit maintained a similar pace of reduction during the intervention period, those without a site visit declined at a slower pace. For urinary catheter utilization **(R-IRR=0.996, CI: 0.993 to 0.999, p=0.016)**, both the site visit group and the no-site visit group also had declining device utilization ratios during the preintervention period, but, while units with a site visit maintained a similar pace of reduction during the intervention period, those without a site visit experienced a reversal in trend from decreasing during the preintervention to increasing during the intervention period.

Figure B-5. Aggregate Infection Rates, Device Utilization Ratios, and Estimated Trend Lines From the Unadjusted Model for Cohorts 1 to 6, by Site Visit Status (With or Without a Site Visit)



CAUTI = catheter-associated urinary tract infection; CLABSI = central line–associated bloodstream infection; NHSN = National Healthcare Safety Network

Notes: For each outcome (or row of graphs), subgroups connected by a gold bar at the top of the row did *not* have statistically significant pairwise differences in effects (that is, no pairwise differential effects). For each graph, red trend lines depict a statistically significant preintervention to intervention change in slopes (or effect), while blue trend lines indicate a non–statistically significant effect. Months to the left of the vertical black line (months 1 to 12) represent the preintervention period, and months to the right (months 13 to 24) represent the intervention period. Sample size for NHSN CLABSI Sample: 658 units (No Site Visit: 356; Site Visit: 302). Sample size for Central Line Utilization Sample: N = 659 units (No Site Visit: 356; Site Visit: 303). Sample size for NHSN CAUTI Sample: N = 664 units (No Site Visit: 356; Site Visit: 308). Sample size for Urinary Catheter Utilization Sample: N = 663 units (No Site Visit: 356; Site Visit: 307).

NHSN CLABSI Rate (Cohorts 1 to 6)

Table B-17. Estimated program effects on NHSN CLABSI rates, by site visit: incidence rate ratios (IRR) and associated confidence intervals (CI) and percent changes from the unadjusted model for cohorts 1 to 6

Effect	IRR (95% CI)	Percent Change (95% CI)	p-value
Difference in rate change (slope): intervention vs. preintervention period (ref) for No Site Visit	1.002 (0.973 to 1.033)	0.2 (-2.7 to 3.3)	0.877
Difference in rate change (slope): intervention vs. preintervention period (ref) for Site Visit	0.986 (0.954 to 1.018)	-1.4 (-4.6 to 1.8)	0.380
Difference in differences in rate of change (slope): Site Visit vs. No Site Visit (ref)	0.983 (0.941 to 1.028)	-1.7 (-5.9 to 2.8)	0.454

CI = confidence intervals; CLABSI = central line–associated bloodstream infection; IRR = incidence rate ratios; NHSN = National Healthcare Safety Network

Sample size: N = 658 units (No Site Visit: 356; Site Visit: 302)

Central Line Utilization (Cohorts 1 to 6)

Table B-18. Estimated Program Effects on Central Line Utilization, By Site Visit: Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted Model for Cohorts 1 to 6

Effect	IRR (95% CI)	Percent Change (95% CI)	p-value
Difference in rate change (slope): intervention vs. preintervention period (ref) for No Site Visit	1.005 (1.002 to 1.008)	0.5 (0.2 to 0.8)	0.000*
Difference in rate change (slope): intervention vs. preintervention period (ref) for Site Visit	1.001 (0.998 to 1.004)	0.1 (-0.2 to 0.4)	0.560
Difference in differences in rate of change (slope): Site Visit vs. No Site Visit (ref)	0.996 (0.992 to 1.000)	-0.4 (-0.8 to -0.0)	0.035*

CI = confidence intervals; IRR = incidence rate ratios

* Statistically significant at $\alpha = 0.05$

Sample size: N = 659 units (No Site Visit: 356; Site Visit: 303)

NHSN CAUTI Rate (Cohorts 1 to 6)

Table B-19. Estimated Program Effects on NHSN CAUTI Rates, By Site Visit: Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes from the Unadjusted Model for Cohorts 1 to 6

Effect	IRR (95% CI)	Percent Change (95% CI)	p-value
Difference in rate change (slope): intervention vs. pre-intervention period (ref) for No Site Visit	1.010 (0.985 - 1.036)	1.0 (-1.5 to 3.6)	0.416
Difference in rate change (slope): intervention vs. pre-intervention period (ref) for Site Visit	0.993 (0.967 - 1.020)	-0.7 (-3.3 to 2.0)	0.594
Difference in differences in rate of change (slope): Site Visit vs. No Site Visit (ref)	0.983 (0.947 - 1.019)	-1.7 (-5.3 to 1.9)	0.344

CI = confidence intervals; IRR = incidence rate ratios

*Statistically significant at α = .05.
[1]**Sample size:** N = 664 units (No Site Visit: 356; Site Visit: 308)

Indwelling Urinary Catheter Utilization (Cohorts 1 to 6)

Table B-20. Estimated Program Effects on Urinary Catheter Utilization, By Site Visit: Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes from the Unadjusted Model for Cohorts 1 to 6

Effect	IRR (95% CI)	Percent Change (95% CI)	p-value
Difference in rate change (slope): intervention vs. pre-intervention period (ref) for No Site Visit	1.004 (1.002 - 1.006)	0.4 (0.2 to 0.6)	0.000*
Difference in rate change (slope): intervention vs. pre-intervention period (ref) for Site Visit	1.000 (0.998 - 1.002)	0.0 (-0.2 to 0.2)	0.949
Difference in differences in rate of change (slope): Site Visit vs. No Site Visit (ref)	0.996 (0.993 - 0.999)	-0.4 (-0.7 to -0.1)	0.016*

CI = confidence intervals; IRR = incidence rate ratios
*Statistically significant at α = .05.
[1]**Sample size:** N = 663 units (No Site Visit: 356; Site Visit: 307)

C. Exploratory Aims: Cohorts 1 to 6 Sample

Exploratory Aims

To complement Figure C-1 and further illuminate the associations between hospital/intensive care unit (ICU) characteristics and each of the four outcomes (National Healthcare Safety Network [NHSN] CLABSI and CAUTI infection rates and central line and urinary catheter utilization ratios), Table C-1 displays the levels of each predictor from the highest to lowest in terms of their average infection rate or device utilization ratio. For example, as shown in the second column of Table C-1, the estimated NHSN CLABSI rates were highest for burn/trauma units, followed by medical/surgical units, then neuro/neurosurgical units, and lastly, cardio/cardiothoracic units. Discussion on the details of these associations follows.

Table C-1. Highest to Lowest Estimated Average Infection Rates or Device Utilization Ratios for Each Predictor With More Than Two Levels in the Adjusted Models for Cohorts 1 to 6

Predictor	NHSN CLABSI: Highest to Lowest Rates	Central Line Utilization: Highest to Lowest Ratios	NHSN CAUTI: Highest to Lowest Rates	Urinary Catheter Utilization: Highest to Lowest Ratios
ICU Type	Burn/Trauma	Cardio	Burn/Trauma	Med/Surg
	Med/Surg	Med/Surg	Neuro	Cardio
	Neuro	Burn/Trauma	Med/Surg	Burn/Trauma
	Cardio	Neuro	Cardio	Neuro
Cohorts	Cohort 6	Cohorts 1 & 2	Cohorts 1 & 2	Cohorts 1 & 2
	Cohorts 1 & 2	Cohorts 3, 4, & 5	Cohorts 3, 4, & 5	Cohort 6

	Cohorts 3, 4 & 5	Cohort 6	Cohort 6	Cohorts 3, 4, & 5
Ownership Type	Government	Non-gov/Nonprofit	Government	For profit
	Non-gov/Nonprofit	For profit	Non-gov/Nonprofit	Non-gov/Nonprofit
	For profit	Government	For profit	Government

CAUTI = catheter-associated urinary tract infection; CLABSI = central line–associated bloodstream infection; ICU = incidence rate ratios; NHSN = National Healthcare Safety Network

Notes: For each outcome, predictor categories are ordered from highest to lowest in terms of the estimated average infection rate or device utilization. For example, among ICU types, the average CLABSI rate is highest for burn/trauma units, followed by medical/ surgical units, then neuro units, and lastly, cardio units.

With regard to ICU type (Table C-1), burn/trauma units had, on average, the highest CLABSI and CAUTI rates, cardio units had the highest central line utilization, and medical/surgical units had the highest urinary catheter utilization. On the other hand, cardio units had the lowest CLABSI and CAUTI rates, and neuro/neurosurgery units had the lowest central line and urinary catheter utilization. When examining pairwise differences across ICU types for each outcome, the following differences emerged as statistically significant (Figure C-1):

- CLABSI rates for burn/trauma ICUs were 39 percent higher compared with medical/surgical units (IRR=1.392, CI: 1.040 to 1.863, p=0.026), and 48 percent higher relative to cardio/cardiothoracic units (IRR=1.477, CI: 1.080 to 2.019, p=0.015).
- In terms of central line utilization, when compared with medical/surgical units, cardio/cardiothoracic ICUs had 17 percent higher utilization ratios (IRR=1.167, CI: 1.078 to 1.263, p<0.001) whereas neuro/neurosurgery ICUs had 28 percent lower utilization (IRR=0.723, CI: 0.640 to 0.816, p<0.001). Relative to cardio/cardiothoracic units, neuro/neurosurgery units had 38 percent lower utilization (IRR=0.619, CI: 0.542 to 0.708, p<0.001), and similarly, burn/trauma units had 22 percent lower utilization (IRR=0.778, CI: 0.665 to 0.909, p=0.002). Lastly, burn/trauma units had 26 percent higher utilization compared with neuro/neurosurgery units (IRR=1.256, CI: 1.049 to 1.504, p=0.013).
- CAUTI rates for neuro/neurosurgery units and burn/trauma units were, respectively, 95 percent (IRR=1.949, CI: 1.604 to 2.368, p<0.001) and 102 percent (IRR=2.021, CI: 1.599 to 2.553, p<0.001) higher relative to medical/surgical units. Compared with cardio/cardiothoracic units, neuro/neurosurgery ICUs had 96.1 percent higher rates (IRR=1.961, CI: 1.567 to 2.454, p<0.001) and burn/trauma units had 103 percent higher rates (IRR=2.033, CI: 1.572 to 2.628, p<0.001).
- In terms of urinary catheter utilization, neuro/neurosurgery ICUs had 16 percent lower utilization ratios compared with medical/surgical ICUs (IRR=0.837, CI: 0.761 to 0.922, p<0.001)

and 11 percent lower utilization ratios relative to cardio/cardiothoracic units (IRR=0.887, CI: 0.798 to 0.986, p=0.026).

With respect to cohort membership (Table C-2), Cohort 6 units had, on average, the highest CLABSI rates while Cohorts 1 and 2 had the highest CAUTI rates and central line and urinary catheter utilization. When examining pairwise differences across cohort groups for each outcome (Figure E-3), no statistically significant associations were found for CAUTI rates, but:

- CLABSI rates were 15 percent lower in Cohorts 3, 4, and 5 units compared with Cohorts 1 and 2 (IRR=0.847, CI: 0.739 to 0.971, p=0.018) and were 30 percent higher in Cohort 6 relative to Cohorts 3, 4, and 5 (IRR=1.297, CI: 1.046 to 1.608, p=0.018).
- In terms of central line utilization, compared with Cohorts 1 and 2, Cohorts 3, 4, and 5 units had 10 percent lower utilization (IRR=0.900, CI: 0.844 to 0.959, p=0.001) and Cohort 6 had 11 percent lower utilization (IRR=0.890, CI: 0.795 to 0.996, p=0.042).
- In terms of urinary catheter utilization, both Cohorts 3, 4, and 5 (IRR=0.838, CI: 0.798 to 0.880, p<0.001) and Cohort 6 (IRR=0.840, CI: 0.767 to 0.920, p<0.001) had 16 percent lower utilization compared with Cohorts 1 and 2.

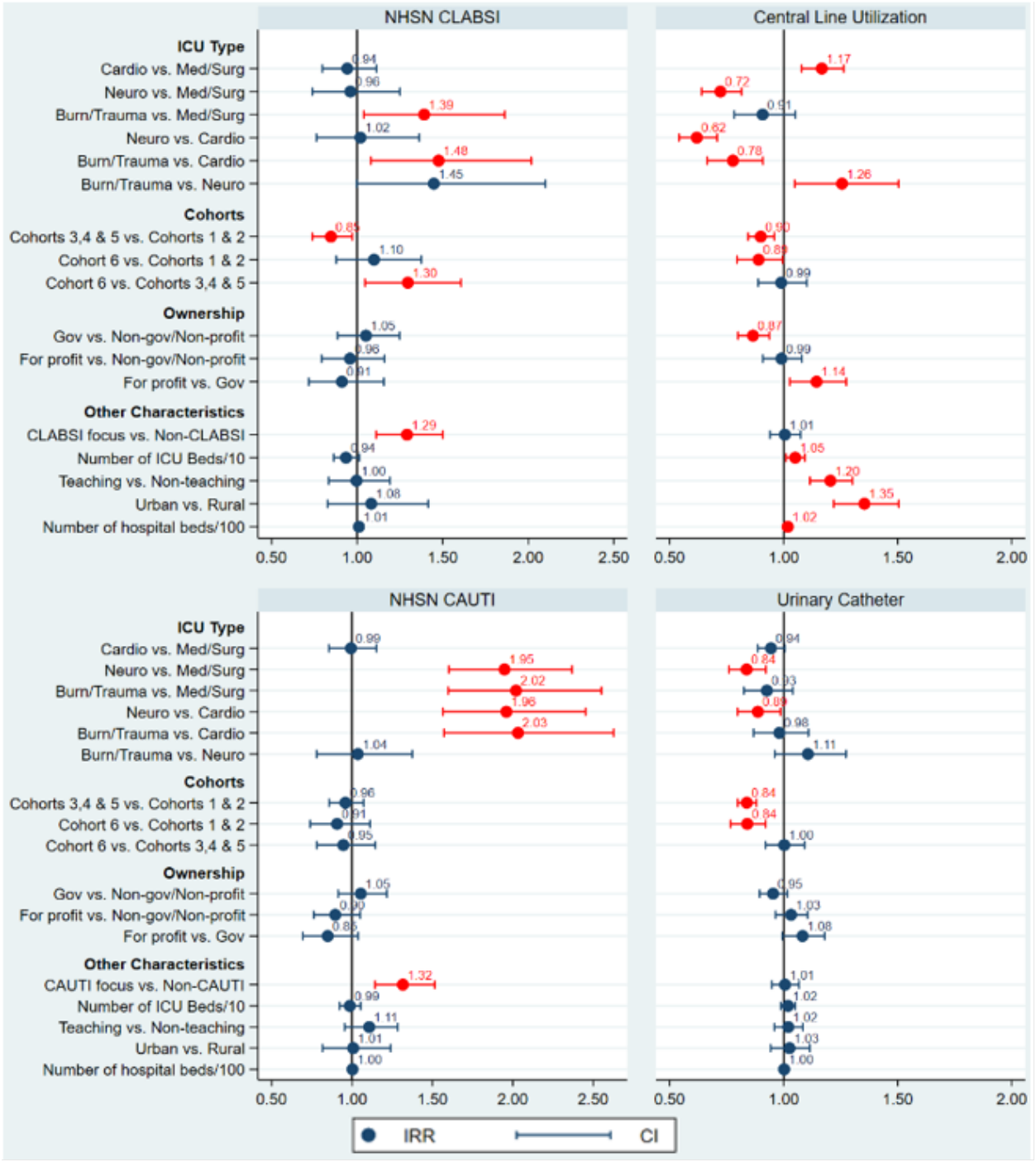
With respect to infection focus (Figure C-1), a CLABSI focus was significantly associated with 29 percent higher mean CLABSI rates (IRR=1.292, CI: 1.112 to 1.501, p=0.001), and a CAUTI focus was associated with 32 percent higher mean NHSN CAUTI rates (IRR=1.317, CI: 1.144 to 1.515, p<0.001), which seem counterintuitive, but may indicate that units declared a focus on the infection with which they were having more difficulty.

Ownership type was significantly associated with only central line utilization, which was highest for units in nongovernment/nonprofit-owned hospitals and lowest for units in government-owned hospitals (Table C-3). Specifically (see Figure C-1), units in government-owned hospitals had 13 percent lower utilization than those in nongovernment/nonprofit hospitals (IRR=0.866, CI: 0.799 to 0.937, p<0.001) while units in for-profit hospitals had a 14.4 percent higher utilization than those in government hospitals (IRR=1.144, CI: 1.027 to 1.275, p=0.015).

The remaining characteristics—ICU bed size and the hospital characteristics (teaching status, urban status, ownership type, and hospital bed size)—were associated with only central line utilization, as follows:

- A 10-bed increase in ICU size was associated with a 5 percent increase in central line utilization (IRR=1.051, CI: 1.010 to 1.093, p=0.013), while a 100-bed increase in hospital size was associated with a 2 percent increase (IRR=1.018, CI: 1.009 to 1.027, p<0.001).
- Units in teaching hospitals had 21 percent higher central line utilization than those in nonteaching hospitals (IRR=1.205, CI: 1.116 to 1.301, p<0.001), and units in urban hospitals had 35 percent higher utilization than those in rural hospitals (IRR=1.354, CI: 1.219 to 1.504, p<0.001).

Figure C-1. Estimated Associations between Infection Rates or Device Utilization Ratio, and ICU and Hospital Characteristics From the Adjusted Models for Cohorts 1 to 6: Incidence Rate Ratios (IRR) and Corresponding 95% Confidence Intervals (CI)



CI = confidence intervals; CAUTI = catheter-associated urinary tract infection; CLABSI = central line–associated bloodstream infection; ICU = intensive care unit; IRR = incidence rate ratios; NHSN = National Healthcare Safety Network

Notes: The black vertical line corresponds to an IRR = 1. A 95% CI (shown in red) that *does not cross* the black line indicates that the association is *statistically significant*, and a CI that *crosses* the black line (shown in blue) indicates that the association is *not statistically significant*. Sample size for the adjusted models: NHSN CLABSI: N = 612 units; Central Line Utilization: N = 607 units; NHSN CAUTI: N = 612 units; Urinary Catheter Utilization: N = 612 units.

NHSN CLABSI Rate (Cohorts 1 to 6)

Table C-2. Estimated Associations between NHSN CLABSI Rates and ICU and Hospital Characteristics: Incidence Rate Ratios (IRR) and Corresponding 95% Confidence Intervals (CI) and Percent Changes from the Adjusted Models for Cohorts 1 to 6

NHSN CLABSI Rates by Characteristics	Predictor	IRR (95% CI)	Percent Change (95% CI)	p-value
ICU Type	Cardio vs. Med/Surg (ref)	0.943 (0.797 to 1.115)	-5.7 (-20.3 to 11.5)	0.490
	Neuro vs. Med/Surg (ref)	0.961 (0.739 to 1.251)	-3.9 (-26.1 to 25.1)	0.768
	Burn/Trauma vs. Med/Surg (ref)	1.392 (1.040 to 1.863)	39.2 (4.0 to 86.3)	0.026*
	Neuro vs. Cardio (ref)	1.020 (0.763 to 1.363)	2.0 (-23.7 to 36.3)	0.896
	Burn/Trauma vs. Cardio (ref)	1.477 (1.080 to 2.019)	47.7 (8.0 to 101.9)	0.015*
	Burn/Trauma vs. Neuro (ref)	1.449 (0.999 to 2.101)	44.9 (-0.1 to 110.1)	0.051
Infection Focus	CLABSI vs. Non-CLABSI focus	1.292 (1.112 to 1.501)	29.2 (11.2 to 50.1)	0.001*
Cohorts	Cohorts 3 & 4 & 5 vs. Cohorts 1 & 2	0.847 (0.739 to 0.971)	-15.3 (-26.1 to -2.9)	0.018*
	Cohorts 6 vs. Cohorts 1 & 2	1.099 (0.878 to 1.376)	9.9 (-12.2 to 37.6)	0.411
	Cohorts 6 vs. Cohorts 3 & 4 & 5	1.297 (1.046 to 1.608)	29.7 (4.6 to 60.8)	0.018*
Number of ICU Beds	Number of ICU Beds/10	0.935 (0.864 to 1.013)	-6.5 (-13.6 to 1.3)	0.100
Hospital Characteristics	Teaching vs. Nonteaching	0.997 (0.834 to 1.192)	-0.3 (-16.6 to 19.2)	0.973
	Urban vs. Rural	1.083 (0.828 to 1.416)	8.3 (-17.2 to 41.6)	0.562
Ownership Type	Gov vs. Non-gov/Nonprofit	1.052 (0.886 to 1.249)	5.2 (-11.4 to 24.9)	0.563
	For profit vs. Non-gov/Nonprofit	0.959 (0.793 to 1.160)	-4.1 (-20.7 to 16.0)	0.665
	For profit vs. Gov	0.912 (0.718 to 1.157)	-8.8 (-28.2 to 15.7)	0.447
Number of Hospital Beds	Number of hospital beds/100	1.011 (0.993 to 1.029)	1.1 (-0.7 to 2.9)	0.231

CI = confidence intervals; CLABSI = central line–associated bloodstream infection; ICU = intensive care unit; IRR = incidence rate ratios; NHSN = National Healthcare Safety Network

* Statistically significant at the 0.05 level

Central Line Utilization (Cohorts 1 to 6)

Table C-3. Estimated Associations between Central Line Utilization and ICU and Hospital Characteristics: Incidence Rate Ratios (IRR) and Corresponding 95% Confidence Intervals (CI) and Percent Changes From the Adjusted Models for Cohorts 1 to 6

Central Line Utilization by Characteristics	Predictor	IRR (95% CI)	Percent Change (95% CI)	p-value
ICU Type	Cardio vs. Med/Surg (ref)	1.167 (1.078 to 1.263)	16.7 (7.8 to 26.3)	0.000*
	Neuro vs. Med/Surg (ref)	0.723 (0.640 to 0.816)	-27.7 (-36.0 to -18.4)	0.000*
	Burn/Trauma vs. Med/Surg (ref)	0.908 (0.783 to 1.052)	-9.2 (-21.7 to 5.2)	0.197
	Neuro vs. Cardio (ref)	0.619 (0.542 to 0.708)	-38.1 (-45.8 to -29.2)	0.000*
	Burn/Trauma vs. Cardio (ref)	0.778 (0.665 to 0.909)	-22.2 (-33.5 to -9.1)	0.002*
	Burn/Trauma vs. Neuro (ref)	1.256 (1.049 to 1.504)	25.6 (4.9 to 50.4)	0.013*
Infection Focus	CLABSI vs. Non-CLABSI focus	1.005 (0.940 to 1.075)	0.5 (-6.0 to 7.5)	0.880
Cohorts	Cohorts 3 & 4 & 5 vs. Cohorts 1 & 2	0.900 (0.844 to 0.959)	-10.0 (-15.6 to -4.1)	0.001*
	Cohorts 6 vs. Cohorts 1 & 2	0.890 (0.795 to 0.996)	-11.0 (-20.5 to -0.4)	0.042*
	Cohorts 6 vs. Cohorts 3 & 4 & 5	0.989 (0.888 to 1.101)	-1.1 (-11.2 to 10.1)	0.842
Number of ICU Beds	Number of ICU Beds/10	1.051 (1.010 to 1.093)	5.1 (1.0 to 9.3)	0.013*
Hospital Characteristics	Teaching vs. Nonteaching	1.205 (1.116 to 1.301)	20.5 (11.6 to 30.1)	0.000*
	Urban vs. Rural	1.354 (1.219 to 1.504)	35.4 (21.9 to 50.4)	0.000*
Ownership Type	Gov vs. Non-gov/Nonprofit	0.866 (0.799 to 0.937)	-13.4 (-20.1 to -6.3)	0.000*
	For profit vs. Non-gov/Nonprofit	0.990 (0.909 to 1.079)	-1.0 (-9.1 to 7.9)	0.822
	For profit vs. Gov	1.144 (1.027 to 1.275)	14.4 (2.7 to 27.5)	0.015*
Number of Hospital Beds	Number of hospital beds/100	1.018 (1.009 to 1.027)	1.8 (0.9 to 2.7)	0.000*

CI = confidence intervals; CLABSI = central line–associated bloodstream infection; ICU = intensive care unit; IRR = incidence rate ratios

*Statistically significant at the 0.05 level

NHSN CAUTI Rate (Cohorts 1 to 6)

Table C-4. Estimated Associations between NHSN CAUTI Rates and ICU and Hospital Characteristics: Incidence Rate Ratios (IRR) and Corresponding 95% Confidence Intervals (CI) and Percent Changes From the Adjusted Models for Cohorts 1 to 6

NHSN CAUTI Rates by Characteristics	Predictor	IRR (95% CI)	Percent Change (95% CI)	p-value
ICU Type	Cardio vs. Med/Surg (ref)	0.994 (0.856 to 1.154)	-0.6 (-14.4 to 15.4)	0.936
	Neuro vs. Med/Surg (ref)	1.949 (1.604 to 2.368)	94.9 (60.4 to 136.8)	0.000*
	Burn/Trauma vs. Med/Surg (ref)	2.021 (1.599 to 2.553)	102.1 (59.9 to 155.3)	0.000*
	Neuro vs. Cardio (ref)	1.961 (1.567 to 2.454)	96.1 (56.7 to 145.4)	0.000*
	Burn/Trauma vs. Cardio (ref)	2.033 (1.572 to 2.628)	103.3 (57.2 to 162.8)	0.000*
	Burn/Trauma vs. Neuro (ref)	1.037 (0.781 to 1.376)	3.7 (-21.9 to 37.6)	0.803
Infection Focus	CAUTI vs. Non-CAUTI focus	1.317 (1.144 to 1.515)	31.7 (14.4 to 51.5)	0.000*
Cohorts	Cohorts 3 & 4 & 5 vs. Cohorts 1 & 2	0.959 (0.858 to 1.073)	-4.1 (-14.2 to 7.3)	0.467
	Cohorts 6 vs. Cohorts 1 & 2	0.908 (0.741 to 1.113)	-9.2 (-25.9 to 11.3)	0.352
	Cohorts 6 vs. Cohorts 3 & 4 & 5	0.947 (0.782 to 1.146)	-5.3 (-21.8 to 14.6)	0.573
Number of ICU Beds	Number of ICU Beds/10	0.987 (0.923 to 1.055)	-1.3 (-7.7 to 5.5)	0.700
Hospital Characteristics	Teaching vs. Nonteaching	1.107 (0.955 to 1.284)	10.7 (-4.5 to 28.4)	0.176
	Urban vs. Rural	1.008 (0.818 to 1.241)	0.8 (-18.2 to 24.1)	0.943
Ownership Type	Gov vs. Non-gov/Nonprofit	1.055 (0.915 to 1.217)	5.5 (-8.5 to 21.7)	0.463
	For profit vs. Non-gov/Nonprofit	0.896 (0.764 to 1.052)	-10.4 (-23.6 to 5.2)	0.181
	For profit vs. Gov	0.850 (0.696 to 1.038)	-15.0 (-30.4 to 3.8)	0.110
Number of Hospital Beds	Number of hospital beds/100	1.004 (0.988 to 1.020)	0.4 (-1.2 to 2.0)	0.623

CAUTI = catheter-associated urinary tract infection; CI = confidence intervals; ICU = intensive care unit; IRR = incidence rate ratios; NHSN = National Healthcare Safety Network

* Statistically significant at the 0.05 level

Indwelling Urinary Catheter Utilization (Cohorts 1 to 6)

Table C-5. Estimated Associations between Urinary Catheter Utilization and ICU and Hospital Characteristics: Incidence Rate Ratios (IRR) and Corresponding 95% Confidence Intervals (CI) and Percent Changes From the Adjusted Models for Cohorts 1 to 6

Urinary Catheter Utilization by Characteristics	Predictor	IRR (95% CI)	Percent Change (95% CI)	p-value
ICU Type	Cardio vs. Med/Surg (ref)	0.944 (0.887 to 1.006)	-5.6 (-11.3 to 0.6)	0.075
	Neuro vs. Med/Surg (ref)	0.837 (0.761 to 0.922)	-16.3 (-23.9 to -7.8)	0.000*
	Burn/Trauma vs. Med/Surg (ref)	0.926 (0.826 to 1.040)	-7.4 (-17.4 to 4.0)	0.194
	Neuro vs. Cardio (ref)	0.887 (0.798 to 0.986)	-11.3 (-20.2 to -1.4)	0.026*
	Burn/Trauma vs. Cardio (ref)	0.981 (0.868 to 1.109)	-1.9 (-13.2 to 10.9)	0.759
	Burn/Trauma vs. Neuro (ref)	1.106 (0.961 to 1.274)	10.6 (-3.9 to 27.4)	0.161
Infection Focus	CAUTI vs. Non-CAUTI focus	1.006 (0.948 to 1.068)	0.6 (-5.2 to 6.8)	0.844
Cohorts	Cohorts 3 & 4 & 5 vs. Cohorts 1 & 2	0.838 (0.798 to 0.880)	-16.2 (-20.2 to -12.0)	0.000*
	Cohorts 6 vs. Cohorts 1 & 2	0.840 (0.767 to 0.920)	-16.0 (-23.3 to -8.0)	0.000*
	Cohorts 6 vs. Cohorts 3 & 4 & 5	1.003 (0.920 to 1.092)	0.3 (-8.0 to 9.2)	0.953
Number of ICU Beds	Number of ICU Beds/10	1.019 (0.988 to 1.051)	1.9 (-1.2 to 5.1)	0.236
Hospital Characteristics	Teaching vs. Nonteaching	1.020 (0.959 to 1.085)	2.0 (-4.1 to 8.5)	0.526
	Urban vs. Rural	1.026 (0.943 to 1.115)	2.6 (-5.7 to 11.5)	0.553
Ownership Type	Gov vs. Non-gov/Nonprofit	0.953 (0.895 to 1.016)	-4.7 (-10.5 to 1.6)	0.140
	For profit vs. Non-gov/Nonprofit	1.032 (0.964 to 1.105)	3.2 (-3.6 to 10.5)	0.360
	For profit vs. Gov	1.083 (0.994 to 1.180)	8.3 (-0.6 to 18.0)	0.070
Number of Hospital Beds	Number of hospital beds/100	1.002 (0.995 to 1.010)	0.2 (-0.5 to 1.0)	0.576

CAUTI = catheter-associated urinary tract infection; CI = confidence intervals; ICU = intensive care unit; IRR = incidence rate ratios

* Statistically significant at the 0.05 level

NHSN CAUTI Rate (Cohorts 1 to 6)

Table C-6. Estimated Program Effects on NHSN CAUTI Rates, By Site Visit: Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted Model for Cohorts 1 to 6

Effect	IRR (95% CI)	Percent Change (95% CI)	p-value
Difference in rate change (slope): intervention vs. preintervention period (ref) for No Site Visit	1.010 (0.985 to 1.036)	1.0 (-1.5 to 3.6)	0.416
Difference in rate change (slope): intervention vs. preintervention period (ref) for Site Visit	0.993 (0.967 to 1.020)	-0.7 (-3.3 to 2.0)	0.594
Difference in differences in rate of change (slope): Site Visit vs. No Site Visit (ref)	0.983 (0.947 to 1.019)	-1.7 (-5.3 to 1.9)	0.344

CAUTI = catheter-associated urinary tract infection; CI = confidence intervals; IRR = incidence rate ratios; NHSN = National Healthcare Safety Network

Sample size: N = 664 units (No Site Visit: 356; Site Visit: 308)

Indwelling Urinary Catheter Utilization (Cohorts 1 to 6)

Table C-7. Estimated Program Effects on Urinary Catheter Utilization, By Site Visit: Incidence Rate Ratios (IRR) and Associated Confidence Intervals (CI) and Percent Changes From the Unadjusted Model for Cohorts 1 to 6

Effect	IRR (95% CI)	Percent Change (95% CI)	p-value
Difference in rate change (slope): intervention vs. preintervention period (ref) for No Site Visit	1.004 (1.002 to 1.006)	0.4 (0.2 to 0.6)	0.000*
Difference in rate change (slope): intervention vs. preintervention period (ref) for Site Visit	1.000 (0.998 to 1.002)	0.0 (-0.2 to 0.2)	0.949
Difference in differences in rate of change (slope): Site Visit vs. No Site Visit (ref)	0.996 (0.993 to 0.999)	-0.4 (-0.7 to -0.1)	0.016*

CI = confidence intervals; IRR = incidence rate ratios

* Statistically significant at $\alpha = 0.05$

Sample size: N = 663 units (No Site Visit: 356; Site Visit: 307)

Appendix 5. Monthly Aggregate Rates and Ratios

Monthly Aggregate Data for NHSN CLABSI and CAUTI rates, population CLABSI and CAUTI rates, and indwelling urinary catheter and central line utilization ratios

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A. Monthly Aggregate Rates and Ratios

NHSN CLABSI Rates

Table A1. NHSN CLABSI Rate: Aggregate Data (N = 658 units; Cohort 1: 164; Cohort 2: 106; Cohort 3: 119; Cohort 4: 104; Cohort 5: 117; Cohort 6: 49)

Time Period	Program Month	Number of CLABSIs	Central Line Days	Aggregate CLABSI Rates per 1,000 Central Line Days	Number of Units Submitting Data	Percent of Units Submitting Data
Preintervention period	B1	130	112624	1.15	639	97.1%
	B2	145	115500	1.26	641	97.4%
	B3	148	114528	1.29	642	97.6%
	B4	149	112879	1.32	645	98.0%
	B5	119	110312	1.08	643	97.7%
	B6	147	112881	1.30	642	97.6%
	B7	133	111331	1.19	645	98.0%
	B8	150	111906	1.34	648	98.5%
	B9	123	115563	1.06	654	99.4%
	B10	144	110394	1.30	655	99.5%
	B11	134	116949	1.15	651	98.9%
	B12	107	115885	0.92	656	99.7%
	Total	1629	1360752	1.20	N/A	N/A
Intervention period	M1	113	114313	0.99	655	99.5%
	M2	113	116657	0.97	656	99.7%
	M3	116	113185	1.02	657	99.8%
	M4	116	113326	1.02	655	99.5%
	M5	112	110135	1.02	655	99.5%
	M6	103	113894	0.90	650	98.8%
	M7	101	111273	0.91	640	97.3%
	M8	109	110142	0.99	627	95.3%
	M9	116	108463	1.07	623	94.7%
	M10	86	104196	0.83	610	92.7%
	M11	102	106384	0.96	609	92.6%
	M12	65	95097	0.68	539	81.9%
	Total	1252	1317065	0.95	N/A	N/A

CLABSI = central line–associated blood stream infection; NHSN = National Healthcare Safety Network

Note: Within each metric, monthly unit level data that did not pass quality checks or contained values of 0 in the numerator and denominator were deleted from analysis. Therefore, values for infection counts, device days, patient days, and number of units reporting may not match across all tables in Appendix 5.

Population CLABSI Rates

Table A-2. Population CLABSI Rate: Aggregate Data (N = 658 units; Cohort 1: 164; Cohort 2: 106; Cohort 3: 119; Cohort 4: 104; Cohort 5: 117; Cohort 6: 49)

Time Period	Program Month	Number of CLABSIs	Patient Days	Aggregate CLABSI Population Rates per 10,000 Patient Days	Number of Units Submitting Data	Percent of Units Submitting Data
Preintervention period	B1	130	224481	5.79	639	97.1%
	B2	145	229983	6.30	640	97.3%
	B3	148	229304	6.45	642	97.6%
	B4	149	229166	6.50	644	97.9%
	B5	119	224341	5.30	643	97.7%
	B6	147	233093	6.31	642	97.6%
	B7	133	226064	5.88	645	98.0%
	B8	150	230027	6.52	648	98.5%
	B9	123	237354	5.18	654	99.4%
	B10	144	229194	6.28	655	99.5%
	B11	134	238668	5.61	651	98.9%
	B12	107	240773	4.44	655	99.5%
	Total	1629	2772448	5.88	N/A	N/A
Intervention period	M1	111	235428	4.71	654	99.4%
	M2	113	241170	4.69	655	99.5%
	M3	116	236805	4.90	656	99.7%
	M4	116	239682	4.84	654	99.4%
	M5	112	230473	4.86	654	99.4%
	M6	103	239216	4.31	650	98.8%
	M7	101	231630	4.36	640	97.3%
	M8	109	231626	4.71	627	95.3%
	M9	116	230802	5.03	623	94.7%
	M10	86	218716	3.93	610	92.7%
	M11	102	226425	4.50	609	92.6%
	M12	65	200353	3.24	539	81.9%
	Total	1250	2762326	4.53	N/A	N/A

CLABSI = central line–associated bloodstream infection

Note: Within each metric, monthly unit level data that did not pass quality checks or contained values of 0 in the numerator and denominator were deleted from analysis. Therefore, values for infection counts, device days, patient days, and number of units reporting may not match across all tables in Appendix 5.

Central Line Utilization Ratios

Table A-3. Central Line Utilization Aggregate Data (N = 659 units; Cohort 1: 165; Cohort 2: 106; Cohort 3: 119; Cohort 4: 104; Cohort 5: 117; Cohort 6: 49)

Time Period	Program Month	Number of Central Line Days	Number of Patient Days	Aggregate Central Line Device Utilization	Number of Units Submitting Data	Percent of Units Submitting Data
Preintervention period	B1	112624	224609	50.14	641	97.3%
	B2	115292	230027	50.12	641	97.3%
	B3	114528	229380	49.93	644	97.7%
	B4	112747	229219	49.19	645	97.9%
	B5	110312	224450	49.15	645	97.9%
	B6	112881	233481	48.35	647	98.2%
	B7	111334	226183	49.22	647	98.2%
	B8	111906	230060	48.64	649	98.5%
	B9	115565	237404	48.68	656	99.5%
	B10	110394	229321	48.14	658	99.8%
	B11	116949	239561	48.82	657	99.7%
	B12	115659	240880	48.02	657	99.7%
	Total	1360191	2774575	49.02	N/A	N/A
Intervention period	M1	114064	236084	48.32	656	99.5%
	M2	116442	241305	48.26	658	99.8%
	M3	112997	236870	47.70	658	99.8%
	M4	113202	239849	47.20	657	99.7%
	M5	109962	230609	47.68	657	99.7%
	M6	113894	239373	47.58	652	98.9%
	M7	111273	231777	48.01	644	97.7%
	M8	110146	231683	47.54	629	95.4%
	M9	108463	230863	46.98	625	94.8%
	M10	104196	218753	47.63	612	92.9%
	M11	106384	226482	46.97	610	92.6%
	M12	95099	200394	47.46	540	81.9%
	Total	1316122	2764042	47.62	N/A	N/A

Note: Within each metric, monthly unit level data that did not pass quality checks or contained values of 0 in the numerator and denominator were deleted from analysis. Therefore, values for infection counts, device days, patient days, and number of units reporting may not match across all tables in Appendix 5.

NHSN CAUTI Rates

Table A-4. NHSN CAUTI Rate: Aggregate Data (N = 664 units; Cohort 1: 165; Cohort 2: 106; Cohort 3: 120; Cohort 4: 106; Cohort 5: 118; Cohort 6: 49)

Time Period	Program Month	Number of CAUTIs	Urinary Catheter Days	Aggregate CAUTI Rates per 1,000 Urinary Catheter Days	Number of Units Submitting Data	Percent of Units Submitting Data
Preintervention period	B1	237	136167	1.74	644	97.0%
	B2	214	137517	1.56	645	97.1%
	B3	197	136553	1.44	647	97.4%
	B4	221	135846	1.63	649	97.7%
	B5	197	133840	1.47	649	97.7%
	B6	182	137623	1.32	650	97.9%
	B7	221	132281	1.67	651	98.0%
	B8	204	133323	1.53	653	98.3%
	B9	200	135918	1.47	658	99.1%
	B10	203	131468	1.54	662	99.7%
	B11	178	137388	1.30	659	99.2%
	B12	166	138705	1.20	663	99.8%
	Total	2420	1626629	1.49	N/A	N/A
Intervention period	M1	187	135390	1.38	663	99.8%
	M2	173	137960	1.25	664	100.0%
	M3	133	133521	1.00	664	100.0%
	M4	175	133694	1.31	662	99.7%
	M5	122	127906	0.95	661	99.5%
	M6	158	131791	1.20	655	98.6%
	M7	156	126998	1.23	647	97.4%
	M8	129	125495	1.03	632	95.2%
	M9	143	125732	1.14	628	94.6%
	M10	121	118530	1.02	615	92.6%
	M11	139	122439	1.14	611	92.0%
	M12	116	110961	1.05	546	82.2%
	Total	1752	1530417	1.14	N/A	N/A

CAUTI = catheter associated urinary tract infection; NHSN = National Healthcare Safety Network

Note: Within each metric, monthly unit level data that did not pass quality checks or contained values of 0 in the numerator and denominator were deleted from analysis. Therefore, values for infection counts, device days, patient days, and number of units reporting may not match across all tables in Appendix 5.

Population CAUTI Rates

Table A-5. Population CAUTI Rate: Aggregate Data (N = 663 units; Cohort 1: 164; Cohort 2: 106; Cohort 3: 120; Cohort 4: 106; Cohort 5: 118; Cohort 6: 49)

Time Period	Program Month	Number of CAUTIs	Patient Days	Aggregate CAUTI Population Rates per 10,000 Patient Days	Number of Units Submitting Data	Percent of Units Submitting Data
Preintervention period	B1	237	225276	10.52	644	97.1%
	B2	214	230717	9.28	644	97.1%
	B3	197	229955	8.57	647	97.6%
	B4	220	229650	9.58	648	97.7%
	B5	197	225694	8.73	649	97.9%
	B6	182	234821	7.75	650	98.0%
	B7	221	227494	9.71	651	98.2%
	B8	204	231425	8.81	653	98.5%
	B9	200	237117	8.43	658	99.2%
	B10	203	229540	8.84	661	99.7%
	B11	178	239288	7.44	658	99.2%
	B12	164	242507	6.76	662	99.8%
	Total	2417	2783484	8.68	N/A	N/A
Intervention period	M1	186	237860	7.82	662	99.8%
	M2	173	242904	7.12	663	100.0%
	M3	133	238729	5.57	663	100.0%
	M4	175	241385	7.25	661	99.7%
	M5	122	232480	5.25	661	99.7%
	M6	158	240847	6.56	655	98.8%
	M7	156	233220	6.69	647	97.6%
	M8	129	233222	5.53	632	95.3%
	M9	143	231663	6.17	628	94.7%
	M10	121	219583	5.51	615	92.8%
	M11	139	226653	6.13	611	92.2%
	M12	116	202107	5.74	545	82.2%
	Total	1751	2780653	6.30	N/A	N/A

CAUTI = catheter associated urinary tract infection

Note: Within each metric, monthly unit level data that did not pass quality checks or contained values of 0 in the numerator and denominator were deleted from analysis. Therefore, values for infection counts, device days, patient days, and number of units reporting may not match across all tables in Appendix 5.

Indwelling Urinary Catheter Utilization Ratios

Table A-6. Indwelling Urinary Catheter Utilization: Aggregate Data (N = 663 units; Cohort 1: 164; Cohort 2: 106; Cohort 3: 120; Cohort 4: 106; Cohort 5: 118; Cohort 6: 49)

Time Period	Program Month	Number of Catheter Days	Number of Patient Days	Aggregate Catheter Device Utilization	Number of Units Submitting Data	Percent of Units Submitting Data
Preintervention period	B1	136167	225276	60.44	644	97.1%
	B2	137334	230717	59.52	644	97.1%
	B3	136553	229955	59.38	647	97.6%
	B4	135678	229650	59.08	648	97.7%
	B5	133840	225694	59.30	649	97.9%
	B6	137623	234959	58.57	651	98.2%
	B7	132281	227494	58.15	651	98.2%
	B8	133323	231425	57.61	653	98.5%
	B9	135918	237120	57.32	659	99.4%
	B10	130768	229540	56.97	661	99.7%
	B11	136579	239924	56.93	661	99.7%
	B12	137858	242507	56.85	662	99.8%
	Total	1623922	2784261	58.33	N/A	N/A
Intervention period	M1	134527	237860	56.56	662	99.8%
	M2	137139	242904	56.46	663	100.0%
	M3	132810	238729	55.63	663	100.0%
	M4	132971	241589	55.04	662	99.8%
	M5	127906	232484	55.02	662	99.8%
	M6	131791	240971	54.69	656	98.9%
	M7	126998	233223	54.45	648	97.7%
	M8	125495	233234	53.81	633	95.5%
	M9	125732	231663	54.27	628	94.7%
	M10	118530	219583	53.98	615	92.8%
	M11	122439	226653	54.02	611	92.2%
	M12	110865	202290	54.80	546	82.4%
	Total	1527203	2781183	54.91	N/A	N/A

Note: Within each metric, monthly unit level data that did not pass quality checks or contained values of 0 in the numerator and denominator were deleted from analysis. Therefore, values for infection counts, device days, patient days, and number of units reporting may not match across all tables in Appendix 5.

Appendix 6. Baseline Aggregate and National ICU Infection Rates

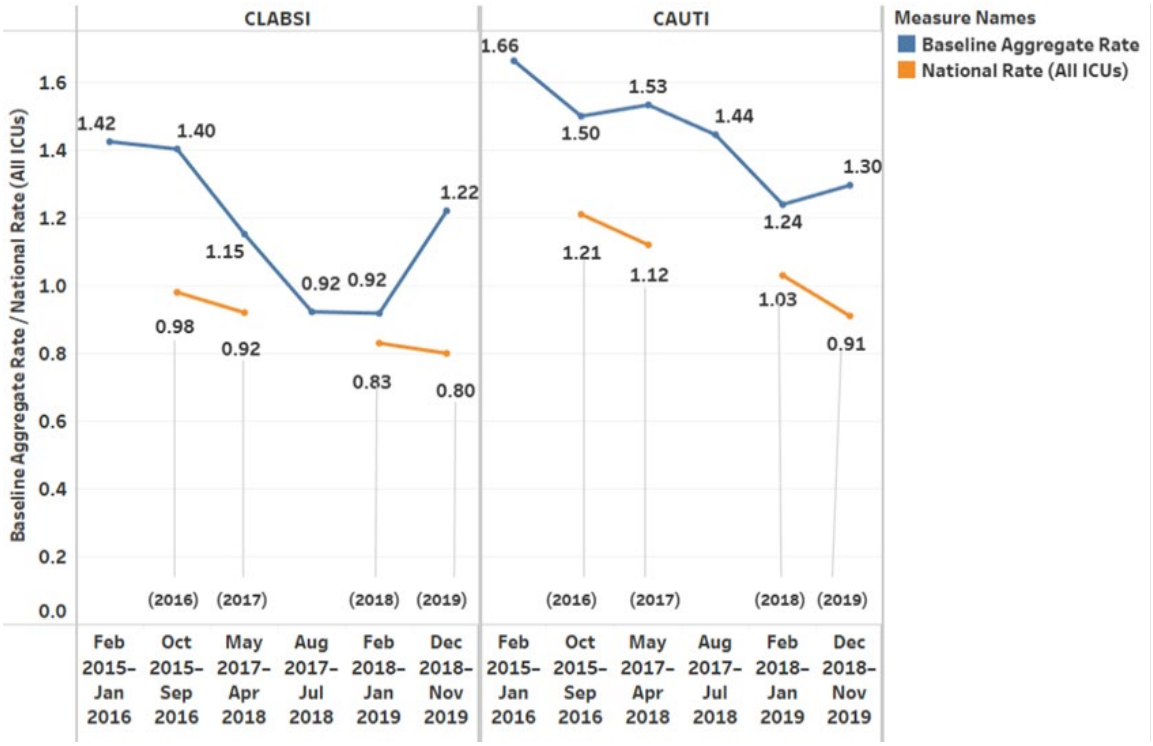
(See Section G)

A. Baseline Aggregate and National ICU Infection Rates

To provide context to the magnitude of infection rates observed in the intensive care units (ICUs) that participated in the AHRQ ICU Project, we compared the baseline aggregate rates of the six participating cohorts with the yearly National Healthcare Safety Network (NHSN) central line–associated blood stream infection (CLABSI) and catheter-associated urinary tract infection (CAUTI) rates of all ICUs reported in Centers for Disease Control and Prevention's (CDC's) NHSN HAI Progress Reports, 2016–2019 (Figure A-1). Notice that the baseline periods of the cohorts do not match up exactly with the (calendar) years for the national data. To facilitate the comparison, each cohort's baseline period (which falls in two calendar years) was matched up with the calendar year that covers more of the cohort's baseline months. Below are a few observations from Figure A-1:

- National CLABSI and CAUTI rates in ICUs declined consistently from 2016 to 2019.
- Baseline aggregate rates also declined consistently from Cohort 1 to Cohort 5 (2015 to 2018), but baseline rates for Cohort 6 (2019, which was pre-COVID) were higher than that of the prior cohort (Cohort 5).
- CAUTI rates are generally higher than CLABSI rates (both nationally and among participating ICUs).
- Participating ICUs had much higher CLABSI and CAUTI baseline rates compared with the national rates in corresponding years.

Figure A-1. NHSN CLABSI and CAUTI Rates: Baseline Aggregate Rates of Participating Cohorts (Cohorts 1 to 6) and National Rates for all ICUs



CAUTI = catheter-associated urinary tract infection; CLABSI = central line–associated bloodstream infection; HAI = healthcare-associated infection; ICU = intensive care unit; NHSN = National Healthcare Safety Network; NICU = neonatal intensive care unit

Notes: Baseline aggregate NHSN CLABSI and CAUTI rates for each cohort (Cohorts 1 to 6) were calculated from data submitted by participating ICUs. Data on national rates were calculated by taking the ratio of the total number of observed infections and the total device days reported in CDC's NSHN HAI Progress Reports, 2016–2019. The data include all ICUs and exclude wards (and other non–critical care locations) and NICUs in acute care hospitals that reported data. The number of these ICUs that reported data are as follows: CLABSI—2016: 3,125; 2017: 3,139; 2018: 3,093; 2019: 3,079; CAUTI—2016: 3,130; 2017: 3,139; 2018: 3,101; 2019: 3,081.

Appendix 7. COVID-19 Stress on Program Implementation and ICU Infection Rates

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A. Background

In March 2020, the Agency for Healthcare Research and Quality (AHRQ) Safety Program for Intensive Care Units (ICUs): Preventing CLABSI and CAUTI was suspended due to the coronavirus disease 2019 (COVID-19) pandemic. Participating hospitals were burdened with high patient volume and their attention shifted to the pandemic response. In August 2020, the program resumed after the first wave of cases subsided and units indicated they were ready to focus on central line–associated blood stream infection (CLABSI)/catheter-associated urinary tract infection (CAUTI) prevention.

To assess the impact of the pandemic on program outcomes and participation, the National Program Team (NPT) utilized a publicly available national dataset managed by the U.S. Department of Health and Human Services (HHS). Updated weekly, the dataset contained *facility-level* data on COVID-related capacity aggregated to a weekly level. The population included in the dataset was 1) all hospitals registered with the Centers for Medicare & Medicaid Services (CMS) as of June 1, 2020, and 2) non-CMS hospitals reporting into the dataset since July 15, 2020. For this analysis, the NPT utilized data from July 31, 2020, onward.

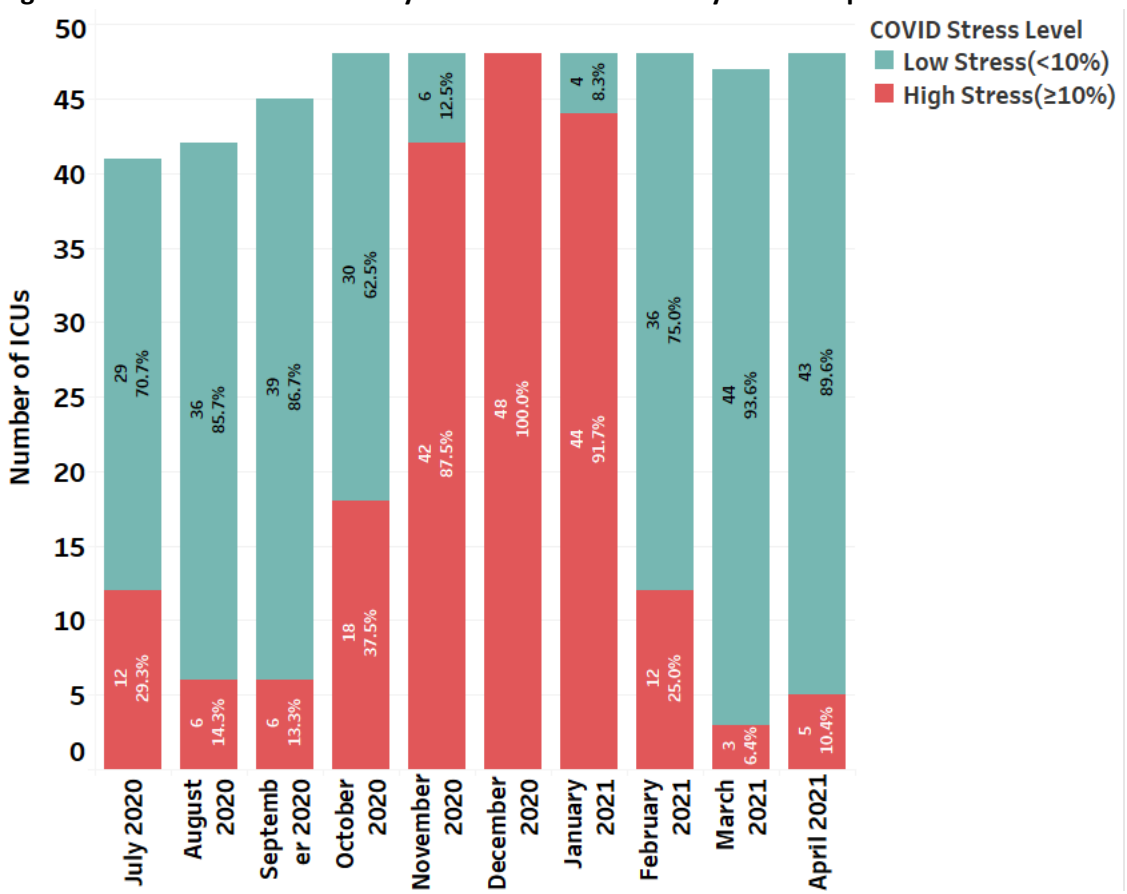
Using these data, the NPT calculated a monthly COVID Stress Metric (CSM) modeled after the University of Washington's Institute for Health Metrics and Evaluation (IHME) framework for measuring COVID stress. It was generated by first calculating the weekly (7-day average: Thursday to Friday) fraction of staffed hospital beds with a confirmed or suspected adult COVID patient[1] and then averaging the weekly fractions to produce a monthly CSM. The monthly CSMs were then merged to the monthly aggregate CLABSI and CAUTI infection rates and central line and urinary catheter utilization of Cohort 6 participating units via the hospital's CMS Certification number. The current analysis is limited to Cohort 6 program months when COVID stress data were available (July 2020 to April 2021[2]). Note that because the CMS COVID data are at the hospital level, participating units belonging to the same facility have the same value of CSM. **In all the analyses that follow, only 48 of the 49 participating units were included because one unit's facility did not report any data within the HHS COVID dataset**.

[1] For any given week, the fraction of staffed hospital beds with a confirmed or suspected adult COVID patient was calculated as the ratio of the week's average number of patients currently hospitalized in an adult inpatient bed who have confirmed or suspected COVID-19 divided by the week's average of total number of staffed inpatient adult beds in the hospital.
[2] The July 2020 facility-level COVID data consisted of data from the last week of July 2020 only.

B. COVID Stress

Based on the facility-level monthly CSMs and following IHME's cutoffs[3] units were categorized as having low COVID stress (CSM less than 10%) or high COVID stress (CSM greater than or equal to 10%). Figure B-1 shows the number of ICU participants that fell into each category between July 2020 and April 2021. The number of units that experienced high COVID stress was highest (88.0 to 91.7%) through the months of November 2020 through January 2021, with all units (100%) reporting high COVID stress in the month of December 2020.

Figure B1. Distribution of Monthly COVID Stress Levels: July 2020 to April 2021



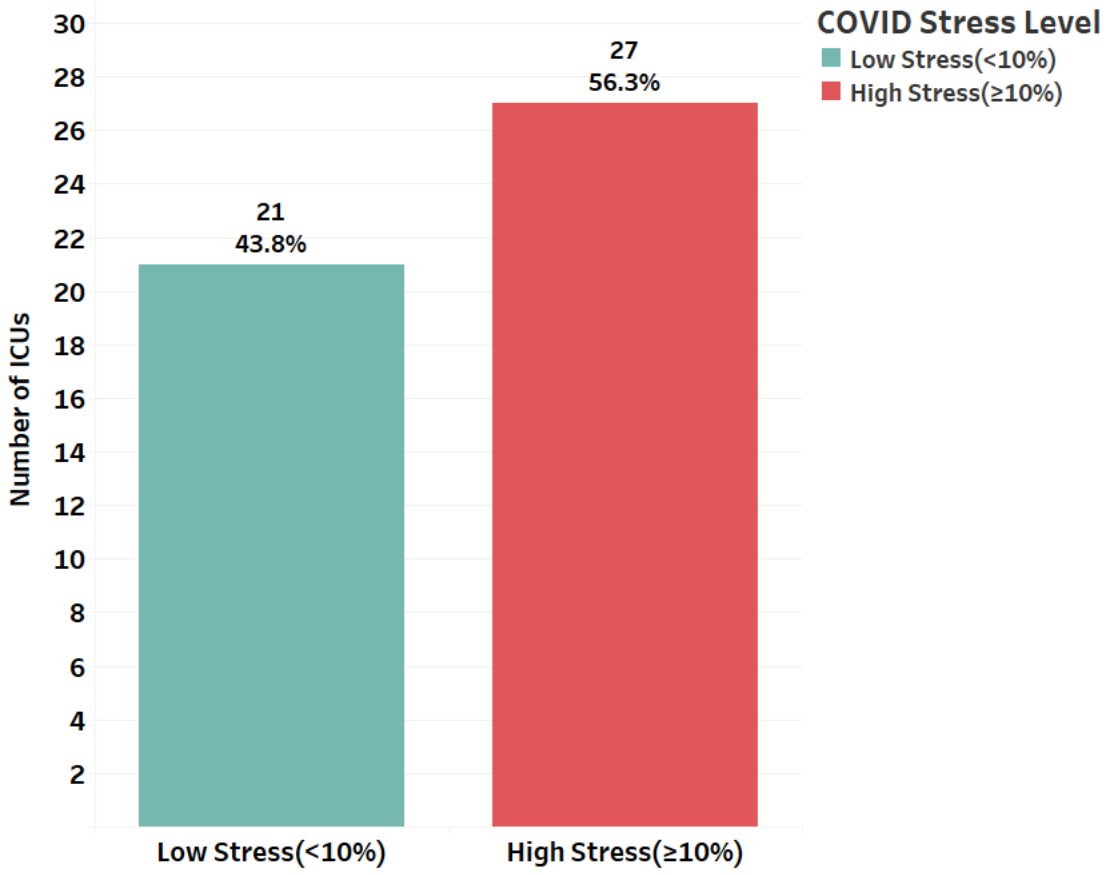
COVID19 = coronavirus disease 2019; CSM = COVID Stress Metric; ICU = intensive care unit

Notes: Labels inside the bars show the number and percentage of units with low stress and high stress based on monthly COVID Stress Metric (CSM) values. CSM was calculated using facility-level data from the U.S. Department of Health and Human Services. Total N = 48 units, but the total number of units changes across months due to sporadic COVID19 reporting.

[3] See Figures 22 and 23, https://www.healthdata.org/sites/default/files/files/Projects/COVID/2021/briefing_United_States_of_America.pdf

Figure B-2 shows the overall COVID stress levels aggregated across part of the program gap period and the remaining implementation period[4] (July 2020 to April 2021). Overall, 21 ICUs had low COVID stress, and 27 ICUs had high COVID stress during this combined period.

Figure B-2. Distribution of Overall COVID Stress Levels From July 2020 to April 2021



CSM = COVID Stress Metric; ICU = intensive care unit

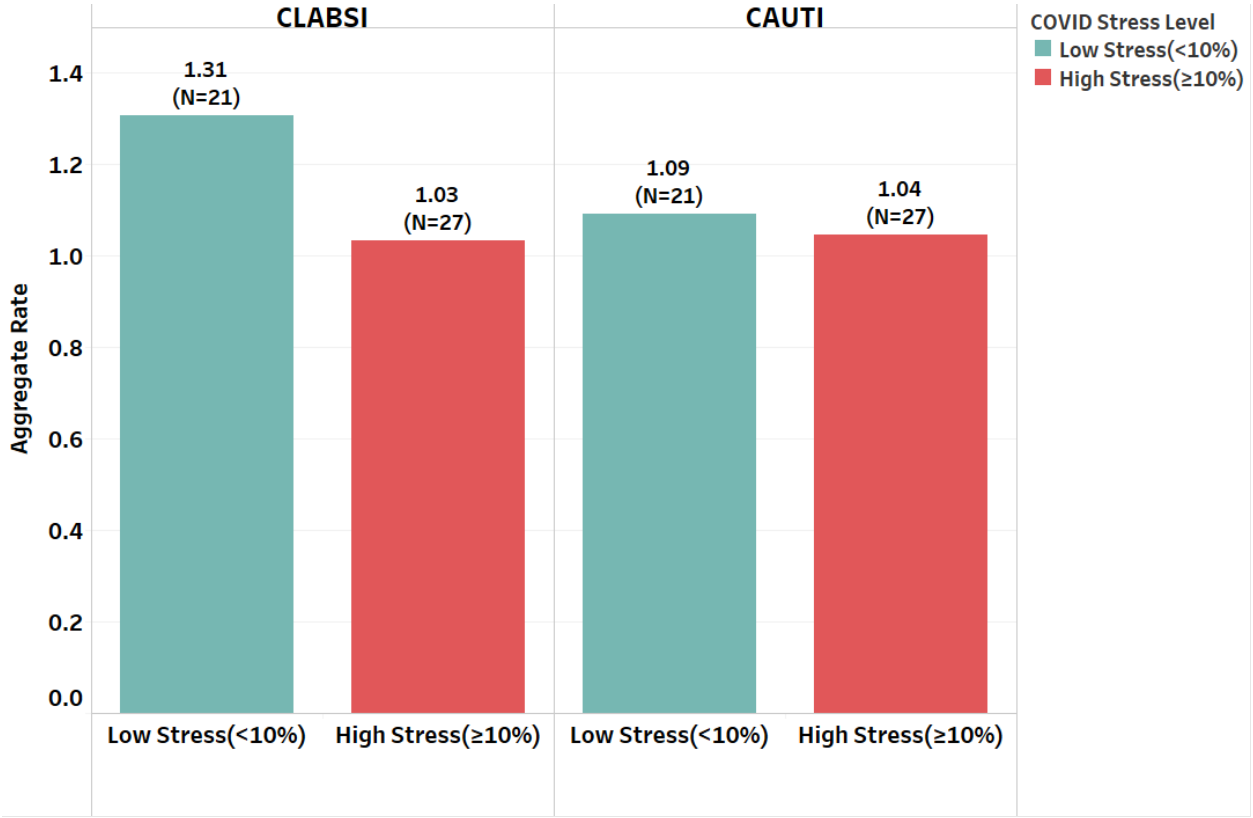
Notes: Labels on top of the bars show the number and percentage of units with low stress and high stress based on overall average of weekly COVID Stress Metric (CSM) values from July 2020 to April 2021. CSM was calculated using facility-level data from the U.S. Department of Health and Human Services. Total N = 48 units.

[4] That is, the average of the weekly (7-day average: Thursday to Friday) fraction of staffed hospital beds with a confirmed or suspected adult COVID patient, across all weeks within the July 2020 to April 2021 period.

C. COVID Stress and Outcomes

Aggregate infection rates and device utilization ratios were calculated separately for the low and high overall COVID stress groups. Figure C-1 shows that ICUs with low overall COVID stress had higher CLABSI (1.31) and CAUTI (1.09) rates than their high overall COVID stress counterparts (CLABSI rate=1.03, CAUTI rate=1.04). Figure C2 shows that ICUs with high overall COVID stress had a slightly higher central line utilization ratio (52.6%) compared to ICUs with low overall COVID stress (50.5%), while low overall COVID stress ICUs experienced slightly higher urinary catheter utilization (55.95%) than high overall COVID stress ICUs (52.89%).

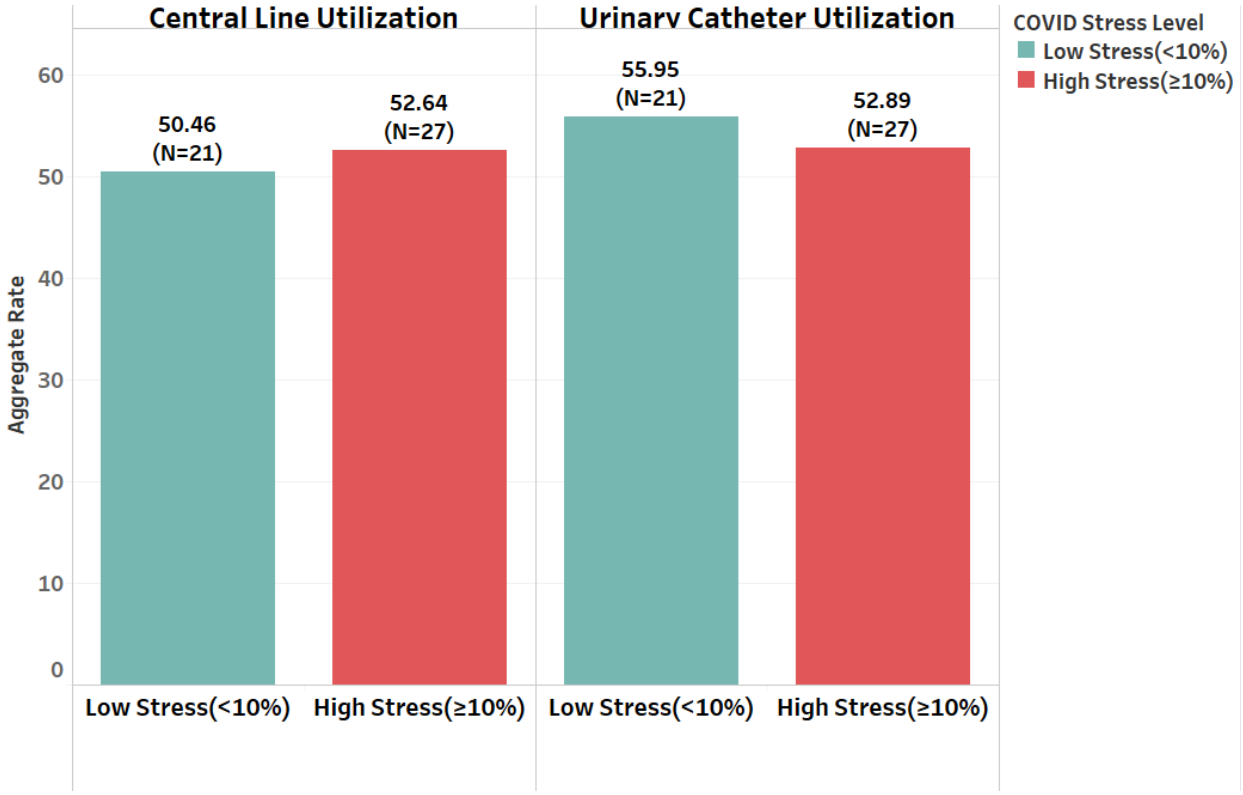
Figure C1. Aggregate CLABSI and CAUTI rates, by overall COVID stress levels from July 2020 to April 2021



CAUTI = catheter-associated urinary tract infection; CLABSI = central line–associated bloodstream infection; CSM = COVID Stress Metric; ICU = intensive care unit

Notes: Units were classified as having low or high overall COVID stress based on overall average of weekly COVID Stress Metric (CSM) values from July 2020 to April 2021. CSM was calculated using facility-level data from the U.S. Department of Health & Human Services. Total N = 48 units.

Figure C2. Aggregate Central Line and Urinary Catheter Utilization Ratios, by Overall COVID Stress Levels From July 2020 to April 2021



CSM = COVID Stress Metric

Notes: Units were classified as having low or high overall COVID stress based on overall average of weekly COVID Stress Metric (CSM) values from July 2020 to April 2021. CSM was calculated using facility-level data from the U.S. Department of Health & Human Services. Total N = 48 units.

D. COVID Stress and Program Participation

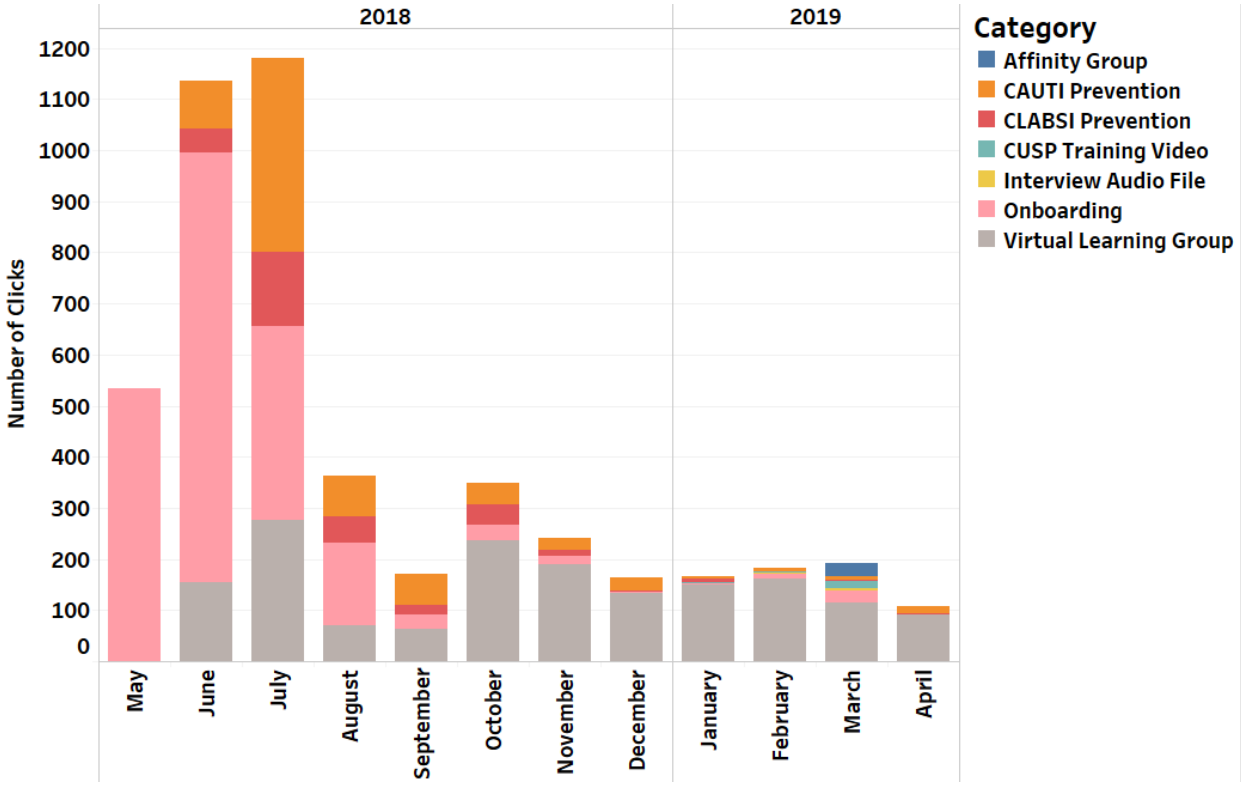
The program resumed during August 2020, but, as the number of COVID cases increased during the fall and winter that followed, State leads reported to the NPT that Cohort 6 units were disengaged, and it was difficult for them to get the units on the phone for coaching calls. To assess whether the units were also disengaged from the program's educational resources, American Hospital Association (AHA) analyzed the monthly resource engagement of Cohort 6 units and compared that to the monthly resource engagement of units in Cohorts 3 through 5.[5]

[5] Participation data were tracked via Adobe for Cohorts 1 and 2. For Cohorts 3 to 6, participation data were tracked mainly through CDS, but in a few cases via SurveyMonkey, when there were issues accessing CDS in the beginning of the program. We did not include Cohorts 1 and 2 in the resource engagement analysis because of substantial differences in the quantity and mix of offerings available to them relative to Cohorts 3 to 6.

Resource engagement or access was measured by the number of clicks made on a link to the resource tracked via AHA's Comprehensive Data System (CDS), or SurveyMonkey. Figures D-1 through D-4 show that engagement patterns during the monitoring months differed between Cohorts 3 through 5 and Cohort 6. More specifically, Cohorts 3 through 5 saw a spike of activity, particularly focused on onboarding webinars and on-demand modules, in the first 2 to 3 months of the monitoring period. Activity then rapidly tapered off as units tended to only engage with the monthly Virtual Learning Group webinars (VLGs) in the latter three quarters of the monitoring period with only a few instances of access to other tools. VLG engagement also tended to decrease over the course of the monitoring period.

In Cohort 6, after the first three monitoring months, the program was suspended and units entered a gap period (March 2020 through July 2020). Engagement ceased during the beginning of the gap period (March to May 2020) as expected. In June 2020, 2 months prior to the resumption of the program, the NPT reached out to State leads asking them to assess units' readiness to resume the program. As units started to prepare for the program to restart, they were asked to revise their Action Plan as needed. This involved the unit reviewing program resources. As a result, there was a large spike in engagement with onboarding webinars and on-demand modules in the 2 months (June to July 2020) prior to the program's resuming in August 2020. This engagement did not taper off as in previous cohorts, because there was another spike in activity in January 2021 and February 2021, the 9th and 10th month of program implementation, specifically with VLGs and Supplemental Webinars. These different patterns of engagement between Cohorts 3 through 5 and Cohort 6 are manifestations of the effects of the implementation gap and, more generally, the COVID19 pandemic on the participating units, as discussed next.

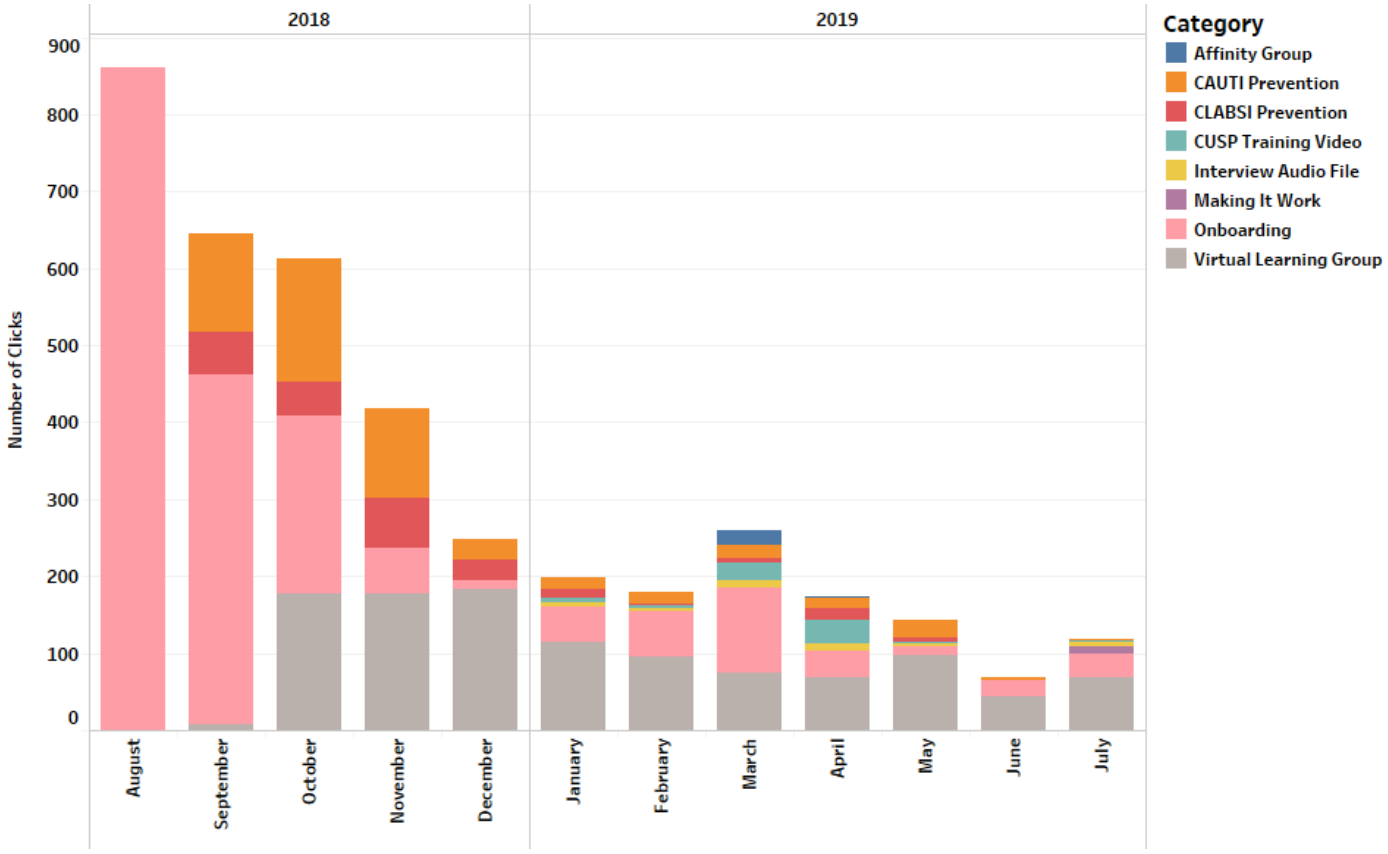
Figure D1. Access to Educational Resources (Cohort 3)



CAUTI = catheter-associated urinary tract infection; CLABSI = central line–associated bloodstream infection; CUSP = Comprehensive Unit-based Safety Program

Notes: N=123

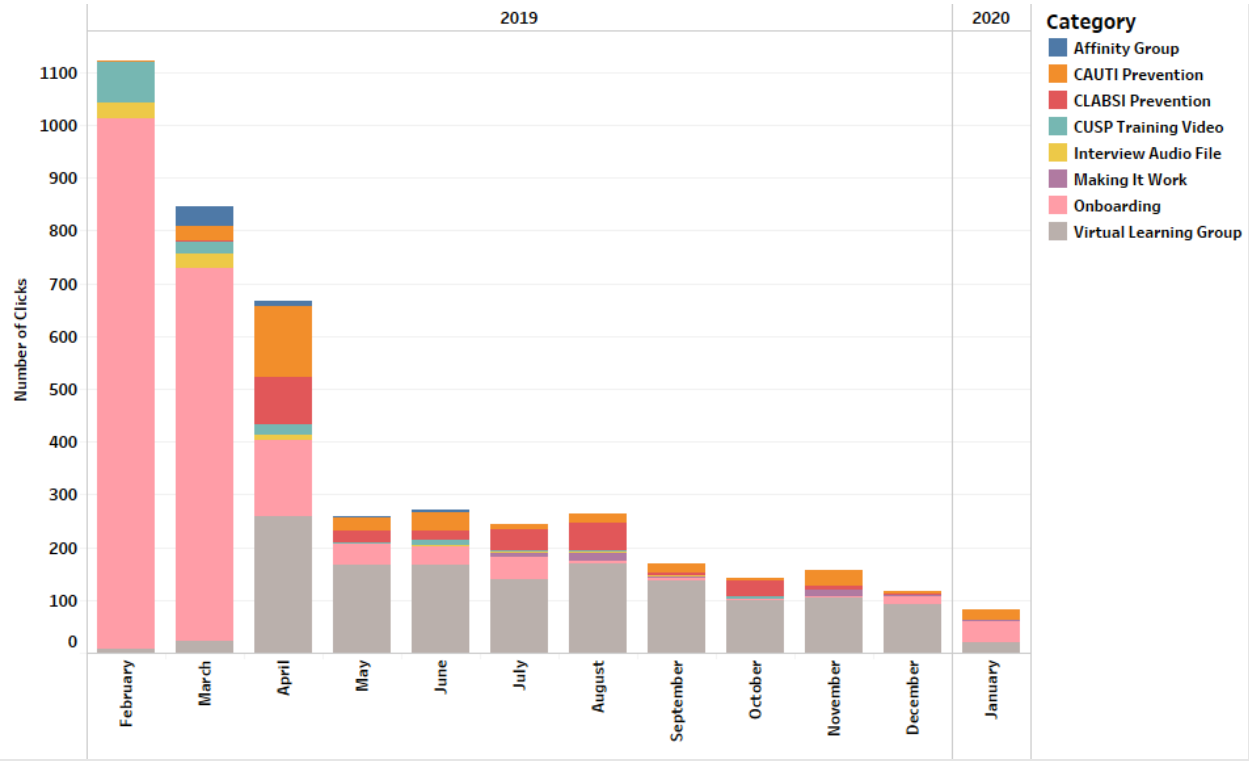
Figure D2. Access to Educational Resources (Cohort 4)



CAUTI = catheter-associated urinary tract infection; CLABSI = central line–associated bloodstream infection; CUSP = Comprehensive Unit-based Safety Program

Notes: N=106

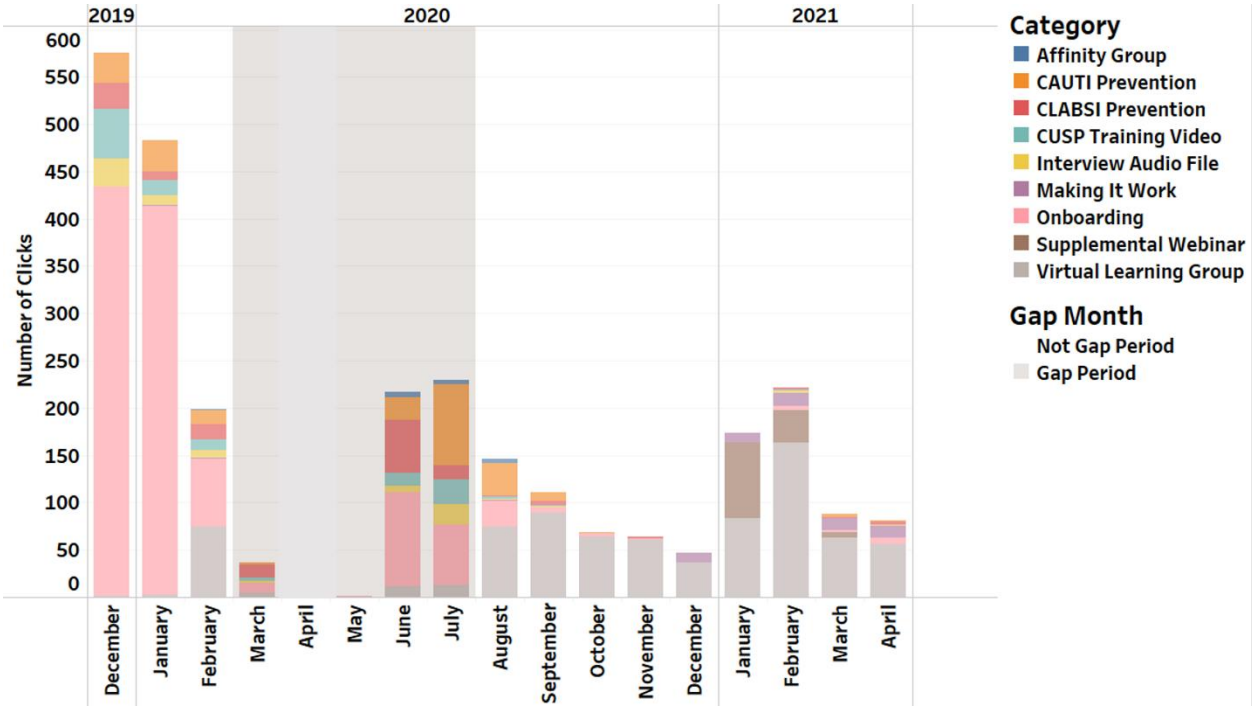
Figure D3. Access to Educational Resources (Cohort 5)



CAUTI = catheter-associated urinary tract infection; CLABSI = central line–associated bloodstream infection; CUSP = Comprehensive Unit-based Safety Program

Notes: N=119

Figure D4. Access to Educational Resources (Cohort 6)



CAUTI = catheter-associated urinary tract infection; CLABSI = central line–associated bloodstream infection; CUSP = Comprehensive Unit-based Safety Program

Notes: N=49. Affinity Groups were not offered to Cohort 6 units. In lieu of Affinity Groups, Supplemental Webinars were provided to Cohort 6 units.

More broadly, units reported that they needed time to recover from the systemic shock brought upon by the pandemic. Units reported a gradual increase in engagement over the first few months after the resumption of the program, with daily multidisciplinary rounds, device insertion and maintenance audits, and more immediate root cause analysis of CLABSI and CAUTI events once again becoming routine by the end of 2020.

E. Conclusions

From August 2020 through April 2021, program participants simultaneously managed their program participation, the treatment of COVID-19 patients, and their overall pandemic response. However, the impact of COVID stress (as measured by the overall CSM) on outcomes is unclear. It does not appear that higher overall COVID stress coincided with higher infection rates among the participating units. However, participating units as a whole, regardless of COVID stress, saw an increase in CLABSI rates during the pandemic, mirroring the national trend (Weiner-Lastinger, 2021). In terms of device

utilization, while higher overall COVID stress participants saw slightly higher central line utilization, this was not the case for urinary catheter utilization. It should be noted the CSM focused only on hospital COVID-related bed occupancy as a measure of COVID stress and did not take into account other ways the pandemic may have affected the unit's staffing, resources, and processes.

In terms of resource engagement, the program pause and restart appeared to be linked to a different engagement pattern in Cohort 6 compared to Cohorts 3 through 5. While education engagement tapered off in the latter monitoring months for Cohorts 3 through 5, Cohort 6 saw an uptick in engagement, likely prompted by the program restart, which may have triggered a renewed sense of engagement with the program, as well as other factors that may be unrelated to the program and not tracked in this study (e.g., a unit's internal motivation).