PREVENT HAIs Healthcare-Associated Infections

AHRQ Safety Program for Improving Antibiotic Use:

Acute Care Cohort

Final Report

Agency for Healthcare Research and Quality

CUSP

AHRQ Safety Program for Improving Antibiotic Use

Acute Care Cohort Final Report
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Prepared by:
Johns Hopkins Medicine
NORC at the University of Chicago

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The opinions expressed in this document are those of the authors and do not reflect the official position of AHRQ or the U.S. Department of Health and Human Services. None of the investigators have any affiliations or financial involvement that conflict with the material presented in this document.

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EXECUTIVE SUMMARY

E.1. Background

The Program

The AHRQ Safety Program for Improving Antibiotic Use (Safety Program) is a multiyear program (2016–2021) focused on developing and enhancing antibiotic stewardship programs (ASPs) across the continuum of care—acute care hospitals, long-term care facilities, and ambulatory care practices throughout the United States—as well as equipping frontline providers with the necessary knowledge and skills to enhance their antibiotic prescribing practices. The Safety Program is a collaborative intervention funded and guided by the Agency for Healthcare Research and Quality (AHRQ), and led by Johns Hopkins Medicine (JHM) and NORC at the University of Chicago (NORC). JHM/NORC engaged with three organizations that also function as Quality Innovation Networks–Quality Improvement Organizations (QIN/QIO)—Health Services Advisory Group (HSAG), Stratis Health, and Health Quality Innovators (HQI)—to assist with implementing the Safety Program.

The Safety Program uses a multipronged approach to guide participating sites in developing or improving their ASPs. JHM/NORC initially assisted sites with developing sustainable ASPs. After local leaders of ASP were identified and trained, the focus shifted to assisting both members of the ASPs and frontline providers with the following: (1) understanding how to address the attitudes, beliefs, and culture that often pose challenges to improve antibiotic prescribing; and (2) learning and incorporating best practices for the diagnosis and treatment of common infections into clinicians' daily practice using the Four Moments of Antibiotic Decision Making framework. The Four Moments of Antibiotic Decision Making, an approach to evaluating and re-evaluating the need for antibiotic use in real time, was developed as part of the Safety Program.[1]

Program Rollout and Metrics

The Safety Program consisted of a pilot period followed by three distinct cohorts: acute care, long-term care, and ambulatory care. The pilot period focused on developing metrics and educational materials for each of the three cohorts and pilot testing all material across three Integrated Healthcare Delivery Systems: Geisinger Health System (Pennsylvania), Johns Hopkins Health System (Maryland), and Atrium Health[a] (North Carolina and South Carolina). All Safety Program content was accessible to participants on the Safety Program's project Web site. Metrics included:

(1) Structural assessment to understand the general infrastructure, local stewardship practices (if any), and experience with quality improvement initiatives at each participating site and ways they changed during the course of the Safety Program

[a]Formerly known as Carolinas HealthCare System

(2) An AHRQ Survey on Patient Safety Culture appropriate to the setting completed by individual participants at each site at the beginning and end of each cohort

(3) Team Antibiotic Review Forms (acute care and long-term care only) completed by frontline staff and ASPs at each site to understand how sites incorporated the Four Moments framework into their decision making

(4) Monthly antibiotic prescribing data during the course of the program

(5) Quarterly *Clostridioides difficile* (*C. difficile*) rates (acute care and long-term care only)

(6) Monthly urine cultures per patient day (long-term care only)

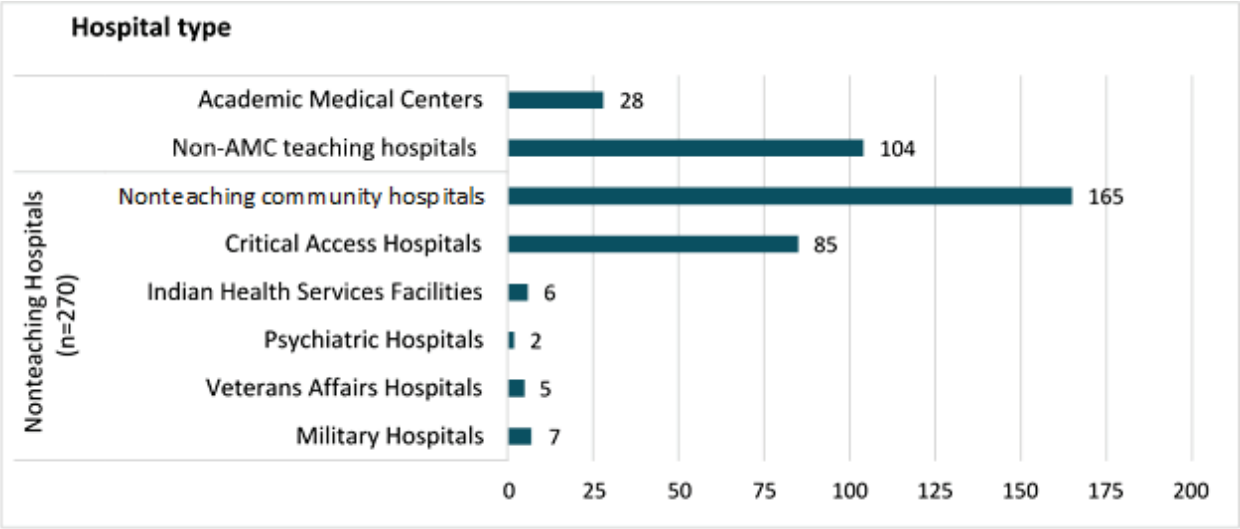
This report focuses on the activities of the Safety Program in the post-pilot Acute Care Cohort, tasked to include 250–500 acute care hospitals. Participants in the Acute Care Cohort enrolled from July through November 2017 and began program implementation in December 2017. Lessons learned from implementation of the acute care portion of the program during the pilot period—such as quality and scope of the educational material, ease of data collection, clarity of outcomes, and feedback from the Safety Program's Technical Expert Panel and participating sites—were used to inform refinements to the Safety Program for the Acute Care Cohort. These refinements included additional Webinar topics and One-Page and One-Page Guidance documents, more opportunities to attend each Webinar, the addition of Office Hours, revisions to the data collection template, and provision of continuing medical education (CME) and continuing pharmacy education (CPE) for physicians and pharmacists, respectively.

Participating Hospitals (Recruitment)

During the Acute Care Cohort, 476 units from 402 acute care hospitals in all 10 U.S. Department of Health and Human Services regions completed the program (defined as participating units). Of the 402 participating hospitals, about 40 percent had fewer than 100 beds, one-third had 100–299 beds, and one-quarter had at least 300 beds.

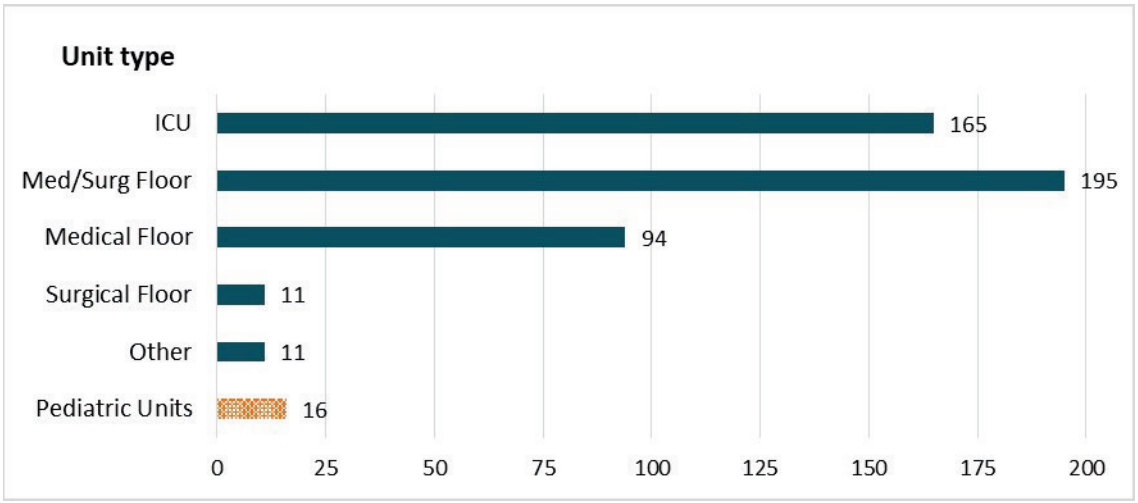
Exhibit E-1 shows the number of enrolled facilities by hospital type.

EXHIBIT E-1: NUMBER OF ENROLLED FACILITIES BY HOSPITAL TYPE



As shown in Exhibit E-2, of the 476 participating units, 35 percent were intensive care units (ICUs), 41 percent were medical/surgical floors, 20 percent were medical floors, and 2 percent were surgical floors. There were 16 pediatric units, including 6 ICUs, 9 medical/surgical floors, and 1 other type.

EXHIBIT E-2: NUMBER OF PARTICIPATING UNITS BY TYPE



E.2. Results and Impact

Evaluation Domains

The evaluation of the program's impacts on hospital units participating in the Acute Care Cohort employed a pre-post longitudinal design, with the primary outcome being unit-level days of antibiotic therapy per 1,000 patient-days. *C. difficile* laboratory-identifiable events per 10,000 patient-days,

compliance with completion of the Team Antibiotic Review Form, and changes in the AHRQ Hospital Survey on Patient Safety Culture (HSOPS) were evaluated as secondary outcomes.

Key Impacts

Adoption of Safety Program

Adoption of the Safety Program was assessed by the Structural Assessment form, which was collected from each participating site at the beginning and end of the 1-year Acute Care Cohort intervention period (Appendix A-6). The Structural Assessment consisted of seven questions to understand the general infrastructure and local antibiotic stewardship program (if any), experience with quality improvement initiatives at each participating site, and ways responses changed over the course of the Safety Program.

At the beginning of the Safety Program, 91 percent of participating hospitals reported having an ASP; this percentage increased to 98 percent at end of intervention ($p<0.001$). After program implementation, compliance with four key components of ASPs (i.e., interventions before and after prescription of select antibiotics, existence of local antibiotic guidelines, physician and pharmacist ASP leads with dedicated salary support, and quarterly tracking and reporting of antibiotic use) improved from 8 percent to 74 percent over the 1-year period ($p<0.01$).

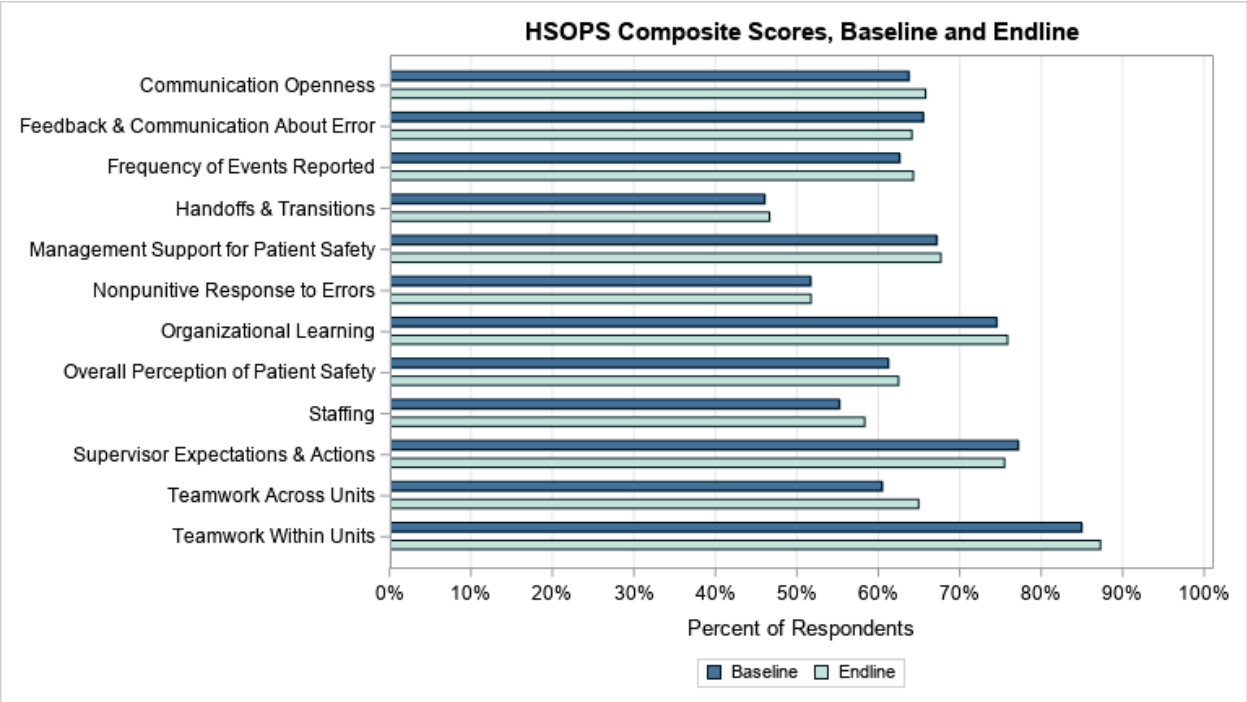
Patient Safety Culture/HSOPS

All health-care workers in participating units were encouraged to complete the AHRQ HSOPS at both the beginning and the completion of the Safety Program. Respondents were allowed to choose one of three options to record their responses. For the baseline HSOPS, 39 percent of units submitted HSOPS data administered within a 6-month period before the start of the cohort (Option A); 47 percent of units provided a list of their eligible staff who received a customized, secure survey link to complete the HSOPS on the program Web site (Option B); and 6 percent of units distributed the HSOPS survey link directly to their eligible staff (Option C).

For the endline HSOPS, 7 percent of units selected Option A, 11 percent selected Option B, and 26 percent selected Option C. The remaining units (56%) did not select an option or responded that they were unable to administer the endline HSOPS at their units using any of the three options.

After implementation of the Safety Program, self-reported teamwork across units improved by 4.5 percent ($p=0.017$) in participating units. Composite scores for other domains did not change significantly from baseline to endline (Exhibit E-3).

EXHIBIT E-3: HSOPS COMPOSITE SCORE FOR PARTICIPATING SITES BEFORE AND AFTER THE COHORT



Antibiotic Decision Making Process

Participating units were asked to complete and submit Team Antibiotic Review Forms each month during the intervention period (March 2018 through November 2018); units were asked to complete and submit at least 10 forms per month. The purpose of the form was to encourage development of relationships between the ASP and frontline clinicians through structured discussions regarding patients actively receiving antibiotics. The Team Antibiotic Review Form includes a review of the Four Moments of Antibiotic Decision Making:

Moment 1: Does my patient have an infection that requires antibiotics?

- The patient has a suspected or confirmed infection that requires antibiotics

Moment 2: Have I ordered appropriate cultures before starting antibiotics? What empiric therapy should I initiate?

- Appropriate cultures were ordered before antibiotics were started
- Specific reactions for reported antibiotic allergies were documented
- Empiric antibiotics were compliant with local guidelines

Moment 3: A day or more has passed since initiating antibiotics. As I have more clinical and microbiologic data available can I stop antibiotics, can I narrow antibiotics, or can I change from intravenous to oral antibiotics?

- Discontinue antibiotics if they are not needed
- Change to narrower agents if antibiotics can be narrowed
- Change to oral therapy if antibiotics can be changed from intravenous to oral

Moment 4: What duration of therapy is needed for my patient's diagnosis?

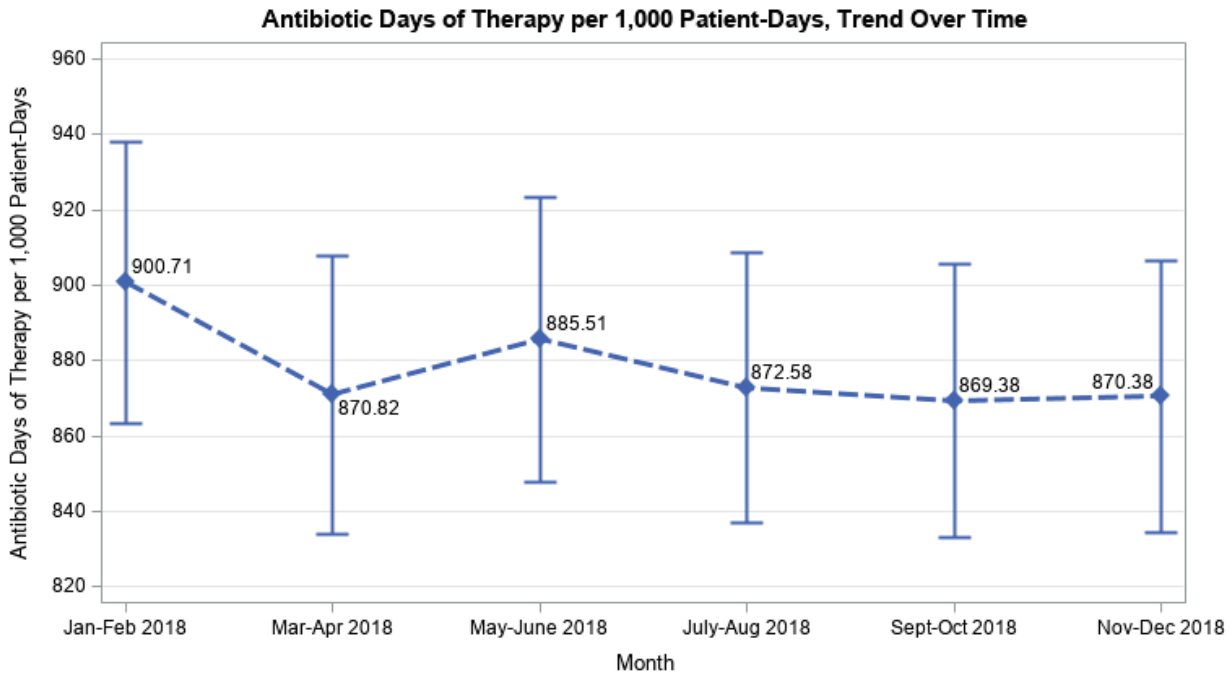
- A planned duration has been documented in the medical record
- The planned duration is consistent with local guidelines

All nine aspects related to the Four Moments of Antibiotic Decision Making improved throughout the intervention period, with five aspects showing statistically significant improvements: "suspected/confirmed infection," "appropriate culture ordered," "decision made to discontinue antibiotics," "decision made to narrow antibiotics," and "planned duration of therapy documented in progress notes." Refer to Section 3.5.4 Team Antibiotic Review Form and Exhibit 32 for more details.

Antibiotic Use

For the Acute Care Cohort, there was a statistically significant decrease of 30.3 total antibiotic days of therapy (DOT) per 1,000 patient-days from baseline (January–February 2018) to end of intervention (November–December 2018) (95% confidence interval [CI]: -52.6 to -8.0, p=0.008). The decrease was also statistically significant from baseline to other intervention periods, including March–April (-29.9, 95% CI: -45.4 to -14.3, p<0.001), July–August (-28.1, 95% CI: -50.3 to -5.9, p=0.013), and September–October (-31.3, 95% CI: -54.5 to -8.2, p=0.008). To understand this trend, Exhibit E-4 presents bimonthly antibiotic DOT per 1,000 patient-days, over time. The changes were significant between baseline and each of the bimonth intervals throughout the intervention periods (March–December 2018), except for May–June 2018.

EXHIBIT E-4: BIMONTHLY ANTIBIOTIC DAYS OF THERAPY PER 1,000 PATIENT-DAYS



Out of five selected antibiotic classes, only use of fluoroquinolones (including ciprofloxacin, levofloxacin, and moxifloxacin) had a significant decrease over time (i.e., from the baseline to intervention subperiods).

Changes in antibiotic use varied by hospital and unit characteristics: From baseline to end of intervention, there was a significant decrease in total DOT per 1,000 patient-days among units in nonacademic medical centers (AMCs)[b] (-28.1, 95% CI: -52.2 to -3.9, p=0.023); units in nonteaching hospitals (-39.2, 95% CI: -78.0 to -7.6, p=0.017); and units in hospitals that are not critical access hospitals (-26.0, 95% CI: -49.1 to -2.9).

Comparison with nonparticipating units from Premier hospitals: As a comparison group for the Safety Program Acute Care Cohort, we used monthly antibiotic use data extracted from the Premier Healthcare Database, weighted to address the imbalance in observed characteristics between the two samples. More details about the Premier Healthcare Database are available in subsequent sections of this report; unlike in the Safety Program, there were no significant reductions in antibiotic use observed in the Premier sample from January–February 2018 to November–December 2018.

C. difficile Laboratory-Identifiable Events

Among participating units, the number of *C. difficile* events per 10,000 patient-days decreased over the intervention period. The estimated number of *C. difficile* laboratory-identifiable (LabID) events per 10,000 patient-days was 6.3 for Q1, 5.2 for Q2, 6.0 for Q3, and 5.1 for Q4. From Q1 to Q4, the incidence rate decreased significantly by -19.5 percent (95% CI: -33.5% to -2.4%, p=0.027).

E.3. Conclusions

The Acute Care Cohort produced important, positive impacts in launching and enhancing ASPs in hospitals across the United States. The Safety Program successfully equipped frontline providers with tools and resources to become stewards of their own antibiotic use. The AHRQ Safety Program for Improving Antibiotic Use provided hospital units with the novel approach of incorporating the Four Moments of Antibiotic Decision Making framework into their daily clinical activities. Moreover, the Safety Program taught health-care workers how they could work together to develop a culture of safety and teamwork in their hospital units.

Despite implementation challenges that are typical of any large, complex initiative (e.g., need for multipronged outreach efforts, obtaining participating site staff buy-in), the Safety Program engaged a diverse cohort of acute care hospitals and resulted in promising improvements in the quality of ASPs, as well as decreases in the rates of antibiotic use and *C. difficile* LabID events. Perhaps most notably, it assisted hospitals of various sizes and with differing levels of resources with establishing stewardship programs and becoming compliant with four key components of ASPs that were identified after an extensive environmental scan (interventions before and after prescription of select antibiotics, existence of local antibiotic guidelines, physician and pharmacist ASP leads with dedicated salary support, and quarterly tracking and reporting of antibiotic use).

[b]Non-AMCs include nonteaching hospitals and teaching hospitals that are not academic medical centers.

CHAPTER 1: BACKGROUND

Chapter Summary

This chapter describes the purpose of the *AHRQ Safety Program for Improving Antibiotic Use* (Safety Program) as a tool for antibiotic stewardship (AS) efforts aimed at changing the culture of antibiotic prescribing in acute care, long-term care, and ambulatory care settings. We also describe the Johns Hopkins Medicine/NORC at the University of Chicago (JHM/NORC) project team, which worked closely with the Agency for Healthcare Research and Quality (AHRQ) in the design and execution of the Safety Program. Additionally, we discuss the roles of the Technical Expert Panel (TEP), and the three organizations, which also operate as Quality Innovation Networks–Quality Improvement Organizations (QIN-QIOs), that assisted the JHM/NORC team throughout the Safety Program.

Overview of the AHRQ Safety Program for Improving Antibiotic Use

The fundamental goal of the Safety Program is to improve the culture of antibiotic prescribing across the United States. The overarching goals of this multiyear project for participating sites are to:

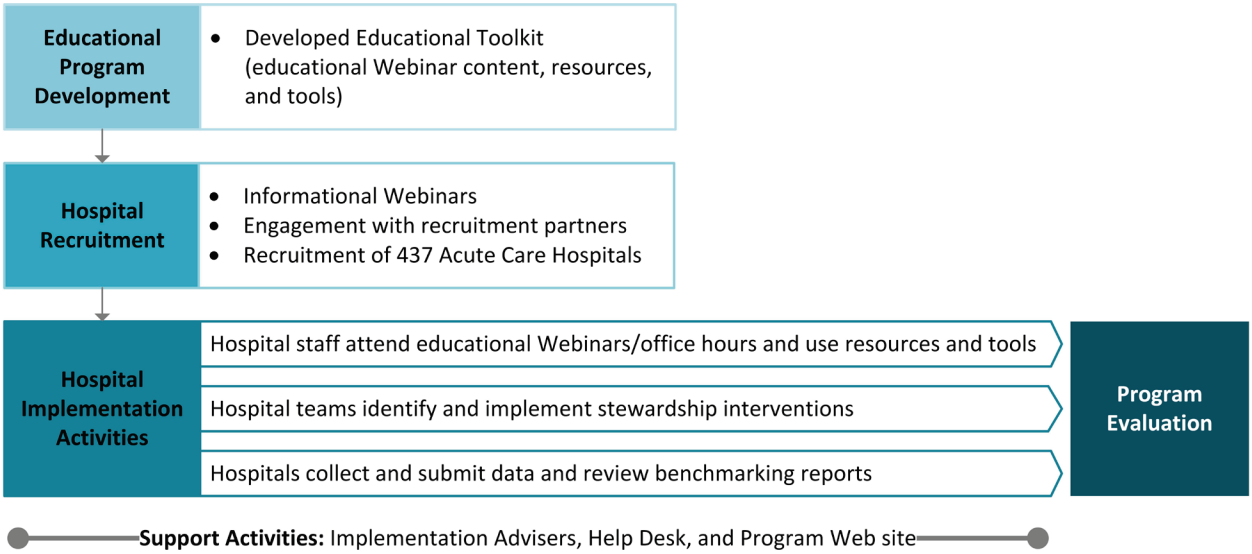
- Develop and/or enhance existing AS Programs (ASPs) that allow for sustained optimized antibiotic use
- Understand how to address the attitudes, beliefs, and culture that often pose challenges to improving antibiotic prescribing
- Incorporate best practices for the diagnosis and treatment of common infections into daily practice using the Four Moments of Antibiotic Decision Making framework

The program has three major components:

- An Acute Care Cohort, whose findings are presented in this report
- A Long-Term Care Cohort, implemented from December 2018 through November 2019
- An Ambulatory Care Cohort, implemented from December 2019 through November 2020

Exhibit 1 provides an overview of the Acute Care Cohort program.

EXHIBIT 1: OVERVIEW OF ACUTE CARE COHORT PROGRAM



The JHM/NORC Project Team

The AHRQ Safety Program for Improving Antibiotic Use is a collaborative intervention funded and guided by AHRQ, and led by JHM and NORC. A TEP provided input into the design of the Safety Program and the implementation strategies. The TEP consisted of 27 subject matter experts representing leaders in ASPs across acute care, long-term care, and ambulatory care settings, patient leaders/patient advocacy groups, experts with experience conducting large-scale interventional studies involving adaptive changes, executives from integrated health-care delivery systems, and ex-officio members from Federal Government agencies. The TEP met prior to the onset of the pilot and during implementation of the Acute Care Cohort.

Three quality improvement organizations that also function as QIN-QIOs—Health Quality Innovators (HQI), Health Services Advisory Group (HSAG), and Stratis Health—also supported the Safety Program. Individuals from these organizations served as "Implementation Advisers" for the participating hospitals. One specific Implementation Adviser was assigned to each hospital to provide assistance with program implementation as well as technical aspects of the Safety Program (e.g., ensuring all participants had access to the educational toolkit, ensuring awareness of when Webinars or Office Hours were being held, and assisting with data submission questions). Communication between participating sites and Implementation Advisers occurred at least monthly through prearranged telephone calls. The JHM/NORC team had scheduled calls with all Implementation Groups every other week throughout the Acute Care Cohort, both to receive regular updates of Safety Program progress and to assist with troubleshooting.

1.1. Background

Although antibiotics can be vital for improving patient outcomes, their use is not always benign and they can cause harm. Examples of antibiotic-associated harm include *Clostridioides difficile* infections, organ dysfunction, allergic reactions, and the development of antibiotic resistance on both a patient and a population level.[2] Thus, the relative pros and cons of antibiotic use should be carefully weighed every time they are considered for a patient.

Antibiotic stewardship is a concerted effort to prescribe antibiotics only when they are needed, and to use the right antibiotic, at the right dosage, by the right route, and for the right duration of time. The ultimate goal of ASPs is to improve patient outcomes while alleviating antibiotic-associated patient harm.[3,4] Traditionally, ASPs have used a "top-down" approach, with most efforts to improve antibiotic use directed by the ASP. While there continues to be a need for ASPs, equipping frontline clinicians with the necessary tools to incorporate stewardship practices into their daily decision making is equally, if not more, important.

Establishment of local hospital ASPs is recommended by several national agencies, including the Centers for Disease Control and Prevention (CDC) and The Joint Commission. In 2014, the CDC developed guidance on the Core Elements of Hospital Antibiotic Stewardship Programs—recommendations to assist ASPs in achieving success. A survey conducted in 2015 through the National Healthcare Safety Network of 4,569 U.S. acute care hospitals indicated that only 48 percent had implemented all seven recommended core elements of hospital ASPs.[5]

The premise of the Safety Program is that ASPs alone will be unlikely to improve long-term antibiotic prescribing practices by frontline clinicians. Rather, improving prescribing practices by frontline clinicians involves changes to the culture surrounding antibiotic prescribing (e.g., understanding the potential harm associated with antibiotics, improved teamwork, improved communication, and respecting and encouraging dissenting opinions), as well as improved understanding of best practices in the diagnosis and treatment of common infectious diseases syndromes. The Safety Program comprehensively addresses these issues by supporting ASPs and reaching out to improve prescribing practices by frontline clinicians. Moreover, the Safety Program has expanded these concepts beyond the acute care setting—into both long-term care and ambulatory care settings—with content and implementation approaches adapted to each setting.

1.2. Project Governance

As previously described, the Safety Program was developed and executed by JHM/NORC under the close guidance of AHRQ. Additional program support was provided by a TEP and Implementation Advisers. Exhibit 2 describes the respective roles in the design, implementation, and evaluation of these groups in the Acute Care Cohort.

EXHIBIT 2: NATIONAL PROJECT TEAM PLUS PARTNERS, AHRQ SAFETY PROGRAM FOR IMPROVING ANTIBIOTIC USE

Organization	Role
Johns Hopkins Medicine (JHM)	JHM faculty led development of the educational toolkit for the Safety Program. JHM was responsible for leading Webinars and Office Hours, assisting participating sites with site-specific questions that arose over the course of the Safety Program, overall program management, and budget oversight.
NORC at the University of Chicago	NORC led recruitment of the acute care hospitals; onboarded participating hospital units to the Cohort; and supported a range of implementation activities, including hosting the Webinars and Office Hours, developing and hosting the program Web site for the educational materials and data collection tools, collecting and analyzing data from participating units, and conducting the program evaluation.
Technical Expert Panel (TEP)	The TEP was composed of physicians, pharmacists, nurse practitioners, representatives from integrated health-care delivery systems, representatives from patient advocacy groups, and ex-officio members of government agencies. The TEP provided guidance on program content, implementation, and evaluation. Appendix A-1 details the members and qualifications of the TEP.
Implementation Advisers	Three quality improvement organizations—Health Quality Innovators, Health Services Advisory Group, and Stratis Health—served as Implementation Adviser organizations. Staff members at each organization provided one-on-one support to participating sites. Each organization was responsible for providing assistance on program implementation to designated hospitals.

The next two sections, respectively, describe the program roles and responsibilities of the TEP and the Implementation Advisers.

1.2.1. Technical Expert Panel

Development of the Safety Program included establishing a TEP—a panel of 27 subject matter experts (including nine ex-officio members), from a wide range of crosscutting disciplines with practical knowledge of antibiotic stewardship approaches in acute, long-term care, and ambulatory settings—that provided input into Safety Program design. Appendix A-1 details the TEP members and their professional affiliations.

TEP National Acute Care Meeting

The Safety Program held the in-person National Acute Care TEP meeting on Thursday, September 28, 2017 at the NORC offices in Bethesda, MD. The goals of the meeting were to discuss:

1. Improvements to the educational toolkit content that had been developed during the pilot period
2. Lessons learned from the pilot period for the acute care, long-term care, and ambulatory care settings, and modifications planned for the Acute Care Cohort that was already underway
3. Preliminary results from qualitative analyses of participant interviews
4. Progress to date with recruitment of facilities for the Acute Care Cohort
5. Data collection and implementation approaches for the Acute Care Cohort

The TEP Meeting focused on general lessons learned from the pilot, as well as ways these could inform the Acute Care Cohort. The TEP members provided numerous recommendations and suggestions throughout the discussions, including:

- Suggestions to enhance educational content geared toward stewardship leaders as well as frontline staff at Safety Program participating sites
- Suggestions on improving program participation by offering Office Hours to foster dialogue between participant sites, as well as opportunities to request more guidance from JHM/NORC on site-specific issues
- Strategies to improve communication strategies among ASPs, frontline staff, and patients/family members
- Strategies to encourage more engagement during Webinars and Office Hours
- Suggestions on data elements that would accurately capture the Safety Program's impact

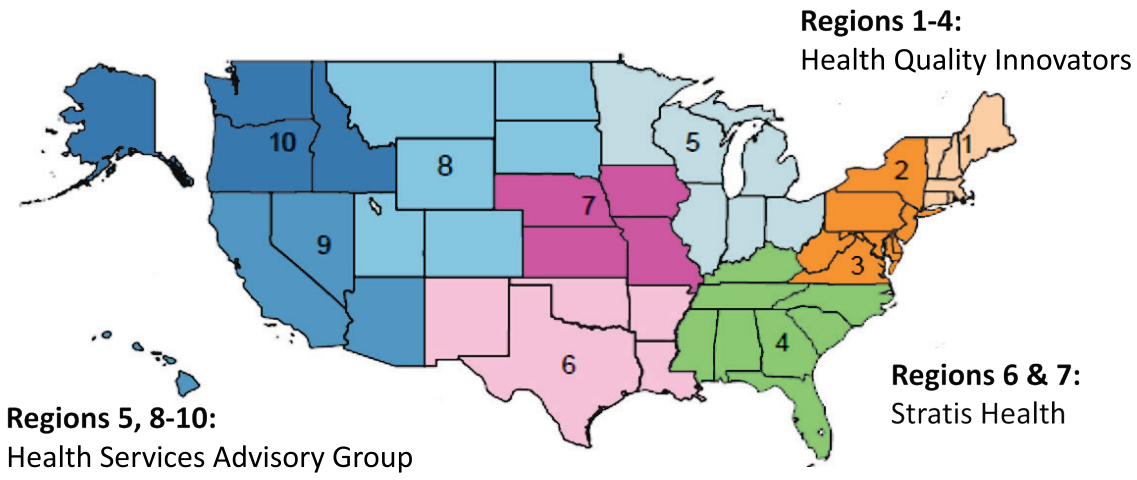
1.2.2 Implementation Advisers

The qualifications of the three quality improvement organization JHM/NORC partnered with to serve as Implementation Adviser organizations for the Safety Program are as follows:

- **HQI** is an independent, nonprofit consulting organization established in 1984. HQI serves as the Maryland and Virginia Quality Improvement Organization, and as the regional "boots on the ground" for two major Hospital Improvement Innovation Networks. HQI has experience working with health-care professionals developing internal improvement capacity.
- **HSAG** is a multistate quality improvement organization that provides health-care quality expertise to both care providers and care recipients. Established in 1979, HSAG, amongst other successes, has experience in reducing healthcare-associated conditions in nursing homes, improving antibiotic stewardship in outpatient settings, and improving infection control practices in ambulatory surgical centers.
- **Stratis Health** is an independent nonprofit organization that leads collaboration and innovation in health-care quality and patient safety. Stratis Health has more than 40 years of experience, specializing in reducing healthcare-associated infections in hospitals and nursing homes. Stratis Health has supported quality improvement on behalf of Medicare for Minnesota since 1971.

Dedicated staff members at each organization (see Implementation Adviser Activities section below) provided frequent and consistent one-on-one support to enrolled hospitals that participated in the program, to assist with ensuring successful implementation of the Safety Program. Of note, the three quality improvement organizations were assigned to hospitals in States for which they did not have other federally funded activities underway. Exhibit 3 shows the distribution of U.S. Department of Health and Human Services (HHS) regions by organization.

EXHIBIT 3: HHS REGIONS BY IMPLEMENTATION ADVISER ORGANIZATION



Implementation Adviser Activities

Within each Implementation Adviser organization, several individual Implementation Advisers worked with an assigned set of hospitals within their regions. The Implementation Advisers were the primary point-of-contact for hospitals, and helped answer questions and troubleshoot issues. Questions and issues beyond the scope of their expertise were relayed to the JHM/NORC team, who then contacted the relevant site.

Throughout the 12-month implementation period of the Acute Care Cohort, the Implementation Advisers provided ongoing support to hospitals for Safety Program implementation and data collection activities. They also triaged their respective hospitals both qualitatively (through monthly phone calls) and quantitatively (through reviewing data collection status updates and Webinar attendance metrics) to identify sites that needed additional support—based on program participation, program activity implementation, and data collection progress. Exhibit 4 details how the Implementation Advisers provided support for the hospitals' activities.

EXHIBIT 4: IMPLEMENTATION ADVISER SUPPORT ACTIVITIES

Hospital Activity	Implementation Adviser Support Activity
1. Antibiotic stewardship program engagement with Implementation Advisers	■ Make initial call with the designated Safety Program lead at each participating hospital to assess current state of the hospital stewardship efforts and site-specific goals from project participation. ■ Conduct, at a minimum, monthly calls with each participating site to assess progress, identify issues, and provide technical assistance.
2. Participation in National Educational Webinars	■ Promote participation on Webinars to participating hospitals in respective HHS regions. ■ Track attendance. ■ Assist with access to Safety Program Web site for all health-care workers in participating units.

Hospital Activity	Implementation Adviser Support Activity
3. Assist sites with troubleshooting data collection issues	■ Provide guidance to sites on data collection requirements. ■ Assist sites with strategies to improve the quantity and quality of Team Antibiotic Review Form completion. ■ Review data collection status reports from NORC to identify sites needing additional assistance with data collection.
4. Identify local interventions	■ Assist hospitals with their self-identified interventions.
5. Review quarterly benchmarking reports	■ Distribute to, and review with hospitals, quarterly benchmarking reports.
6. Participate in Office Hours	■ Participate in Office Hours for hospitals to provide a forum to discuss challenges and areas where further assistance is needed, and to share lessons learned with peers.
7. Inform sites of educational toolkit content	■ Ensure antibiotic stewardship program is encouraging all frontline providers in the participating unit/hospital to join live Webinars and to access the online acute care Safety Program toolkit

For the Acute Care Cohort, JHM/NORC held a Stakeholder/Train-the-Trainer meeting for Implementation Adviser organizations to review and understand their key role in orienting and advising recruited hospitals for each cohort regarding program goals, educational content of the National Educational Webinar toolkit, and data collection requirements. The meeting took place on October 23, 2017, at NORC's offices in Bethesda, MD. Its purpose was to train HQI, HSAG, and Stratis Health on their role as Implementation Adviser organizations during the Acute Care Cohort—with the following specific discussion goals:

1. Provide an overview of the Safety Program focusing on the national acute care program.
2. Review the educational toolkit content.
3. Discuss lessons learned from the pilot for the acute care setting.
4. Provide an overview of facility recruitment for the Acute Care Cohort.
5. Provide examples of daily, weekly, and monthly activities of participating units.
6. Review roles and responsibilities of the Implementation Advisers.
7. Review the schedule of Webinars and Office Hours.
8. Review the data requirements and data submission process for the Acute Care Cohort.

The stakeholder meeting discussed the program's general goals, scope, and timeline, as well as clarification of roles and responsibilities. The meeting helped ensure attendees understood their required tasks and the overarching goals of the Safety Program. The meeting also enabled the group to quickly identify and address any potential barriers to success before the implementation phase of the Acute Care Cohort began. In addition, the meeting attendees reviewed the data collection requirements and data submissions process, and clarified the Implementation Adviser's role in helping hospitals with data collection and submission. Appendix A-2 lists the Stakeholder/Train-the-Trainer attendees.

The meeting solicited the Implementation Adviser organizations' suggestions and ideas to improve the Safety Program, and all recommendations were incorporated into the Safety Program. A few examples include:

- Recommendations to keep sites engaged during the course of the Safety Program by having planned questions as points of discussion, provide examples of possible interventions sites could focus on between Webinars, and have sites that have had local successes related to their ASPs share their experiences with other sites.
- Approaches for checking in on the progress of participating sites through both planned open- and closed-ended questions that Implementation Advisers should ask sites on a monthly basis, and an "exit interview" at the end of the Safety Program to better understand barriers and facilitators of ASP implementation and frontline clinician participation at each site.
- Additional technical issues for which the JHM/NORC team should develop further guidance to assist participating sites, such as understanding numerators and denominators for accurate data collection and accurate completion of Team Antibiotic Review Forms, and reviewing the possible uses of all tools available on the Safety Program relevant to each topic at the end of each Webinar.

CHAPTER 2: PROGRAM IMPLEMENTATION

Chapter Summary

This chapter describes the different facets of Safety Program implementation for the Acute Care Cohort, including: (1) development and refinement of the educational program, (2) recruitment and retention of acute care hospitals, (3) National Educational Webinars and Office Hours, and (4) additional technical assistance and support for the Acute Care Cohort.

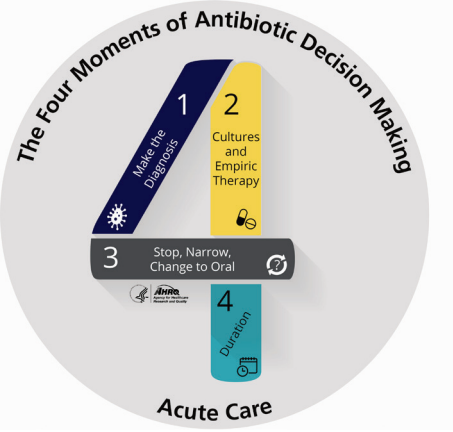
Educational Program and the Four Moments of Antibiotic Decision Making Framework

The Safety Program incorporated aspects of: (1) antibiotic stewardship program (ASP) development, (2) cultural and behavioral change surrounding antibiotic decision making, and (3) improved understanding of the best practices in the diagnosis and treatment of common bacterial infections in hospitalized patients. These topics were addressed in Webinars; monthly Office Hours, narrated presentations, One-Page documents describing the diagnosis, management, and antibiotic therapy for common infectious disease syndromes; and other tools that assist frontline clinicians with improving their antibiotic decision making (e.g., an antibiotic time out tool).

The Four Moments of Antibiotic Decision Making framework, developed specifically for the Safety Program, was incorporated throughout the educational content. It reminds prescribers to consider the following questions every time antibiotics are considered:

EXHIBIT 5: THE FOUR MOMENTS OF ANTIBIOTIC DECISION MAKING

1. Does my patient have an infection that requires antibiotics?
2. Have I ordered appropriate cultures before starting antibiotics? What empiric therapy should I initiate?
3. A day or more has passed. Can I stop antibiotics? Can I narrow therapy or change from IV to oral therapy?
4. What duration of antibiotic therapy is needed for my patient's diagnosis?



Recruitment and Retention of Acute Care Hospitals

Recruitment, which took place from June through November 2017, involved engagement with both Federal and non-Federal partners.

Recruitment Strategies

- The Agency for Healthcare Research and Quality (AHRQ) worked with the Centers for Medicare & Medicaid Services (CMS) and the Centers for Disease Control and Prevention (CDC) to ensure synergy across Federal stewardship initiatives and programs, and to make Hospital Improvement Innovation Networks (HIINs) aware of the Safety Program.
- JHM/NORC worked with non-Federal groups—including hospital associations, The Joint Commission, the Institute for Healthcare Improvement, leaders of health-care networks, the local health department, and others—to assist with recruitment efforts.
- The program leveraged the listservs and newsletters of a range of organizations as dissemination channels, as well as using social media outreach (e.g., via LinkedIn, Twitter, and Facebook).
- JHM/NORC created a public-facing Web site, SafetyProgram4AntibioticStewardship.org, to inform interested sites about the Safety Program and develop recruitment material.
- JHM/NORC led eight Informational Webinars to inform interested sites about the Safety Program and field questions about the Safety Program.

The informational Webinars were held from mid-August through early November 2017 on the following topics:

- Program overview
- Benefits of participation
- Hospital/unit participation requirements
- Data submission requirements
- Program timeline
- Key points of contact for program staff at JHM/NORC
- How to learn more about the program

In total, 437 acute care hospitals enrolled in the Acute Care Cohort; 402 hospitals remained in the cohort for the duration of the Safety Program. These 402 hospitals consisted of:

- 382 academic medical centers, community hospitals, and critical access hospitals including 85 critical access hospitals
- 6 Indian Health Service hospitals
- 7 military hospitals (including five Department of Defense hospitals)
- 5 Veterans Affairs hospitals
- 2 inpatient psychiatric facilities

Retention Strategies

The Implementation Advisers played a principal role in ensuring acute care hospitals engaged in the Safety Program by providing one-on-one support to participating hospitals. They checked in regularly on sites with limited participation in the Safety Program to encourage further engagement. For any sites considering withdrawal, a member of the Johns Hopkins Medicine/NORC at the University of Chicago (JHM/NORC) team personally reached out to the site to assist with troubleshooting any issues limiting participation.

National Educational Webinars and Office Hours

Over the 12-month Cohort implementation period, participating hospitals were invited to attend 17 National Educational Webinars. Each of these Webinars was offered three times[c] on different days and times, to increase opportunities for sites to participate. The Webinars covered both the technical and adaptive components to improving antibiotic prescribing, and guided sites on how to develop ASPs.

All content also was available on the Safety Program Web site. Live Webinars and Office Hours provided an opportunity for direct engagement between JHM/NORC and participating sites. To encourage Webinar participation, educational credits (both continuing education credits for pharmacists and continuing medical education credits for physicians) were only provided to participants on Webinars.

In addition to the National Educational Webinars, sites were encouraged to participate in Office Hours hosted by JHM/NORC, which were held 1 to 2 weeks following each Webinar. Eighteen Office Hours sessions were held over the course of the Acute Care Cohort year. The main goal of these calls was to give sites a venue for informal discussion on how program implementation was progressing at their sites, and to work with the JHM/NORC team to discuss potential solutions for any barriers to successful ASP implementation or ways to improve provider antibiotic-making identified at individual sites. The peer-to-peer discussions also allowed sites to hear that others were struggling with similar issues, and to hear successful strategies other sites used to address barriers. These calls also were a forum for more in-depth discussion around clinical decision making and antibiotic prescribing.

Additional Technical Assistance and Support

In addition to the Webinars and Office Hours, health-care workers at participating sites had access to the Program Web site and the Help Desk, created specifically for the AHRQ Safety Program.

Program Web Site

The NORC-developed Program Web site (SafetyProgram4AntibioticStewardship.org) included both a public-facing component with general information on the program, and a secure log-in component that served as both a repository for educational materials as well as a data collection portal.

The Web site hosted content for users. Within each participating hospital, staff members involved in the Cohort were given log-in credentials for the user side of the Program Web site. By the end of the Cohort, the Web site had 11,650 users. The program materials were heavily used by participating hospitals; by the end of Cohort implementation, the 25 most popular materials on the Web site had more than 12,000 unique downloads (averaging 470 downloads per material).

Help Desk

JHM/NORC also established a Safety Program email address antibioticsafety@norc.org as a centralized resource for information and technical assistance for participating units, Implementation Advisers, and

[c]The final Webinar on sustaining stewardship activities was offered twice.

JHM/NORC staff. The Help Desk provided a point of contact for questions, concerns, and participation requests for information.

JHM/NORC received implementation inquiries via the Help Desk from either health-care workers or their Implementation Advisers. Help Desk staff followed up with appropriate parties to ensure all questions were answered. For 2018, the Help Desk received a total of 3,889 inquiries.

2.1. Educational Program

The educational program for the Acute Care Cohort addressed: (1) ASP development, (2) safety issues and behavioral change surrounding antibiotic prescribing, and (3) best practices in the diagnosis and treatment of common infectious disease treatment in hospitalized patients. These topics were discussed through modalities that included:

- Monthly or bimonthly educational Webinars
- Monthly office hours
- Narrated presentations
- One-Page documents with accompanying User Guides
- Commitment posters to demonstrate a hospital's commitment to judicious antibiotic prescribing

ASP development emphasized the development or improvement of each site's ASP. Subtopics covered included forming the core stewardship team and other necessary relationships for successful ASPs, developing local guidelines, identifying members of and initiating a hospital AS committee, determining which ASP metrics to use and/or report, and engaging diverse personality types in stewardship efforts, among many other topics.

Cultural and behavioral change included National Educational Webinars on four major aspects of cultural and behavioral change: (1) making the case that AS is a patient safety issue, (2) identifying targets for improved antibiotic prescribing, (3) learning from antibiotic-associated adverse events, and (4) improving communication and teamwork.

Best practices in the diagnosis and management of common infectious conditions in hospitalized patients consisted of eight Webinars within the National Educational Webinar series that incorporated the Four Moments of Antibiotic Decision Making framework (Exhibit 7) in reviewing eight infectious disease syndromes:

1. Asymptomatic bacteriuria and urinary tract infections
2. Community-associated lower respiratory tract conditions
    a. Community-associated pneumonia
    b. Chronic obstructive pulmonary disease
    c. Aspiration events and aspiration pneumonia
3. Ventilator-associated pneumonia/hospital-acquired pneumonia (Note: although both topics were addressed during the same Webinar, the final toolkit separated them into two separate presentations).

4. Cellulitis and skin and soft tissue abscesses
5. Diverticulitis and biliary tract infections
6. *Clostridioides difficile* (*C. difficile*) infections
7. Sepsis
8. Bacteremia

One-Page documents and user guides were developed for each syndrome (except sepsis and bacteremia) to give sites recommendations on diagnosis and treatment—including specific agents to consider and dosing suggestions for children and adults. One-Page documents were designed to help sites develop their own local guidelines. They could also be used for local teaching purposes, as either handouts or posters.

To encourage teamwork, communication, and critical thinking using the Four Moments approach, the Safety Program requested that all sites complete 10 Team Antibiotic Review Forms each month. Clinicians selected patients actively receiving antibiotics and used the Team Antibiotic Review form to go through the Four Moments for each of the selected patients in conjunction with members of the ASP.

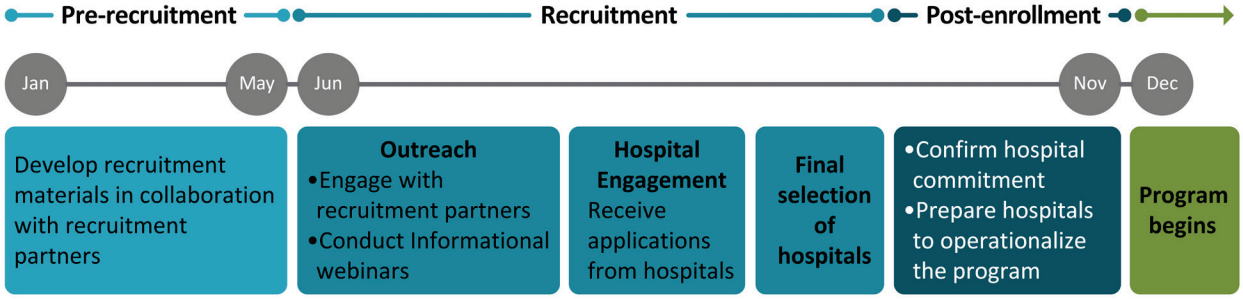
2.2. Recruitment and Retention of Acute Care Hospitals

Target enrollment for the Acute Care Cohort was 250–500 hospitals encompassing the 10 HHS regions (See Appendix A-3). JHM/NORC undertook a systematic strategy to recruit, enroll, and retain hospitals for the Safety Program. The multistep process is described in the next sections.

2.2.1. Recruitment Strategy

Outreach and recruitment were broken up into three distinct phases to ensure Safety Program targets were met. Prerecruitment activities, which spanned January–May 2017, involved development and refinement of recruitment materials, and development and finalization of a recruitment plan. Active recruitment, which spanned June–November 2017, involved engagement with recruitment partners, eight Informational Webinars, receipt and processing of hospital applications and signed letters of commitment, and preparation of hospitals for program activities (particularly around development of their antibiotic stewardship team and data collection activities). Enrolled hospitals started program participation in December 2017. Exhibit 6 provides an overview and timeline for program activities during the Acute Care Cohort's recruitment and immediate post-enrollment period.

EXHIBIT 6: RECRUITMENT PROCESS FLOW, JANUARY–DECEMBER 2017



JHM/NORC used a multipronged recruitment approach, working with a wide range of recruitment partners, including Federal and non-Federal groups.

JHM/NORC and AHRQ worked with *Federal partners*—including CMS and CDC—to ensure synergy across Federal antibiotic stewardship initiatives and programs. AHRQ staff utilized established coordination calls with CMS staff to make HIINs aware of the AHRQ Safety Program, and also encouraged coordination efforts at the local level. CMS staff disseminated information on the Safety Program to HIINs via monthly newsletters and informational Webinars. CDC staff disseminated AHRQ Safety Program information and recruitment efforts via their listservs, and also made announcements and distributed recruitment materials at relevant medical conferences. JHM/NORC coordinated with AHRQ to increase awareness of the Safety Program on AHRQ's weekly electronic newsletter (118,000+ subscribers) and listserv (55,000+ subscribers).

The multitude of n*on-Federal groups that* JHM/NORC worked with concurrently included hospital associations, The Joint Commission, and the Institute for Healthcare Improvement to recruit hospitals within their networks. JHM/NORC also contacted the health systems that had participated in the pilot program—Geisinger Health System, The Johns Hopkins Health System, and Atrium Health—as well as other health systems that had not participated in the pilot. In addition, JHM/NORC leveraged the Institute for Healthcare Improvement, The Joint Commission, and JHM listservs and newsletters as dissemination channels, as well as social media outreach (e.g., via LinkedIn, Twitter, and Facebook).

JHM/NORC created a public-facing Web site SafetyProgram4AntibioticStewardship.org to field requests to join the program, and developed a recruitment page to include frequently asked questions (FAQs), information about upcoming Informational Webinars, an Informational Webinar recording, and the program email address for interested facilities with any questions. The Web site's online application captured hospital characteristics (e.g., size, type, urbanicity), electronic health record information, and hospital contact information (refer to Appendix A-4 for a copy of the online application). The Web site FAQs covered a broad range of topics, including general Acute Care Cohort questions (e.g., benefits of participation, timeline), eligibility, data collection requirements, and the National Educational Webinars.

Eligibility for Participation

For program recruitment, all acute care hospitals were eligible to participate, including rural and critical access hospitals. In general, hospitals were welcome to participate if they could:

1. Identify local antibiotic stewardship leaders, preferably a physician and a pharmacist (with an understanding of the need for variation depending on hospital resources/available personnel)
2. Provide antibiotic use data (days of antibiotic therapy per 1,000 patient-days).

The Safety Program discouraged participation from long-term acute care hospitals, labor and delivery units, and neonatal intensive care units, as the educational toolkit was not geared to these populations.

Recruitment Materials

The recruitment and enrollment materials JHM/NORC developed for recruitment partners and hospitals included the following general and enrollment materials:

General Recruitment Materials

- Outreach fliers
- Informational Webinar outreach materials
- Email blasts for professional societies
- Posts on health care blogs
- Recruitment letters
- Recruitment FAQs
- Scripts for phone and email communications with acute care hospitals/recruitment partners
- Pitch letter for partner communications
- Social media messaging

Enrollment and Postenrollment Materials

- Online enrollment application
- Commitment form
- "Next Steps" document

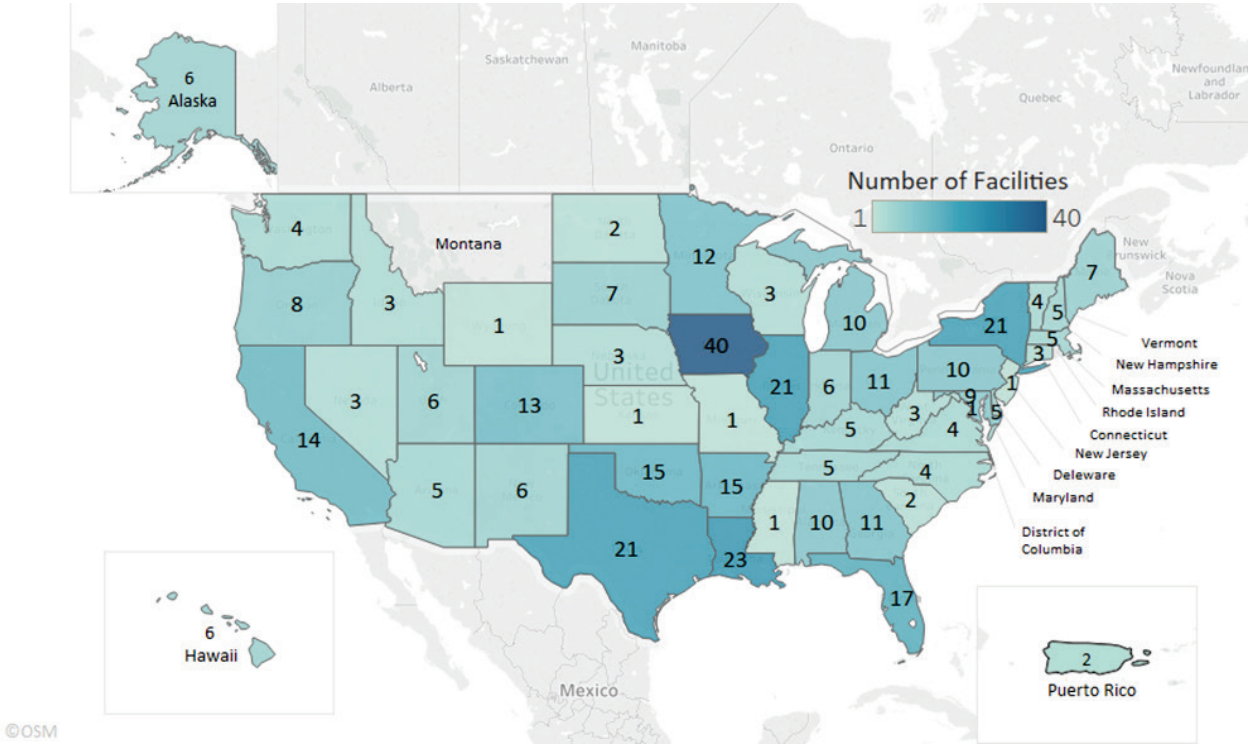
Help Desk for Recruitment Inquiries

The Safety Program email address antibioticsafety@norc.org provided a centralized point of contact for recruitment questions, concerns, and requests for information from acute care hospitals interested in participating in the Safety Program. Program enrollment or recruitment inquiries often related to specific actions to enroll (e.g., submitting an online application or signed letter of commitment), data collection requirement, and/or questions related to the eight Informational Webinars. Refer to Section 2.5 for more details regarding the Safety Program's dedicated Help Desk.

2.2.2. Recruitment Results

As noted, total of 437 acute care hospitals enrolled in the Acute Care Cohort, of which 402 remained for the entire duration of the program. Please see Section 2.2.4 Retention Challenges for information regarding attrition. Exhibit 7 shows the distribution of the 402 participating hospitals. Appendix A-3 has a breakdown of acute care hospitals by HHS region.

EXHIBIT 7: ACUTE CARE FACILITY ENROLLMENT BY STATE*



*Includes one international facility run through the Department of Defense.

Exhibit 8 shows the number of enrolled facilities by hospital type. The hospital classification is based primarily on information from CMS' Provider of Services file, which contains data on characteristics of hospitals and other health-care facilities and the American Hospital Association Annual Survey Database. Of note, in national presentations and manuscripts describing results of the acute care Safety Program, some recategorization occurred for simplicity (e.g., if medical students or house staff rotated at Veterans Affairs hospitals they were considered teaching hospitals).

- **Academic medical centers** were identified by member of Council of Teaching Hospitals and Health Systems of the Association of American Medical Colleges in American Hospital Association (AHA) data and having self-reported teaching status from Hospital Cost Reporting Information System (HCRIS) data.
- **Teaching hospitals** (that were not classified as academic medical centers) were identified by being a minor teaching hospital in AHA data and having self-reported teaching status from HCRIS data.
    - Minor teaching hospitals were identified by having one or more of the following indicators: recognized for one or more Accreditation Council for Graduate Medical Education accredited programs, medical school affiliation reported to the American Medical Association, internship approved by American Osteopathic Association, and residency approved by American Osteopathic Association.
- All other hospitals were grouped into the **nonteaching hospital** category, identified as follows:
    - Psychiatric hospitals and critical access hospitals were identified by provider category subtype code reported in CMS' Provider of Services file (code 04 and 11, respectively).

- Indian Health Service hospitals were identified by the control code reported in the AHA Annual Survey Database (code 47).
- Veterans Affairs or military hospitals were identified by facility names.

EXHIBIT 8: ACUTE CARE PARTICIPANTS BY HOSPITAL TYPE (N=402)

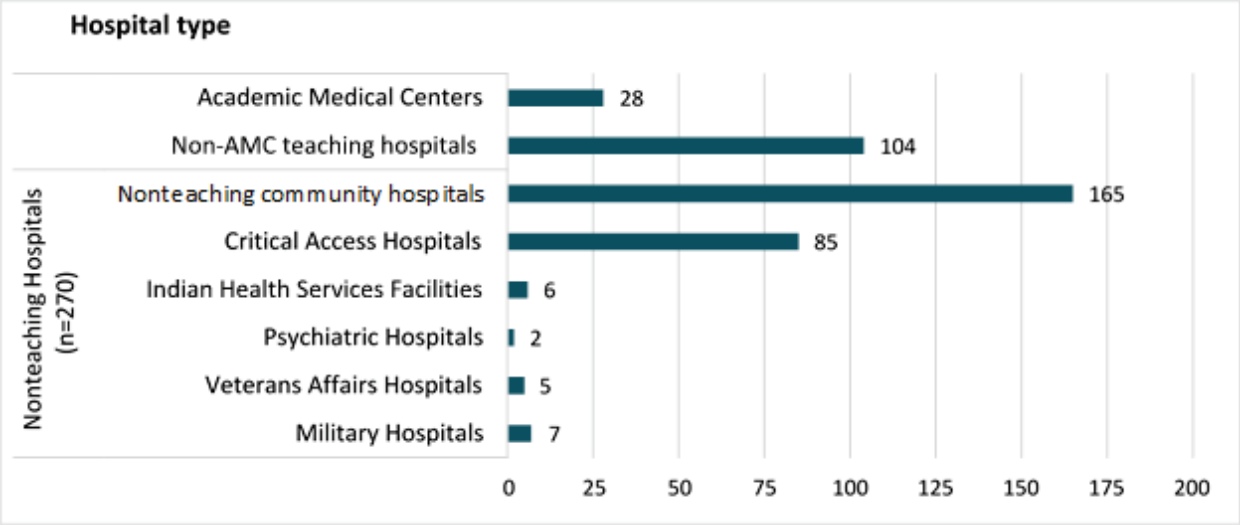
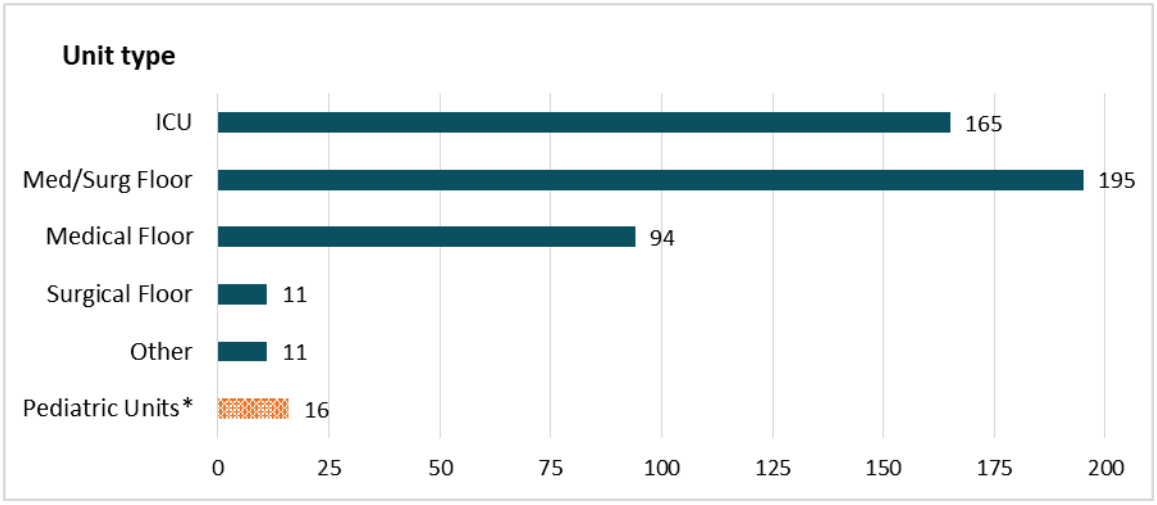


Exhibit 9 provides a breakdown of the types of hospital units participating in the Acute Care Cohort. Overall, the 402 acute care hospitals that participated for the duration of the Cohort involved 476 hospital units, including 16 pediatric units. Unit types were self-reported by hospitals during program registration. Some unit types were grouped together to avoid sample size constraints.

EXHIBIT 9: ACUTE CARE PARTICIPANTS BY UNIT TYPE (N=476)



*There were 16 pediatric units, including 6 ICUs, 9 medical/surgical floors, and 1 other type.

2.2.3. Retention Strategies

The Implementation Advisers played a principal role in keeping acute care hospitals engaged in the Cohort. As detailed earlier, Implementation Advisers provided one-on-one support to participating

hospitals, and were responsible for facility engagement and active participation. They served as the main facilitators for the program—offering continued support and guidance to hospitals regarding data collection, accessing program resources, National Educational Webinar attendance, and other program requirements.

Implementation Adviser engagement activities included:

1. Initial onboarding call to discuss any hospital questions or concerns regarding participation
2. Monthly calls to discuss current issues and questions
3. Monthly and weekly prompting calls and email reminders of upcoming data submissions
4. Ad hoc calls and emails to discuss upcoming program activities, questions regarding benchmarking reports, and other inquiries

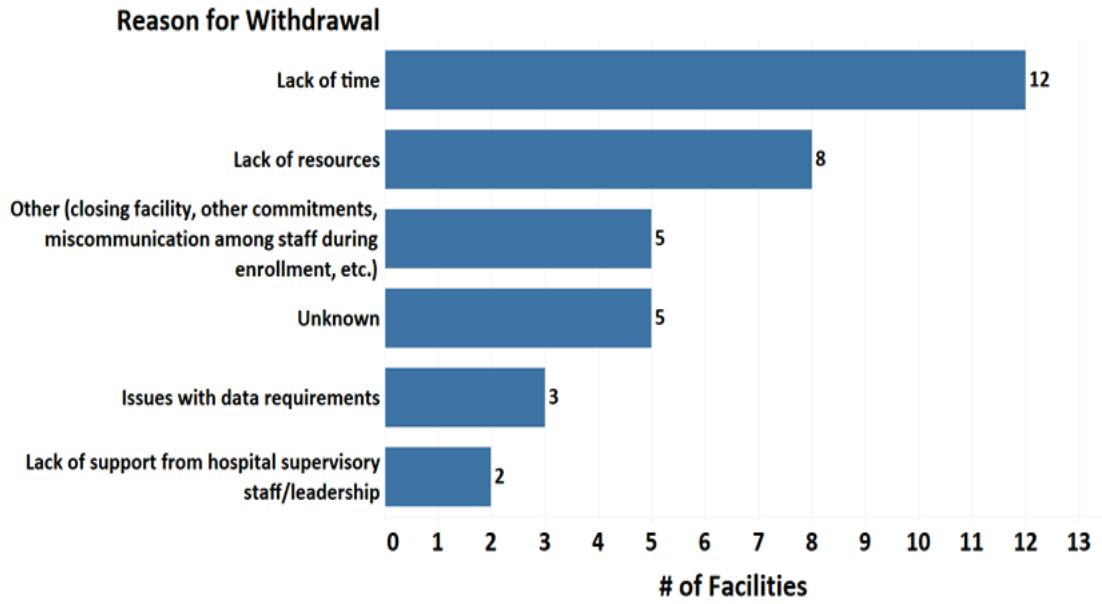
The program also engaged numerous engagement strategies at the program level:

1. Two antibiotic stewardship experts from JHM (an adult infectious diseases physician and a pediatric infectious diseases physician) developed and led all Webinars and Office Hours to provide message consistency, develop continuity across the span of the program, and build the opportunity for ongoing relationships between the experts and the participants.
2. Monthly Office Hours calls enabled hospitals to engage regularly with stewardship experts on a broad range of topics.
3. The Webinars and Office Hours were offered on several different dates and at several times of day to accommodate participants' schedules.
4. JHM/NORC staff worked with hospitals to facilitate data submission.
5. A JHM/NORC lead had email and/or phone contact with any hospital considering withdrawal from the acute care cohort to discuss barriers and potential solutions to remaining in the Safety Program.

2.2.4. Retention Challenges

From the initial recruitment stage on, JHM/NORC emphasized flexibility and the Safety Program's willingness to work with hospitals to remain in the Acute Care Cohort. Implementation Advisers alerted JHM/NORC whenever their hospitals had questions or concerns regarding their continued participation. Once Implementation Advisers contacted JHM/NORC when a hospital or unit was considering withdrawing, one of the Safety Program Principal Investigators reached out directly to hospital staff to answer any questions or concerns, and worked with the hospital to help it remain in the cohort. Over the course of the Acute Care Cohort implementation, 8 percent of enrolled hospitals (n=35) withdrew. Hospitals that withdrew had similar characteristics compared with hospitals that remained for the duration of the program regarding hospital type, teaching status, urban/rural location, and being owned by a larger health system. Exhibit 10 summarizes the reasons hospitals provided for withdrawal.

EXHIBIT 10: REASONS FOR FACILITY WITHDRAWAL (N=35)



2.3. National Educational Webinars and Office Hours

This section highlights the process of engaging hospitals once they agreed to take part in the Acute Care Cohort.

2.3.1 Onboarding of Acute Care Hospitals

Once hospitals had agreed to participate and returned a signed Letter of Commitment to JHM/NORC onboarding activities began. During this period, hospitals established their ASP and started building the needed infrastructure for a successful ASP. Additional onboarding activities included:

- **Introductory Webinar.** JHM/NORC hosted the first National Educational Webinar, "Introduction to the AHRQ Safety Program for Improving Antibiotic Use," which served as an onboarding Webinar for all sites.
- **Identifying a site lead**. Each hospital identified a physician and a pharmacist to become the ASP leads (if leads were not already present at participating sites).
- **Identifying the unit(s) participating in the cohort.** Sites could select one or more than one unit or service (e.g., general wards, intensive care units, hospitalist services) to participate in the cohort.
- **Speaking with information technology (IT) staff to establish the data submission process.** Sites were encouraged to connect with their IT staff prior to the official start of the Acute Care Cohort to develop a process for antibiotic use and *C. difficile* rate data extraction and submission.

2.3.2. Content of National Educational Webinars

Each of the 17 National Educational Webinars, which lasted for 60 minutes, was offered two to three times on different days and times, to provide participating hospitals multiple opportunities to join live Webinars. There was generally 10–15 minutes at the end of each Webinar for questions and answers.

The target audience for the Webinars was either ASP members or both ASP members and frontline staff. The first Webinar was an onboarding Webinar held in December 2017, as hospitals were beginning Acute Care Cohort implementation. This Webinar familiarized participants with the goals of the Safety Program and the components of the educational toolkit. It also informed sites about data collection and submission requirements.

The other 16 Webinars focused on changing the culture of antibiotic prescribing and best practices in improving antibiotic prescribing for common infections. Exhibit 11 outlines the content and timing of the 17 Webinars.

EXHIBIT 11: OVERVIEW OF ACUTE CARE COHORT WEBINAR TOPICS

Order	Month	Webinar Title
1	Dec 2017	Introduction to the AHRQ Safety Program
2	Dec 2017	Antibiotic Stewardship Program Development (Part 1)
3	Dec 2017	Antibiotic Stewardship Program Development (Part 2)
4	Jan 2018	Making Effective Behavior Changes around Antibiotic Prescribing
5	Jan 2018	Making the Case that Improving Antibiotic Use Is a Patient Safety Issue
6	Jan 2018	Improving Communication & Teamwork around Antibiotic Decision Making
7	Feb 2018	Identifying Targets for Improvement in Antibiotic Decision Making
8	Feb 2018	Making Effective Changes in Antibiotic Decision Making
9	Mar 2018	Best Practices in the Diagnosis and Treatment of Asymptomatic Bacteriuria & Urinary Tract Infections
10	Apr 2018	Best Practices in the Diagnosis and Treatment of Community-Associated Lower Respiratory Tract Conditions
11	May 2018	Best Practices in the Diagnosis and Treatment of Cellulitis and Skin and Soft Tissue Abscesses
12	Jun 2018	Best Practices in the Diagnosis and Treatment of Hospital-Acquired and Ventilator-Associated Pneumonia*
13	Jul 2018	Best Practices in the Diagnosis and Treatment of Diverticulitis and Biliary Tract Infections
14	Aug 2018	Best Practices in the Diagnosis and Treatment of *Clostridioides difficile* Infections
15	Sep 2018	Best Practices in the Diagnosis and Treatment of Sepsis
16	Oct 2018	Best Practices in the Diagnosis and Treatment of Bacteremia
17	Nov 2018	Sustaining Stewardship Activities

*The final publicly available educational toolkit will separate out hospital-acquired and ventilator-acquired pneumonia into two separate presentations.

The Webinars were well attended throughout the program, averaging 561 attendees per session (Exhibit 12). Some hospitals gathered in a room together to view the Webinars as a team; to capture this, the Webinars were set up so participants were able to indicate how many attendees from their location were in attendance as they logged in to the Webinar. Feedback requested after each Webinar indicated that participants overall found the Webinars to be helpful (Exhibit 13).

EXHIBIT 12: TOTAL WEBINAR ATTENDANCE BY TOPIC

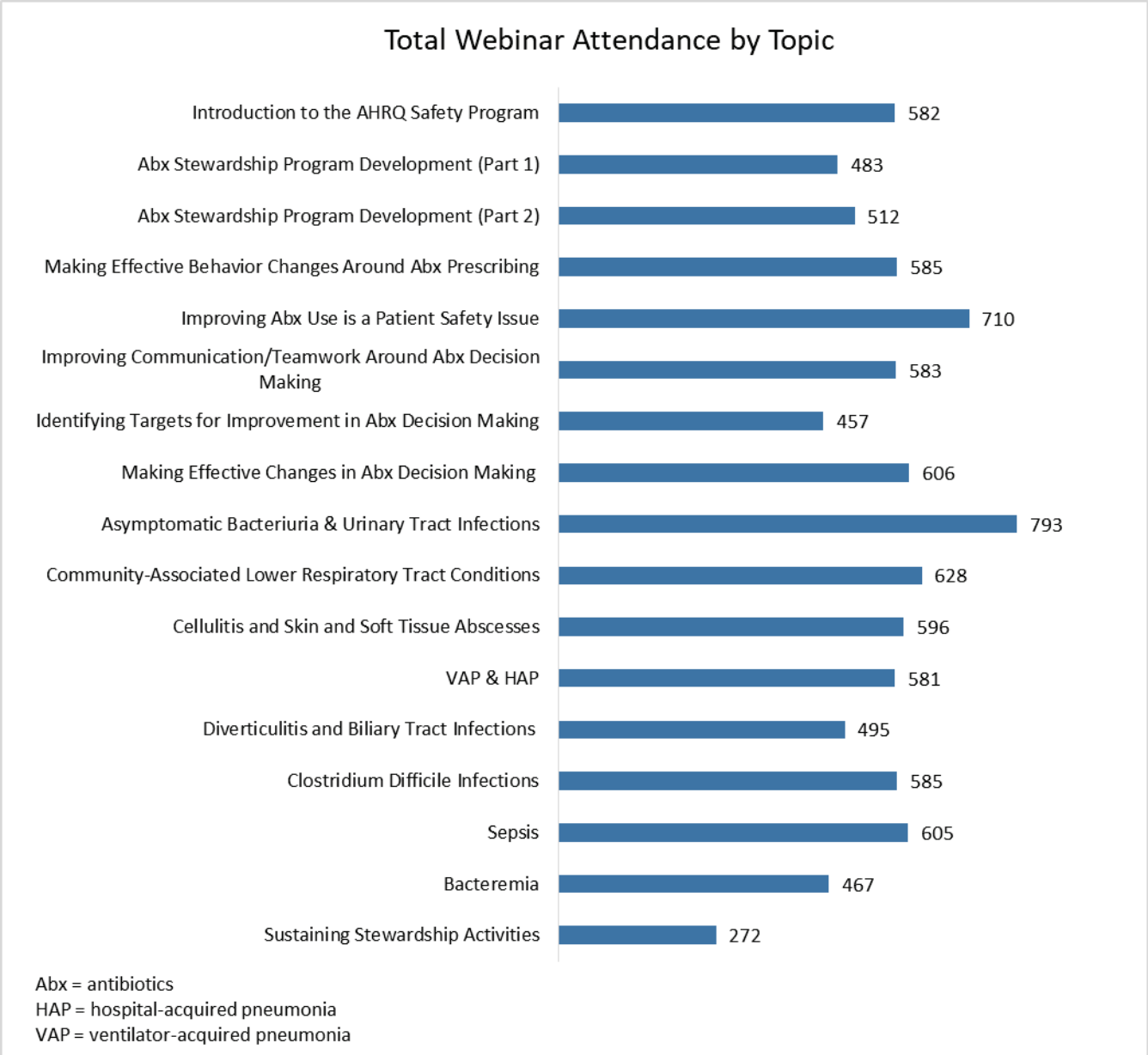
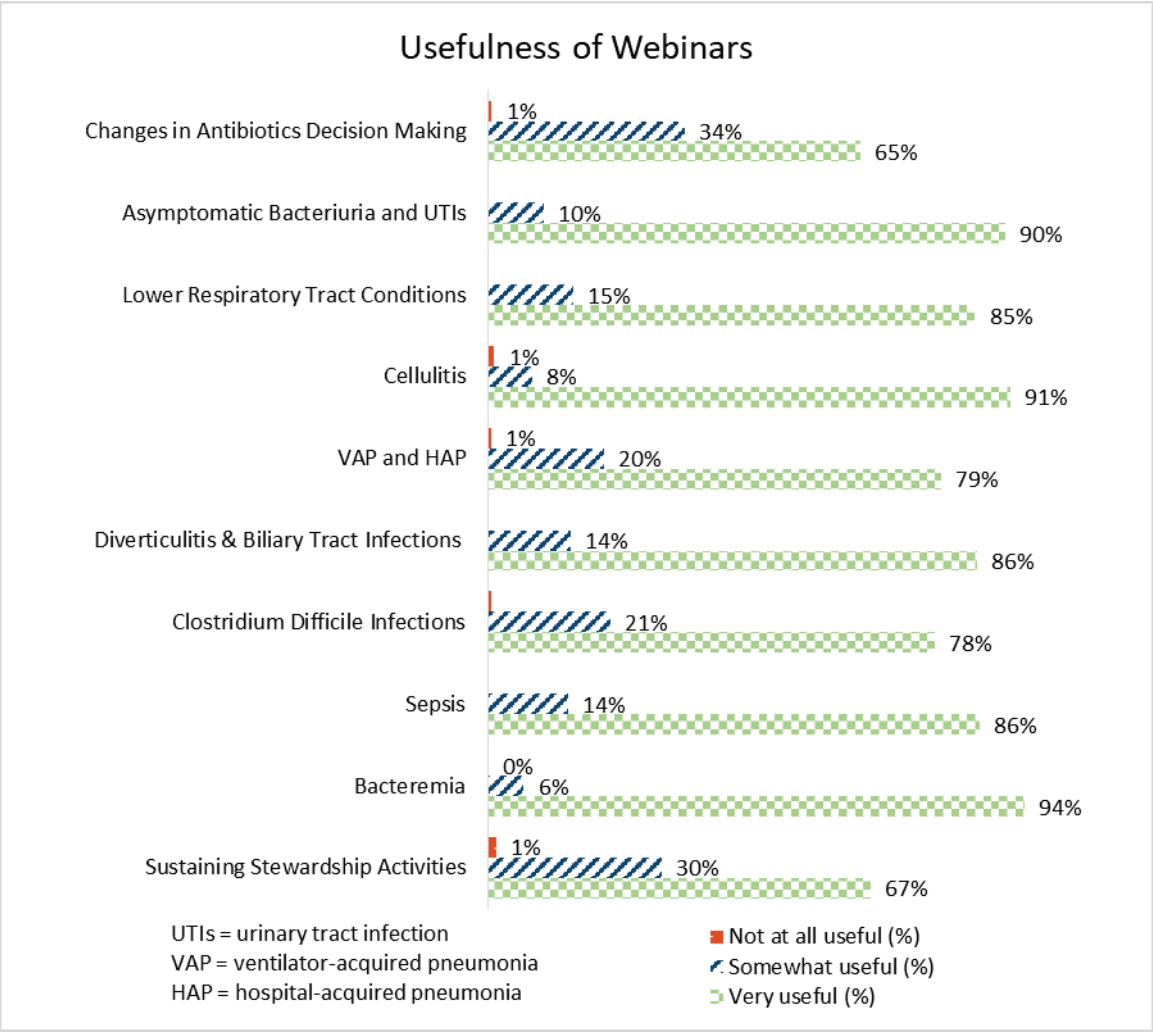


EXHIBIT 13: PARTICIPANT RATINGS OF USEFULNESS OF WEBINARS

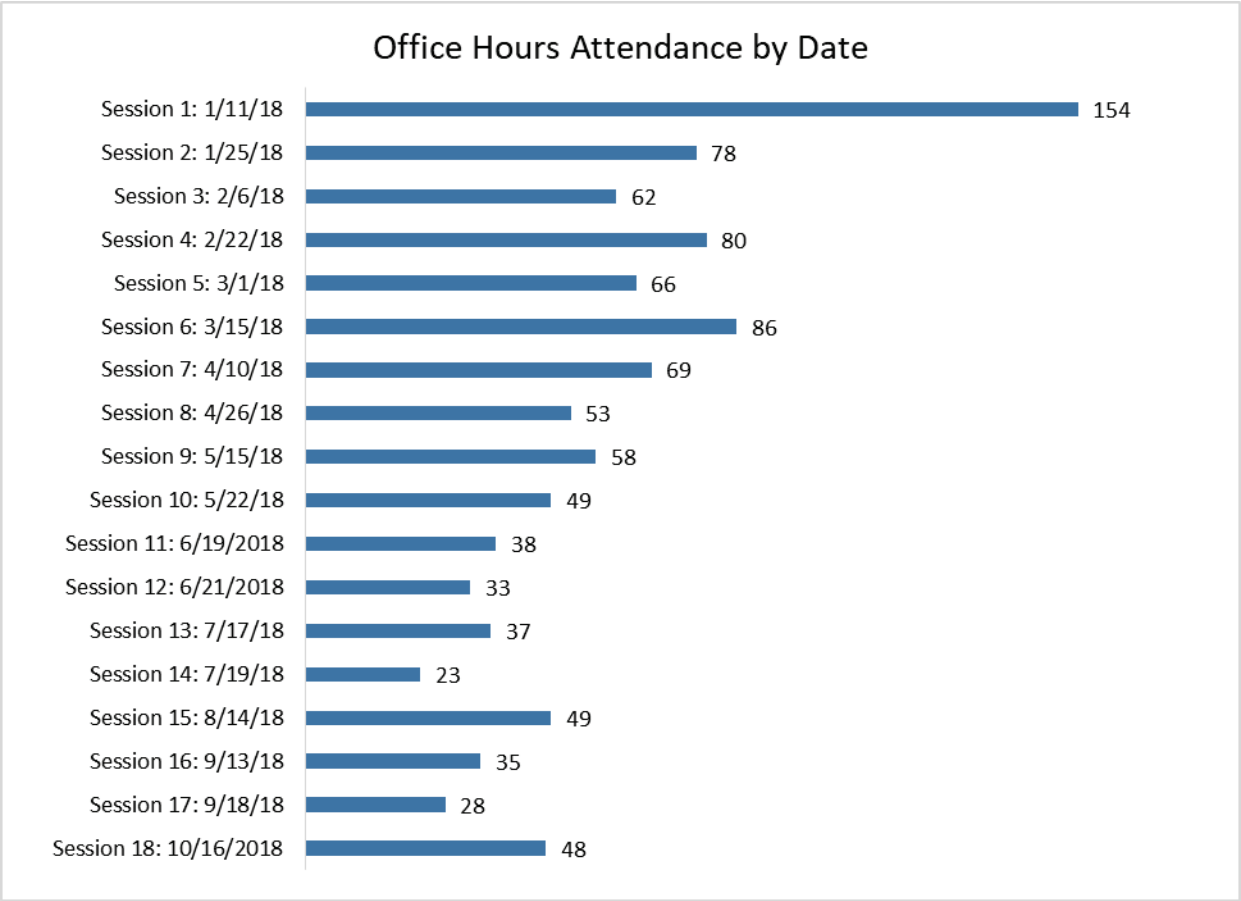


2.3.3. Office Hours

In addition to their Webinar participation, sites were encouraged to participate in optional Office Hours led by JHM/NORC. The main goal of these calls was to give sites a venue for informal discussion on how program implementation was progressing at their sites. Along with discussions on implementation of ASPs, changing behavior, guideline development, and general patient management questions, these calls facilitated peer-to-peer sharing. Participants could discuss barriers sites were encountering and strategies sites developed to address barriers.

Office Hours sessions were held 1 to 2 weeks following each Webinar, with 18 Office Hours sessions held over the course of the Acute Care Cohort year. Attendance averaged 58 participants per session (Exhibit 14).

EXHIBIT 14: OFFICE HOURS ATTENDANCE BY DATE



2.3.4. Other Implementation Activities

In addition to attending Webinars and Office Hours, health-care workers in participating units were encouraged to do the following:

- Incorporate antibiotic time outs into their daily practice.
- Meet at least monthly to complete Team Antibiotic Review forms as a collaborative effort between frontline providers and the ASP team.
- During regular team meetings, identify areas for improvement and develop solutions with input from a multidisciplinary group of health-care workers.
- Review antibiotic use over time and identify areas for improvement.

As part of their participation in the Acute Care Cohort, each unit received quarterly benchmarking reports to compare their unit's progress to those of units in similar hospitals. These reports contained individualized results for all the data the units submitted (Appendix A-5 has a sample quarterly benchmarking report):

- Baseline and endline Structural Assessment
- Baseline and endline HSOPS

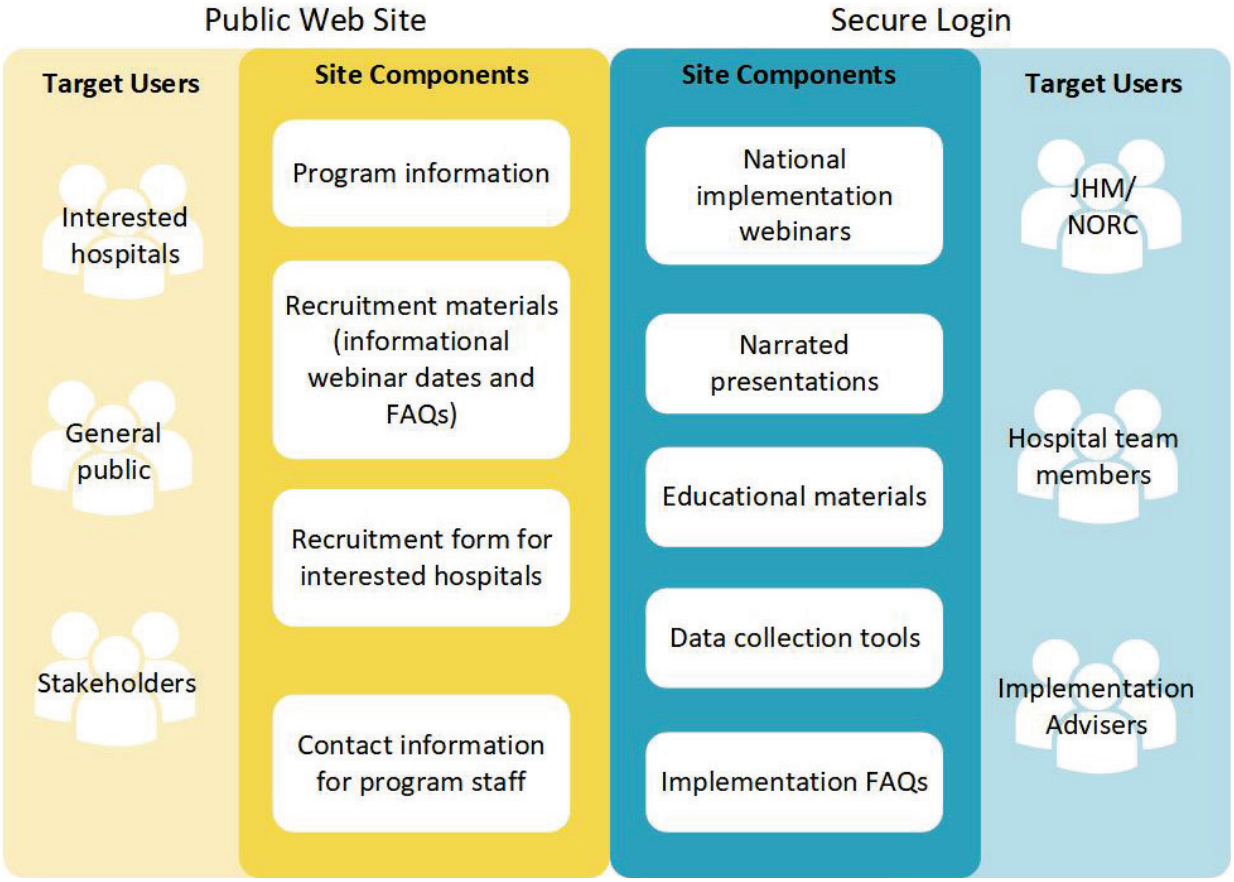
- Q1, Q2, Q3, and Q4 antibiotic days of therapy per 1,000 patient-days
- Q1, Q2, Q3, and Q4 *C. difficile* laboratory-identifiable events
- Team Antibiotic Review Forms for March–May 2018, June–August 2018, and September–November 2018

The reports also included aggregate data results from all participating units in similar hospitals (Hospital Benchmark) and from similar units in all participating hospitals (Unit Benchmark). The Quarterly Benchmarking Reports enabled sites to compare their progress to that of similar hospitals, to see their relative progress over the course of the Safety Program. ASPs were encouraged to share and discuss these reports, both within their team and with the frontline staff and hospital administration. Sharing progress in this way allowed for a celebration of success and/or a renewed effort to improving antibiotic use.

2.4. Program Web Site

To ensure all participants had 24/7 access to the acute care educational toolkit, the program Web site (SafetyProgram4AntibioticStewardship.org) that NORC developed included a public-facing component with general information on the program, and a secure log-in component that served both as a repository for content developed for the Safety Program and a data submission platform. Within each participating hospital, all staff involved in the Safety Program were given log-in credentials for the user side of the program Web site. By the end of the Cohort, that Web site had 11,650 users. Exhibit 15 outlines the structure of the program Web site.

EXHIBIT 15: STRUCTURE OF THE PROGRAM WEB SITE



JHM/NORC continued to add content over the course of the Acute Care Cohort. By the end of the 1-year implementation period, the Web site contained the following resources:

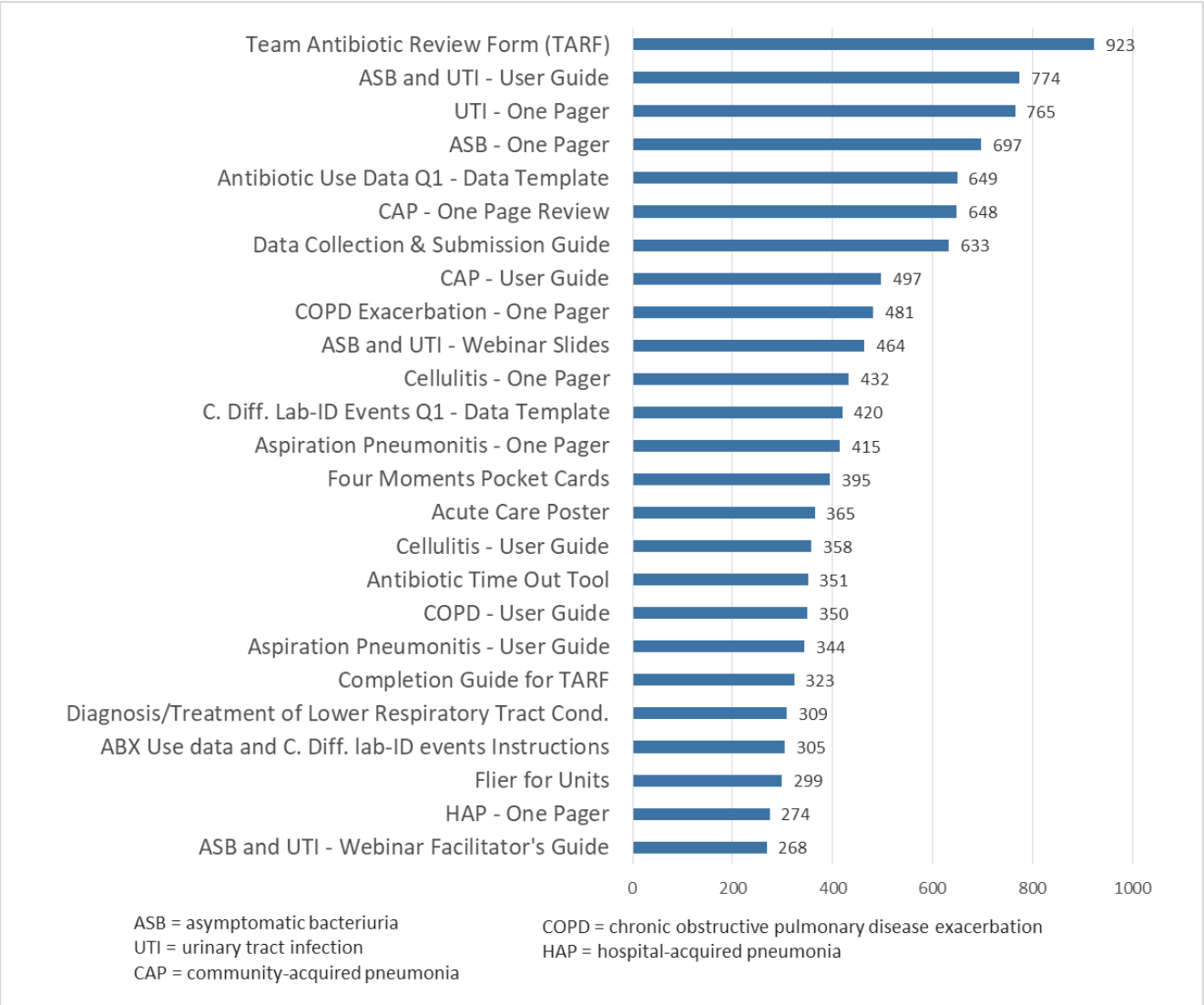
EXHIBIT 16: PROGRAM WEBSITE RESOURCES

Resource Type	Resource Name
Educational Webinars	■ Webinar and Office Hours schedule, Webinar recordings, Webinar slides with facilitator guides
Data Collection information	■ Data collection–related templates and instructions, copies of data collection tools
Implementation Resources	■ Identifying Antibiotic-Associated Adverse Events Form ■ Learning from Antibiotic-Associated Adverse Events Form ■ Antibiotic Time Out Tool ■ Acute Care Poster With Instructions ■ Promotional Flier for Units ■ Four Moments Poster ■ Four Moments Pocket Cards ■ Gap Analysis

Resource Type	Resource Name
One-Page Reviews	■ Instructions for Using One-Page Documents ■ Asymptomatic Bacteriuria and Urinary Tract Infections User Guide ■ Asymptomatic Bacteriuria One Pager ■ Urinary Tract Infection One Pager ■ Community-Acquired Pneumonia One Pager ■ Community-Acquired Pneumonia) User Guide ■ Aspiration Pneumonitis One Pager ■ Aspiration Pneumonitis User Guide ■ COPD Exacerbation One Pager ■ COPD User Guide ■ Cellulitis One Pager ■ Cellulitis User Guide ■ HAP User Guide ■ HAP One Pager ■ Biliary Tract Infection User Guide ■ Biliary Tract Infection One Pager ■ Diverticulitis User Guide ■ Diverticulitis One Pager ■ *Clostridioides difficile* Infection One Pager
Narrated Presentations	■ Approach to Patients Reporting Penicillin Allergies ■ Role of the Bedside Nurse in Antibiotic Stewardship Interventions ■ How Can Your Antibiotic Stewardship Program Collaborate with the Clinical Microbiology Laboratory?

Participants regularly accessed Safety Program Web site content. By the end of the Acute Care Cohort, the 25 most popular materials on the Web site had close to 12,000 unique downloads (averaging 470 downloads per material). Exhibit 17 shows the 25 most frequently downloaded materials from the Safety Program Web site.

EXHIBIT 17: TOP 25 MOST DOWNLOADED AHRQ SAFETY PROGRAM MATERIALS DURING THE ACUTE CARE COHORT



In addition to program resources, the Safety Program site leads had access to the data portal section to submit data for their units.

2.5. Help Desk

NORC established the Safety Program email address antibioticsafety@norc.org as a centralized resource for information and technical assistance for participating units and Implementation Advisers. The Help Desk provided a point of contact for participant questions, concerns, and requests for information. The Help Desk developed a central repository for issues, concerns, suggestions, and most importantly, resolutions that came through the Help Desk. Upon contacting the Help Desk, inquirers received an automated response confirming that the Safety Program had received their email and would respond in full as soon as possible. NORC staff monitored the emails daily, and typically responded to all inquiries within 1 to 2 business days. The systematic nature of the monitoring enabled all questions to be

assigned to the appropriate person (e.g., stewardship physicians answered clinical questions, Safety Program staff answered questions about Web site login details).

JHM/NORC received implementation inquiries via the Help Desk either directly from staff at participating sites or through their Implementation Advisers (Section 1.2.2). Any hospital-related issues the Implementation Adviser did not have adequate information to address were sent to the Help Desk. NORC followed up with contacting the appropriate person in the JHM/NORC team to address the question, so the Implementation Adviser could return the correct guidance to the hospital. Examples of implementation inquiries included questions regarding data submissions and benchmarking reports, as well as clinical questions, among many others.

When the Help Desk staff noticed frequently recurring inquiries, these became part of the internal FAQs document for Help Desk staff, and/or part of a weekly Implementation Adviser Q&A resource available throughout the implementation period. For calendar year 2018, the Help Desk received a total of 3,889 initial inquiries.

CHAPTER 3: PROGRAM IMPACT

Chapter Summary

In this chapter, we describe the goals of the Acute Care Cohort evaluation, the data collection timeline for the evaluation quarters, the primary and secondary data sources, the data analysis methods, and key findings.

Evaluation Goals

The evaluation of the Acute Care Cohort sought to answer three major questions:

1. What is the extent to which the Safety Program has been adopted by Acute Care Cohort participating units?
2. What is the effectiveness of the Safety Program in the acute care context? What changes in safety culture, antibiotic prescription decision making, antibiotic usage, and/or Clostridioides difficile (C. difficile) rates have resulted from the Safety Program?
3. Is there any variation in the effectiveness of the Safety Program (measured by change in antibiotic usage) by hospital and unit characteristics (e.g., hospital type, hospital size, unit type, and compliance with four key components of antibiotic stewardship programs (ASPs) identified after an environmental scan of the literature (i.e., interventions before and after prescription of select antibiotics, existence of local antibiotic guidelines, physician and pharmacist ASP leads with dedicated salary support, and quarterly tracking and reporting of antibiotic use improved.

Data Collection Timeline

Data collection for units began following the start of Safety Program participation in December 2017. Most quarterly and monthly data were collected for January–March 2018, April–June 2018, July–September 2018, and October–December 2018.

Data Sources

1. **Structural Assessment**, which collected unit-level information on infrastructure and prior experience with ASP activities. It was administered once at baseline and again at the end of the year, to measure the extent to which the program was adopted by the participating units.

    - **97 percent of units that completed the program submitted a baseline Structural Assessment form and 78 percent of those units submitted an endline form.**

2. **Agency for Healthcare Research and Quality (AHRQ) Hospital Survey on Patient Safety Culture (HSOPS)** examines provider and staff perspectives on 12 domains of patient safety culture. The HSOPS surveys were administered to all unit providers and staff involved in patient care once at baseline and again at the endline, to measure changes in safety culture and assess program

effectiveness. Respondents were allowed to choose one of three options to record their responses (Section 3.3.2 has more option detail).

- For the baseline HSOPS, 39 percent of units submitted HSOPS data administered within a 6-month period before the start of the cohort (Option A); 47 percent of units provided a list of their eligible staff who received a customized, secure survey link to complete the HSOPS on the program Web site (Option B); and 6 percent of units distributed the HSOPS survey link directly to their eligible staff (Option C).
- For the endline HSOPS, 7 percent of units selected Option A; 11 percent selected Option B, and 26 percent selected Option C. The remaining units (56%) did not select an option or responded that they were unable to administer the endline HSOPS at their units using any of the three options.

3. **Team Antibiotic Review Form**, for which the stewardship team at each participating unit was asked to meet with frontline providers in each participating unit to review at least 10 cases of patients with antibiotic prescriptions per month, and to complete a Team Antibiotic Review Forms for each of those patients for March–November 2018.

    - From March to November 2018, **60 percent to 73 percent of units submitted at least 10 completed Team Antibiotic Review Forms per month**.

4. Units were asked to extract, compile, and submit quarterly as antibiotic use data and *C. difficile* laboratory-identifiable (LabID) event data.

    - For each quarter, **81 percent to 93 percent of units submitted quarterly *C. difficile* laboratory events data,** while **77 percent to 93 percent of units submitted quarterly antibiotic usage data**.

5. Antibiotic use data was purchased from Premier Healthcare and compared the change in days of therapy per 1,000 patient-days over time among AHRQ Safety Program acute care participating units with change in antibiotic use data over the time period in Premier hospital units.

Data Analysis Methods

The program evaluation used a pre-post longitudinal study design. The study population included 476 units from 402 hospitals nationwide. The unit of analysis was a participating hospital for structural assessment and a participating unit for all other tools.

- *Adoption of Safety Program*: Frequency distributions were used to describe the antibiotic stewardship-related infrastructure collected from the Structural Assessment, and used a Chi-squared test to compare the difference between baseline and end-of-intervention outcomes.

- *Effectiveness of Safety Program*: HSOPS, Team Antibiotic Review Forms, and days of therapy per 1,000 patient-days, as well as *C. difficile* events per 10,000 patient-days data were used to assess the effectiveness of the Safety Program.

- For HSOPS, a linear mixed model with random hospital unit effects was used to examine the change in each of the 12 HSOPS composite scores from baseline to end of intervention.

- For the Team Antibiotic Review Forms, algorithms to generate the percent of positive responses for each of the nine assessed items was used. A longitudinal linear mixed model with random hospital unit effects was used to analyze the change in each item from the first intervention quarter (March–May 2018) to the second (June–August 2018), and third intervention (September–November 2018).

- Antibiotic days of therapy (DOT) per 1,000 patient-days was collected each month from January to December 2018. A longitudinal linear mixed model with random hospital unit effects was used to assess the change from baseline to intervention periods. DOT per 1,000 patient-days were compared between baseline (January–February 2018) and each of the bimonthly intervention periods (March–April, May–June, July–August, September–October, and November–December 2018). The difference between January–February and November–December also represented the change from baseline to end of intervention. In addition to total DOT, DOT per 1,000 patient-days for five selected antibiotic classes was also evaluated.

- *C. difficile* LabID events per 10,000 patient-days data were collected once each quarter during 2018. A generalized linear model with random hospital unit effects—assuming a Poisson distribution for *C. difficile* events was used to estimate the change from Q1 (January–March 2018) to each of the subsequent quarters (Q2, Q3, and Q4 2018) as well as between Q1 and Q4.

- *Variation in program effectiveness*: A stratified analysis was used to examine changes in antibiotic use over time by selected hospital and unit characteristics—including hospital type, size, unit type, and compliance with four key components of Hospital Antibiotic Stewardship at baseline. As in the analysis of total DOT for the entire Acute Care Cohort, a linear mixed model was employed for the stratified analysis. The stratified variable and its interaction with time (bimonth indicator) were included in the model as independent variables in addition to bimonthly period indicators.

- *Comparison with nonparticipating units from Premier hospitals*: Antibiotic usage data were extracted from the Premier Healthcare Database, and the sample was weighted to be commensurate with the Safety Program participating sites—based on hospital teaching status, urbanicity, census division, unit type, and baseline total number of patient-days (as a proxy of unit size). The change in total DOT per 1,000 patient-days was evaluated between baseline and each of the bimonthly intervention periods for the Acute Care cohort and Premier hospital units. This analysis was conducted for the overall sample as well as by hospital teaching status and unit type.

Findings in Brief

Below is an overview of key findings from participating units:

- *Participation*: A total of 476 units from 402 hospitals across the United States participated and were retained in the Acute Care Cohort. Participating hospitals averaged 205 beds; participating units averaged 30 beds.

- *Adoption of the program*: When evaluating data on compliance with four key components of ASPs, at baseline, 8 percent of hospitals reported compliance with four key components and this increased to 74 percent by the end of the Safety Program.

- *Patient safety culture*: HSOPS composite scores ranged from 47 percent to 87 percent across the 12 domains at baseline. The improvement in the composite "teamwork across units" after program implementation was statistically significant.

- *Incorporation of the Four Moments of Antibiotic Decision Making into clinical practice:* When the intervention started, antibiotic prescription in participating units reflected having incorporated the Four Moments of Antibiotic Decision Making into clinical practice most of the time (>70% for most reviewed items, except for "planned duration of therapy documented in progress note," which only had 45% positive responses). All nine aspects improved throughout the intervention period, and five of these aspects demonstrated statistically significant improvements.

- *Antibiotic use*: For the entire cohort, total DOT per 1,000 patient-days was 900.7 at baseline (January–February 2018) and 870.4 at the end of intervention (November–December 2018), a significant reduction of 30.3 DOT per 1,000 patient-days (95% confidence interval [CI]: -52.6 to -8.0, p=0.008). Antibiotic use also decreased from baseline over other intervention periods, including March–April (-29.9, 95% CI: -45.4 to -14.3, p<0.001), July–August (-28.1, 95% CI: -50.3 to -5.9, p=0.013), and September–October (-31.3, 95% CI: -54.5 to -8.2, p=0.008). Statistically significant decreases in DOT per 1,000 patient-days were also found across diverse unit and hospital types. Out of five selected antibiotic classes (see Exhibit 28), only the use of fluoroquinolones (including ciprofloxacin, levofloxacin, and moxifloxacin) decreased significantly from baseline over intervention periods. No significant reductions in overall antibiotic use were observed in the Premier Healthcare database from January-February 2018 to November-December 2018.

- C. difficile *LabID events*: Many participating units reported zero events. Zero events were reported in almost half of the unit-quarter level observations, and 80 percent (277/345) of units reported zero events for at least one quarter. The estimated number of *C. difficile* LabID events per 10,000 patient-days were 6.3 for Q1, 5.2 for Q2, 6.0 for Q3, and 5.1 for Q4. The 19.5 percent decrease in the incidence rate was statistically significant from Q1 to Q4 (95% CI: -33.5% to -2.4%, p=0.027).

3.1. Evaluation Goals, Research Questions, Data Sources/Measures, and Analytic Methods in Brief

The Acute Care Cohort evaluation goals focused on three facets of Safety Program implementation: the *implementation* itself, its *overall effectiveness*, and *variations* in its effectiveness. To reach these goals, the evaluation sought to answer three major questions:

1. What is the extent to which the Safety Program has been adopted by Acute Care Cohort participating units?
2. What is the effectiveness of the Safety Program in the acute care context? And what changes in safety culture, antibiotic prescription decision making, antibiotic usage, and *C. difficile* rates have resulted from the Safety Program?
3. Is there any variation in the effectiveness of the Safety Program (i.e., change in antibiotic usage) by hospital and/or unit characteristics (e.g., hospital type, hospital size, unit type, and compliance with 4 key components for Antibiotic Stewardship at baseline)?

To answer these questions, the four major data sources the evaluation used were a unit structural assessment, patient safety culture surveys, Team Antibiotic Review Forms, antibiotic use data, and *C. difficile* LabID events (see Exhibit 19 below).

Based on these data sources, the evaluation used a pre-post longitudinal design to evaluate the effectiveness of the intervention, with monthly unit-level days of antibiotic therapy per 1,000 patient days as the primary outcome. Also assessed were changes in the antibiotic stewardship infrastructure among the participating sites, AHRQ HSOPS responses before and after program implementation, teams' assessment of appropriate antibiotic use process, and *C. difficile* laboratory events per 10,000 patient-days.

Exhibit 18 provides a brief synopsis of the goals, research questions, data sources, and analytic methods used to evaluate the Acute Care Cohort. The rest of the chapter provides detail on the data collection plan and timeline (section 3.2), data collection elements (section 3.3), data analytic methods (section 3.4), results (section 3.5), and the limits of the evaluation (section 3.6).

EXHIBIT 18: EVALUATION GOALS, RESEARCH QUESTIONS, DATA SOURCES, AND ANALYTIC METHODS

Evaluation Goals	Research Questions	Data Sources and Measures	Analytic Methods
Goal 1: Implementation of Safety Program	What is the extent to which the Safety Program has been adopted by sites participating in the Acute Care Cohort?	**Structural Assessment:** The Safety Program lead at each unit participating in the Acute Care Cohort completed a five to seven question form to collect information on each hospital's infrastructure to conduct the program, as well as prior involvement in unitwide safety initiatives.	Descriptive statistics and Chi-squared test to assess change in antibiotic stewardship (AS) infrastructure from baseline to end of intervention and to evaluate compliance with 4 key components of AS

Evaluation Goals	Research Questions	Data Sources and Measures	Analytic Methods
GOAL 2: Effectiveness of the Safety Program	What is the effectiveness of the Safety Program in the acute care context? What changes in safety culture, antibiotic usage, and/or clinical outcomes have resulted from the Acute Care Cohort?	**Patient Safety Culture Surveys:** composite scores for each of the 12 domains in AHRQ Hospital Survey on Patient Safety Culture (HSOPS)	Linear mixed model to assess unit-level change in each of the 12 HSOPS composite scores from baseline to end of intervention
		Team Antibiotic Review Forms: Self-assessments of antibiotic use appropriateness—e.g., did they observe the "Four Moments" of stewardship by evaluating submitted Team Antibiotic Review Forms (monthly for intervention periods over March–November 2018)?	Linear mixed model to assess unit-level change in percentage of positive assessed items in antibiotic decision making process between intervention quarters
		Antibiotic usage data and *C. difficile* LabID events data for each participating unit in the Safety Program: ■ Days of therapy (DOT) per 1,000 patient-days (monthly for January–December 2018) ■ Number of *C. difficile* laboratory-identifiable (LabID) events per 10,000 patient days (quarterly for Q1–Q4 2018) **Secondary data for antibiotic usage for Premier hospital units from Premier Healthcare Database:** ■ DOT per 1,000 patient-days (monthly for January–December 2018)	(1) One-group analysis: linear (for DOT) or generalized linear (for *C. difficile* LabID event) mixed model to assess unit-level change in antibiotic use and *C. difficile* event rates over time (2) DID analysis: Linear mixed model to assess differences in the change for antibiotic use between the Safety Program participating unit and Premier units

Evaluation Goals	Research Questions	Data Sources and Measures	Analytic Methods
GOAL 3: Variation in effectiveness of the Safety Program	What is the variation in the change in antibiotic use by selected hospital and unit characteristics?	■ EHR extracts for antibiotic usage Data ■ Hospital and unit characteristics from registration information, baseline structural assessment and other hospital datasets ■ Premier data extraction for Antibiotic usage data ■ Premier data extraction for hospital characteristics (teaching status, urban/rural location, census division) and unit type (intensive care unit, medical, surgery departments)	(1) One-group analysis: linear mixed model to assess unit-level change in antibiotic use over time by hospital and unit characteristics (2) DID analysis: linear mixed model to assess Differences in the change for antibiotic use between the Safety Program participating units and Premier units for each subgroup

3.2. Data Collection Plan and Timeline

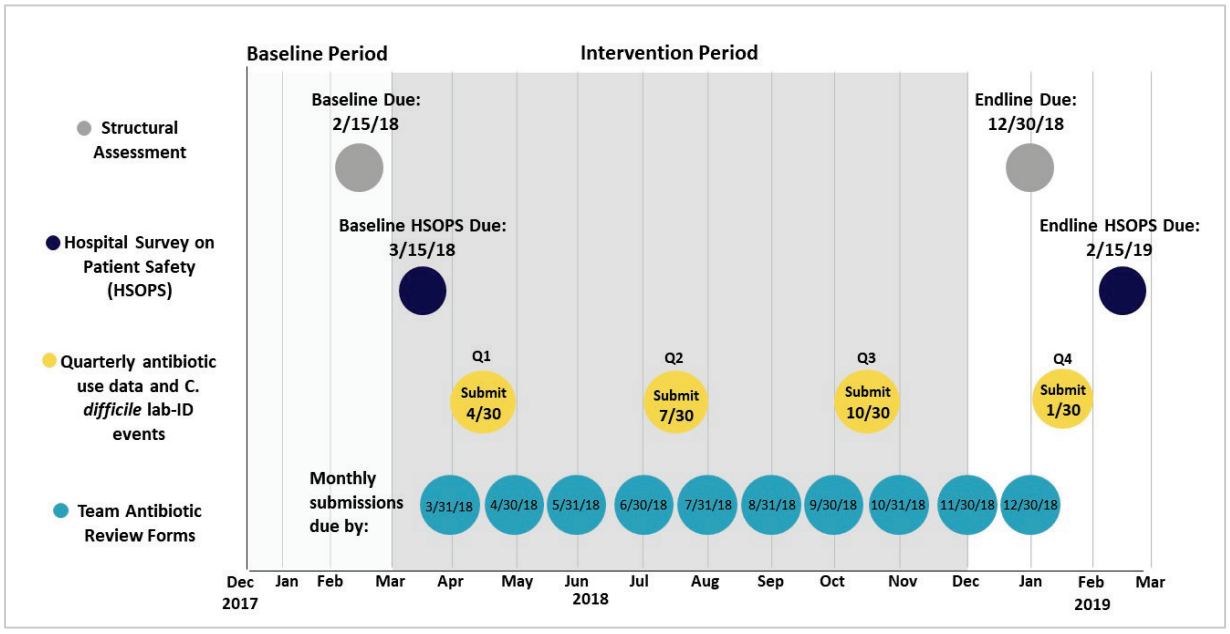
Johns Hopkins Medicine/NORC at the University of Chicago (JHM/NORC) developed an overall data collection plan and tools as part of a comprehensive evaluation strategy to assess adoption of the program in acute care, long-term care and ambulatory care settings; measure the effectiveness of the interventions in participating hospitals or units; evaluate the characteristics of teams associated with successful implementation and improvements in outcomes; and understand the drivers of antibiotic prescribing.

For the Acute Care Cohort, JHM/NORC employed the setting-specific data collection tools developed for the pilot period, consisting of: (1) a Structural Assessment form to collect information on each unit's infrastructure, (2) a template for collecting the monthly DOT to measure DOT per 1,000 patient days, (3) a template for collecting the quarterly number of *C. difficile* LabID events to measure rates per 10,000 patient days, (4) the AHRQ Hospital Survey on Patient Safety Culture to assess changes in safety culture in participating units, and (5) the Team Antibiotic Review Form to assess changes in Four Moments of Antibiotic Decision Making.

During Safety Program registration, each enrolled unit was asked to identify an ASP lead and/or data coordinator, to facilitate the data collection at their respective site and communicate with their Implementation Adviser regarding any data collection issues or updates. Each site received access to the *AHRQ Safety Program for Antibiotic Use Data Collection and Submission Guide*, which was posted on the Web site. The guide contained information on the purpose of the data collection, types of data to be collected and submitted, data collection and submission timeline for each data element, and step-by-step instructions for completing the data collection forms online and submitting the forms on the Web site portal. All data collection forms for the Acute Care Cohort received Paperwork Reduction Act clearance from the Office of Management and Budget (OMB) on September 25, 2017 (OMB clearance number 0935-0238, expiration September 30, 2020). NORC worked with AHRQ to secure the required Authority to Operate designation for the data collection portal on the program Web site.

Units began collecting and submitting the relevant data elements in January 2018, beginning with the baseline Structural Assessment completed for the unit by a member of the ASP, and the baseline HSOPS surveys completed by eligible unit staff. The endline Structural Assessment and HSOPS were completed at the end of the program, beginning in November 2018. Units also began collecting monthly DOT beginning in January 2018, to be reported quarterly for Q1 (January 2018–March 2018), and for subsequent quarters Q2 (April 2018–June 2018), Q3 (July 2018–September 2018), and Q4 (October 2018–December 2018). Team Antibiotic Review Forms were completed by units beginning in March 2018 and ending in November 2018. Exhibit 19 shows the data collection and submission timeline for the data elements collected during the Acute Care Cohort.

EXHIBIT 19: DATA COLLECTION AND SUBMISSION TIMELINE



We used multiple strategies to mitigate data collection burden and increase response rates (i.e., reduce missing responses). First, we provided options to let participating units reuse the same or similar data collected by the units outside of this AHRQ program. For example, in HSOPS data collection, units who collected HSOPS data within the eligible timeframe could submit the same unit-level data for the Safety Program. For the antibiotic use data collection, participating units had the option to submit data in DOT per 1,000 days-present, as per recommendations from the Centers for Disease Control and Prevention (CDC) National Healthcare Safety Network Antimicrobial Use and Resistance Module. Second, we adhered to the criteria to identify participating units with outstanding data issues, and the Implementation Advisers reached out to those units and corrected data issues in a timely manner. Finally, participating units were encouraged to communicate any questions regarding data collection to the program, and we developed and continuously updated data collection FAQs to answer those questions.

3.3. Data Collection Elements

The evaluation employed primary data collection and secondary data sources to meet its research goals. Exhibit 20 details the evaluation domains, data sources/measurement, persons responsible for data collection, and frequency of collection. Associated discussion follows in the next subsections.

EXHIBIT 20: DATA SOURCES/MEASUREMENT, RESPONSIBILITY FOR DATA COLLECTION, AND COLLECTION FREQUENCY

Evaluation Domain	Data Source/Measurement	Person(s) Responsible for Collection	Frequency of Data Collection
Adoption	Structural Assessment	A member of the antibiotic stewardship program (ASP) at participating sites	Baseline and endline
Effectiveness	Hospital Survey on Patient Safety Culture	All eligible staff from participating units	Baseline and endline
Effectiveness	Team Antibiotic Review Form	ASP and frontline staff	10 forms per month during March 2018 through November 2018
Effectiveness	Days of antibiotic therapy per 1,000 patient days by unit	ASP in conjunction with information technology staff	Monthly (submitted quarterly)
Effectiveness	*Clostridioides difficile* laboratory-identifiable events per 10,000 patient days by unit	ASP in conjunction with information technology staff	Quarterly

3.3.1. Structural Assessment

The Structural Assessment form developed for the Acute Care Cohort consisted of seven questions to understand the unit's infrastructure and capacity to carry out the Safety Program. The forms were completed online, via the Safety Program Web site, by a member of the ASP. The Structural Assessment form is contained in Appendix A-6.

The Structural Assessment was administered twice—at baseline and again at endline—to measure the extent to which the program was adopted by the participating units. The baseline Structural Assessment forms were completed between January 5, 2018 and February 15, 2018; the endline forms were completed between December 1, 2018 and December 30, 2018. Of the participating units that completed the program, 97 percent submitted a baseline Structural Assessment form; 78 percent of those units submitted an endline form, as well.

3.3.2. HSOPS

The AHRQ HSOPS is a widely used, validated survey to assess provider and staff perspectives on safety culture. It contains 42 items grouped into 12 composite measures, examining organizational perceptions of 12 domains of culture (ranging from communication about errors to teamwork within and across units). The HSOPS survey asks questions about patient safety issues, medical error, and event reporting.

The HSOPS questionnaire is available at https://www.ahrq.gov/sops/surveys/hospital/index.html. The HSOPS surveys were administered to all unit providers and staff involved in patient care twice during the course of the implementation year, once at baseline and again at the endline, to measure changes in safety culture and assess the effectiveness of the program. The baseline HSOPS was collected between January 5, 2018, and March 15, 2018; the endline between November 1, 2018, and February 15, 2019.

To accommodate the varying capabilities of the participating units to administer the HSOPS within their units, each participating unit in the Acute Care Cohort was asked to select one of three options for collecting the baseline and endline HSOPS as part of the program:

- **Option A**: Participating hospitals that had administered the HSOPS survey for other purposes within a 6-month period before the start of the Cohort (August 2017–March 2018 for the baseline survey), or within the last 3 months of the Cohort (October–December 2018 for the endline survey), were given the option to submit those HSOPS data files. The previously administered HSOPS data would be submitted if the hospital could: (1) provide unit-level data for the unit enrolled in the Cohort, and (2) submit the respondent-level data in accordance with the AHRQ HSOPS Data File Specifications (AHRQ HSOPS data file specifications). Participating units were provided with step-by-step instructions for submitting the HSOPS data files to the program Web site.

- **Option B:** Participating hospitals that had not administered the HSOPS within a 6-month period before the start of the Cohort, or who preferred to administer the HSOPS specifically for the Cohort, were given the option to administer the HSOPS to eligible staff in their participating units. To administer the HSOPS, units were asked to provide their Implementation Adviser with the names and email addresses of all eligible unit providers and staff, who then received a customized, secure survey link to complete the HSOPS on the program Web site. NORC sent an initial email invitation to identified staff with instructions for accessing the HSOPS and timeline for completion. After the initial email, nonresponders each received up to three reminder emails.

- **Option C:** Participating hospitals that had not administered the HSOPS within a 6-month period before the start of the Safety Program, and who were unable or unwilling to share the contact information and email addresses of their unit staff, were given the option to distribute the HSOPS survey link directly to their eligible staff. The survey link, which was distributed by one point of contact at the unit, enabled staff to complete the HSOPS survey on the program Web site without having to collect staff names or email addresses.

For the baseline HSOPS, 39 percent of units selected Option A, 47 percent selected Option B, and 6 percent selected Option C. The remaining units (7%) responded that they were unable to administer the HSOPS at their units using any of the three options. Exhibit 21 displays the response rates for each baseline HSOPS option for the 402 units that completed the program.

EXHIBIT 21: BASELINE HSOPS SELECTIONS BY UNIT AND RESPONSE RATE

HSOPS Selection	% of Units	Response Rate
Option A	38.7%	76.5%*
Option B	47.4%	14.2%**
Option C	6.3%	15.6%***
Unable to administer HSOPS	7.4%	N/A
Total	100%	

*number of units that submitted HSOPS data files divided by number that selected Option A.
**number of individual HSOPS surveys completed on the Safety Program Web site divided by number of unit staff sent email invitations to complete the survey.
***number of individual HSOPS surveys completed on the Safety Program Web site divided by number of eligible unit staff reported by the unit to their Implementation Adviser.
For the endline HSOPS, 7 percent of units selected Option A; 11 percent selected Option B, and 26 percent selected Option C. The remaining units (56%) did not select an option or responded that they were unable to administer the endline HSOPS at their units using any of the three options.

Exhibit 22 displays the response rates for each endline HSOPS option for the units that completed the program.

EXHIBIT 22: ENDLINE HSOPS SELECTIONS BY UNIT AND RESPONSE RATE

HSOPS Selection	% of Units	Response Rate
Option A	7.4%	74.3%*
Option B	11.2%	12.1%**
Option C	25.8%	15.6%***
Unable to administer HSOPS	55.6%	N/A
Total	100%	

*number of units that submitted HSOPS data files divided by number that selected Option A.
**number of individual HSOPS surveys completed on the Safety Program Web site divided by number of unit staff sent email invitations to complete the survey.
***number of individual HSOSP surveys completed on the Safety Program Web site divided by number of eligible unit staff reported by units to their Implementation Adviser

3.3.3. Team Antibiotic Review Form

The stewardship team at each participating unit was asked to meet with frontline clinicians on participating units to review at least 10 cases of patients with active antibiotic prescriptions per month, and to complete a Team Antibiotic Review Form for each of those patients. The goal of the Team Antibiotic Review Form was to foster collaboration and group thinking when reviewing how the Four Moments framework might alter diagnostic and therapeutic decisions for specific patients. The Team Antibiotic Review Form is available at https://www.ahrq.gov/antibiotic-use/acute-care/improve/team-review.html. The forms were available for download on the AHRQ Safety Program Web site, and the completed forms were submitted on the program Web site each month. The team could review all 10 cases on a single day or a few cases each day for a minimum of 10 forms a month. The Team Antibiotic Review Forms were collected between March and November 2018. The participating units were asked to submit the Team Antibiotic Review Forms by the last day of each month. Exhibit 23 shows the

proportion (out of the requested 10) of Team Antibiotic Review Forms submitted by units that completed the program during each month.

EXHIBIT 23: NUMBER OF TEAM ANTIBIOTIC REVIEW FORMS SUBMITTED BY PROGRAM MONTH

Number of Forms Submitted for each Month	% of Units March	% of Units April	% of Units May	% of Units June	% of Units July	% of Units August	% of Units September	% of Units October	% of Units November
0 forms	15%	9%	11%	11%	13%	15%	18%	20%	24%
1–9 forms	21%	21%	16%	18%	17%	16%	16%	14%	15%
≥ 10 forms	65%	71%	73%	71%	70%	68%	66%	66%	60%
Submission of any forms	76%	92%	89%	89%	87%	84%	82%	80%	75%

3.3.4. Antibiotic Use and C. *difficile* LabID Events

To evaluate the effectiveness of the Safety Program on antibiotic prescribing, participating units were asked to extract, compile, and submit antibiotic usage data. The impact of the Safety Program on *C. difficile* rates was also evaluated. See Exhibit 24 for detail on both. Data were extracted from EHR systems or through clinical chart review, and entered into standardized Excel-based templates developed by the program, which were then uploaded onto the Safety Program Web site. The templates for the quarterly antibiotic days of therapy and *C. difficile* LabID events are in Appendixes A-7 and A-8. To facilitate accurate and in-time data extraction, the program provided participating sites the template and instructions for the EHR extracts (e.g., National Drug Codes for selected antibiotics). Hospitals that submitted data to the CDC's National Healthcare Safety Network Antibiotic Use Module were provided with instructions for submitting those data for their participating units.[d,6]

EXHIBIT 24: QUARTERLY EHR DATA ELEMENTS

Data	Description
DOTs per 1,000 patient-days by unit (monthly measure)	A day of antibiotic therapy is defined as any amount of an antibiotic administered to a patient on a single calendar day. Each drug is counted independently. Patient-days are defined as aggregate number of days patients were admitted to that hospital unit.

[d]To reduce the data collection burden, participating units were given the option to upload their data downloaded from the NHSN AUR portal, which typically uses days-present as the denominator. By definition, days-present will be no smaller than patient-days, and using DOT per 1,000 days-present to approximate DOT per 1,000 patient-days will underestimate the antibiotic use. To have comparable measurement across the Cohort, we collected the monthly number of patient-days via the *C. difficile* data template, extracted that information, and replaced the monthly days-present reported in the NHSN AUR to calculate DOT per 1,000 patient-days. For units that submitted NHSN AUR data but failed to provide monthly patient-days data, we reached out to their Implementation Adviser to request that additional information. For the single unit for which we were not able to obtain patient-days for their NHSN AUR data, we imputed the number of patient-days based on their days-present and unit type, according to Moehring RW, *et al.* (2018).[6] Our final analysis included all units that submitted NHSN AUR data and used DOT per 1,000 patient-days as the outcome.

Data	Description
Clostridioides difficile (*C. difficile*) laboratory event episodes per 10,000 patient-days by unit (quarterly measure)	*C. difficile* laboratory event is defined as number of all nonduplicate *C. difficile* toxin-positive laboratory results. Patient-days are defined as the aggregate number of days patients were admitted to that hospital unit.

Participating units were asked to submit data to the program Web site on a quarterly basis during the Cohort, by downloading the template from the Safety Program Web site and uploading the completed template to the same Web site. Data for each quarter were to be submitted within 30 days of the end of the quarter, e.g. April 30, 2018 for Q1 (January–March 2018). Exhibit 25 displays the percentage of units that completed the Safety Program that submitted *C. difficile* LabID events and antibiotic use for each program quarter.

EXHIBIT 25: ANTIBIOTIC USE AND *C. DIFFICILE* LABID DATA SUBMISSION COMPLIANCE

Timeframe	% of Units ***C. difficile* Lab-ID Events**	% of Units **Antibiotic Use Data**
Q1 data (January–March 2018)	93%	93%
Q2 data (April–June 2018)	92%	92%
Q3 data (July–September 2018)	88%	87%
Q4 data (October–December 2018)	81%	77%

3.3.5. Premier Healthcare Database

We requested monthly patient-days and antibiotic days of therapy data for each of the 50 antibiotics collected in the Safety Program Acute Care Cohort among Premier hospital units from the Premier Healthcare Database—a database that contains about one-fourth of the inpatient discharges in the nation, with drug utilization information available by day of stay for each patient. The Premier data was first mapped to hospital department (intensive care unit [ICU], medical, and surgery) based on room and board charge information, then monthly patient-days and antibiotic usage data were extracted for each mapped hospital department for the same study period as the Safety Program (i.e., monthly during January–December 2018). Hospitals participating in the AHRQ Safety Program were excluded from the sample. Other characteristics in the extracted Premier data file include hospital teaching status, census division, and indicator for urban/rural location.

3.4 Data Analytic Methods

3.4.1. Analysis in Brief

Data submissions were assessed for quality and usability in our analysis. Exhibit 26 summarizes number of units with any data submissions and number of units that contributed to the final analytic dataset for each tool/measurement.

EXHIBIT 26: UNITS WITH DATA SUBMISSIONS AND CONTRIBUTING TO FINAL ANALYTIC DATASET

Data Submission Type	Number of Units With Data Submissions	% of Units With Data Submissions	Number of Units That Contributed to Final Analytic Dataset	% of Units That Contributed to Final Analytic Dataset
Total cohort	476	100%	-	-
Structural Assessment, baseline and endline	368	77%	362	76%
Structural Assessment, baseline	460	97%	451	95%
Structural Assessment, endline	373	78%	373	78%
HSOPS, baseline and endline	186	39%	48	10%
HSOPS, baseline	405	85%	162	34%
HSOPS, endline	197	41%	68	14%
Team Antibiotic Review Form data for any month	456	96%	450	95%
Antibiotic use data for any quarter	449	94%	425	89%
C. difficile LabID event data for any quarter	453	95%	394	83%
Submitted all data	113	24%	-	-

The program evaluation, as noted, used a pre-post longitudinal study design. We first described characteristics of participating hospitals and units, including bed size and hospital/unit type, as well as compliance with four key components of antibiotic stewardship at baseline. To evaluate adoption of the program among participating units, facility antibiotic stewardship infrastructure change was assessed from the baseline to the endline as measured by the Structural Assessment. Of note, for some key components of ASPs for which an individual hospital's response was not clear, the assigned Implementation Adviser was requested to follow up with the site to ascertain additional relevant data.

To evaluate the effectiveness of the program, linear or generalized linear mixed models were employed to examine change over time in outcomes collected from several data sources—including patient safety culture from HSOPS, antibiotic decision making process from Team Antibiotic Review Form, and antibiotic use and *C. difficile* events. Antibiotic use over time for the five selected antibiotic classes were examined for the entire cohort, as well. A linear mixed model was specified as:

$$Y_{it} = X\beta = \beta_0 + r_{0i} + \beta_1 Time_{it} + e_{it}$$

In the specification, i indexes the hospital unit, t indexes the time for the measurement, Y_{it} is the outcome for the hospital unit i at time t—for example, HSOPS composite score at baseline, percentage of positive responses for items evaluated on the Team Antibiotic Review Form during March-May 2018, or total DOT per 1,000 patient-days in a bimonth period. In addition, β_0 represents the expected value of Y when time is zero (i.e., baseline); β_1 is a vector and represents the average rate at which Y changes from baseline to follow-up time point in the population; r_{0i} is the random intercept, which captures hospital unit differences in the level of Y at baseline; and $e_{it}$is the error term. For a generalized linear

model (e.g., *C. difficile* events outcome), the outcome $E(Y)$ is linked with the linear predictor $X\beta$ by: $E(Y) = g^{-1}(X\beta)$, where $g(.)$ is the log link function.

We did not impute missing data. Instead, we excluded units from our analysis if they presented too many missing values for a certain outcome. For the rest of the unbalanced data, we assumed a missing at random (MAR) pattern,[e] which would not bias the results from mixed models.[7] Another advantage of mixed models is that they incorporate heterogeneity across hospital units via unit-level random effects.[f],[g] A p-value of less than 0.05 was considered a statistically significant finding. Stratified analyses were also performed to examine the change in antibiotic use over time for subgroups defined by selected hospital and unit characteristics.

We further expanded our study to include data extracted from the Premier Healthcare Database. We first weighted the Premier data to be similar with the Safety Program acute care cohort on observed, baseline characteristics. We then used linear mixed models to assess the change in antibiotic use from January–February 2018 to November–December 2018 for each sample, as well as subgroups for hospital teaching status and unit type in each sample. Please note that though we performed this analysis within a difference-in-difference (DID) framework, we did not present the DID estimator (i.e., the differences in changes between the two samples) due to the lack of comparability between the two samples.

3.4.2. Structural Assessment

Structural assessment data were collected at baseline and endline to measure facility infrastructure related to AS. We compared the AS infrastructure among the participating units at baseline and end of intervention, and then conducted a Chi-squared test to examine the differences in selected items between baseline and endline.

3.4.3. HSOPS

HSOPS data were collected at baseline (or within a 6-month period prior to program implementation) and endline to measure average provider and staff perspectives of patient safety culture in the unit. For units that submitted previously collected HSOPS data, we excluded units whose data were collected

[e]The MAR assumption means that although the missing data are not a random subset of the sample, the probability of a missing value is unrelated to the values that would have been observed had those data points not been missing. Compared with missing completely at random (MCAR, which assumes that missing data is a completely random subset of the sample, we believe MAR is a more tenable assumption because more units had missing Q4 data than earlier quarters.

[f]Specifically, in addition to the population-averaged (or fixed) intercept, we allowed each hospital unit to have its own random intercept, where this random component follows a normal distribution. The slope coefficients, however, are fixed (i.e., not random), so hospital units can start from different baseline levels but will have parallel outcome trajectories over the intervention period.

[g]We compared the Akaike information criterion of models from different specifications to select the most appropriate within-subject covariance structure for Team Antibiotic Review Forms, DOT, and *C. difficile* analyses. In particular, we compared models for the following within-subject covariance structures: first-order autoregressive (AR(1)), first-order autoregressive moving-average (ARMA(1,1)), heterogeneous AR(1), compound symmetry, Toeplitz, and unstructured. We used heterogeneous AR(1) in the end.

prior to 6 months of the program baseline (i.e., allowable date period was from August 2017 to March 2018) for baseline HSOPS, or prior to 3 months of the program endline (i.e., allowable date period was from October 2018 to January 2019) for endline HSOPS, or for those whose data included other units (e.g., hospitalwide data). For units whose staff completed the online HSOPS survey, when there were at least five respondents for the unit, we rolled up responses to the unit level to create composite scores.[8]

Hospital and unit characteristics between respondents and nonrespondents were compared for both baseline and endline HSOPS. Linear mixed models were used to examine the change of each composite score from baseline to endline. A sensitivity analysis was performed that tested the results of the model only for units that submitted data for both time points.

3.4.4. Team Antibiotic Review Form

Team Antibiotic Review Form data were submitted monthly beginning March 31, 2018, and ending December 30, 2018. Nine items were coded as 0 or 1, where 1 indicated that Four Moments were correctly reflected in the process of antibiotic decision making. Responses for each review item were then rolled up to the unit level to calculate the percentage of positive responses for each quarter when at least five forms were submitted by the unit that quarter.[h] A linear mixed model was used to examine the change in the use of Four Moments of Antibiotic Decision Making across intervention quarters (March–May, June–August, and September–November). A sensitivity analysis was conducted to test the results of our model only among units that submitted at least 10 forms for all nine months (March–December 2018).

3.4.5. Antibiotic Use

JHM/NORC reviewed a comprehensive list of antibiotics currently available in the National Healthcare Safety Network (NHSN) Antimicrobial Use module and selected 50 antibiotics likely to be administered to hospitalized patients. The team selected all antibiotics anticipated to be administered either orally, intravenously, or intramuscularly to hospitalized patients in the United States. Monthly antibiotic use data (submitted quarterly) was requested for the 50 selected antibiotics from all participating sites. Monthly DOT for each of the antibiotics were extracted and reported by participating units on a quarterly basis. Due to differing capabilities in data collection, units were given the option to (1) submit data using a shortlist of 14 antibiotics or (2) provide data exported from the NHSN portal directly.[i] To encourage units to track their data, we also accepted quarterly data or data submitted for a larger entity that included other units (e.g., hospitalwide data); however, those units were excluded from our analysis in this report.

The primary outcome of interest was the change in antibiotic DOT per 1,000 patient-days between January–February 2018 and each of the subsequent two-month intervals from March to December 2018. As the best practice Webinars targeting frontline clinicians and the requirement to submit Team

[h]To keep a decent denominator size in calculating the percentage of positive responses, we rolled up the numbers into quarter instead of month for each unit.

[i]Please see discussion in section 3.3.4 for the adaption of NHSN AUR data in our analysis.

Antibiotic Review Forms began in March 2018, antibiotic use data were grouped into bimonthly intervals, enabling comparisons of each bimonthly interval (e.g., March–April, May–June) to the January-February baseline. This approach also enabled a brief evaluation of sustainability during November–December 2018 as the best practices Webinars were completed in October 2018. Changes in overall DOT per 1,000 patient-days during the intervention based on select hospital and unit characteristics were also estimated.

Change in DOT per 1,000 patient-days from January–February to November–December reflected changes from the beginning to the end of the intervention period. The comparison between the first and last bimonthly periods is of particular interest for two major reasons. The primary reason is that these time periods allow for comparison of the beginning and the end of the formal Safety Program. Another reason is that comparing the November–December period to the January–February baseline (all winter months) holds seasonality in antibiotic use roughly constant. Units with extremely low patient-days (zero or close to zero) and units with out-of-range values for DOT per 1,000 patient-days for any month (>2,000) were excluded.[j] Units were also excluded if: (1) they did not report data for the baseline period (January–February); (2) they reported no data from July through December (second half of the program period); or (3) they submitted less than 6 months of data in total (less than half the data points). Two sensitivity analyses were performed. The first sensitivity check included units that reported DOT using the shortlist of 14 antibiotics and defined the outcome variable as total DOT per 1,000 patient-days for the antibiotics on the shortlist. The second sensitivity check restricted the analysis to units that submitted data for all 12 months. Appendix Exhibit B-1.1 presents the flowchart for inclusion in the antibiotic use analysis. Longitudinal linear mixed models with random hospital unit effects were used to examine changes in antibiotic prescriptions over time.

In addition to total antibiotic use, change in DOT per 1,000 patient-days for five selected antibiotic classes was also examined for the entire cohort using same modeling approach. Exhibit 27 details the list of antibiotics for the selected antibiotic classes. This analysis included both units who reported DOT data for the full list of antibiotics and units who reported DOT data for the shortlist of antibiotics.

[j]A DOT per 1,000 patient-days of 2000 means that, on average, all patients admitted to the unit were given two antibiotics each day throughout their stay. The program team selected 2,000 as the cut-off value to rule out units that may have extracted their data incorrectly (e.g., used doses instead of days of therapy as the numerator). Based on this threshold, units that submitted at least one month of data with DOT per 1,000 patient-days greater than 2,000 were asked to confirm or correct their data submission. Most units were able to review their data and address this issue. In our final analysis, we included five units who reviewed their data and confirmed the accuracy of the data points with DOT per 1000 patient-days greater than 2,000.

EXHIBIT 27: SELECTED ANTIBIOTIC CLASSES

Antibiotic Class	Antibiotics
Anti-MRSA	ceftaroline, daptomycin, linezolid, vancomycin
Antipseudomonal beta-lactams	aztreonam, ceftazidime, cefepime, piperacillin/tazobactam
Antipseudomonal carbapenems	imipenem/cilastatin, meropenem
Fluoroquinolones	ciprofloxacin, levofloxacin, moxifloxacin
Nonpseudomonal beta-lactams	ampicillin/sulbactam, ceftriaxone, ertapenem

For total antibiotic use, we also performed analysis stratified by hospital type, hospital bed size, unit type, and baseline antibiotic stewardship infrastructure status; and then estimated the change over time for each stratum. For example, we sought to analyze the changes by academic medical center vs nonacademic medical center, with the hypothesis that an academic medical center likely had more robust stewardship resources at baseline). Exhibit 28 details the subgroup variables used in the stratified analysis.

EXHIBIT 28: SUBGROUP VARIABLES IN STRATIFIED ANALYSIS FOR ANTIBIOTIC USE AND DATA SOURCE

Variable	Subgroup	Data Source[ϕ]
Unit type	ICU Med/surg floor Other	Program Web site registration
Hospital type*	Academic medical centers Nonacademic medical centers Community teaching hospitals Community nonteaching hospitals or noncommunity hospitals Critical access hospitals	American Hospital Association Survey (AHA), Hospital Cost Report Information System, Provider of Services
Hospital bed size*	<100 beds 100–299 beds 300+ beds	Baseline Structural Assessment, Provider of Services, AHA
Compliance four key components for Antibiotic Stewardship	Yes No	Structural Assessment, decided by whether the institution had answered "yes" for ALL of the following questions: having ASP committee, having a physician lead, having a pharmacist lead, developing antibiogram, developing local antibiotic treatment guidelines, prior approval of select antibiotics, post-prescription review with feedback of select antibiotics, and reporting antibiotic DOT rate to track antibiotic usage; the assigned Implementation Adviser requested additional data from sites as needed

[ϕ] For variables available in multiple data sources, we compared the consistency first and harmonized the information when a distinguished inconsistency was found—for example, using information from a hospital's Web site to consolidate hospital type or bed size information
*Some of the hospital and unit categorization selected for this report may differ from the categories used in presentations and publications from the Acute Care Safety Program cohort

To address the substantial imbalance in the Safety Program and the Premier samples, entropy balancing[9] was used to reweight the Premier data to make it more comparable to the Acute Care Cohort in hospital teaching status, urbanicity, census division, unit type, and baseline (January and February) total number of patient-days (as a proxy of unit size). We then used linear mixed models to estimate changes over time in antibiotic use for the weighted Premier sample. Overall changes in antibiotic use and changes for selected hospital and unit characteristics were both examined.

Although the weighting approach yielded good balance on the few observed characteristics common to both samples, the significant preweighting disparities between the two samples (e.g., unit size) suggested that even after reweighting the Premier sample there remained substantial unobserved differences. Moreover, the method of data extraction was considerably different for the Premier sample, making the outcome measures in the Premier data not directly commensurable with those from the Safety Program.

3.4.6. *C. difficile* LabID Events

Unit-onset *C. difficile* LabID events data were collected quarterly for each participating unit. Change in *C. difficile* LabID events per 10,000 patient-days from Q1 (January–March 2018) to each subsequent quarter (Q2=April–June 2018, Q3=July–September 2018, Q4=October–December 2018) were evaluated. Appendix Exhibit B-1.2 presents the flowchart for units included in the analysis of *C. difficile* LabID events data. A generalized linear mixed model with a Poisson distribution with random hospital unit effect was used to model the number of *C. difficile* LabID events, including the natural logarithm of each unit's number of patient-days as the unit's own offset in the model (because we had unbalanced data for number of patient-days on hospital units). The difference in incidence rate from Q1 to each of the subsequent quarters was evaluated for the entire Acute Care Cohort.

3.5 Results

The sections below describe findings in evaluating the adoption and effectiveness of the Safety Program in the context of the Acute Care Cohort, beginning with characteristics of participating hospitals and units, followed by a structural assessment to assess adoption of the program, HSOPS to assess the change in staff perspectives of patient safety culture, Team Antibiotic Review Forms to assess incorporation of the Four Moments of Antibiotic Decision Making into practice, antibiotic days of therapy to assess changes in antibiotic use, and *C. difficile* LabID rates to assess changes in *C. difficile* events.

3.5.1. Findings Highlights

Below is a summary of key findings from participating units:

- Characteristics of participating hospitals and units:

A total of 476 units from 402 hospitals across the United States participated and were retained in the Acute Care Cohort (termed "participating units"). The number of beds averaged 205 in participating hospitals (the majority of which were non-teaching hospitals) and 30 in participating units.

- Antibiotic stewardship infrastructure:

  At baseline, most participating hospitals reported having an established ASP, although there was wide variety in actual stewardship-related activities. After program implementation, aspects of the CDC Core Elements for Antibiotic Stewardship improved significantly. Hospitals that complied with four key components of ASPs (i.e., interventions before and after prescription of select antibiotics, existence of local antibiotic guidelines, physician and pharmacist ASP leads with dedicated salary support, and quarterly tracking and reporting of antibiotic use improved from 8 percent to 74 percent over the one-year period ($p<0.01$). Patient safety culture:

HSOPS composite scores ranged from 46 percent to 85 percent across the 12 domains at baseline. The composite "teamwork across units" improved significantly after program implementation.

- Incorporation of the Four Moments of Antibiotic Decision Making into clinical practice:

When the intervention started, antibiotic prescription in participating units reflected the Four Moments most of the time (>70% for most reviewed items, except for "planned duration of therapy documented in the medical record," which only had 45% positive responses). All nine aspects improved continuously from March–May to June–August and to September–November, and for 5 of those months the improvement was statistically significant. (Note: Data collection for this metric only encompassed three quarters of the intervention period.)

- Antibiotic use:

For the entire cohort, total antibiotic DOT per 1,000 patient-days for all 50 antibiotics decreased by 30.3 DOT per 1,000 patient-days (95% CI: -52.6 to -8.0, p=0.008) from baseline (January–February 2018) to end of intervention (November–December 2018). The changes were significant between baseline and each bimonth interval throughout the intervention period (March–December 2018), except for May–June 2018. Out of the five selected antibiotic classes, only fluoroquinolones (including ciprofloxacin, levofloxacin, and moxifloxacin) exhibited a significant decrease from baseline.

There was a decrease in total DOT per 1,000 patient-days from baseline among units in nonacademic medical center (AMC) hospitals, driven by non-teaching hospitals. Hospitals that did not comply with all four of the key components of ASPs at the beginning of the Safety Program had significant reductions in antibiotic use by the end of the Safety Program, when compared to hospitals who were already complying with all four key components at the beginning of the Safety Program.

The overall reduction in antibiotic use among the Safety Program participating units comparing January-February and November-December 2018 was not observed in the Premier Healthcare database during this same time period.

- *C. difficile* LabID events:

Many participating units reported zero events— with almost half of the unit-quarter level observations reporting zero events, and 80 percent of units reporting zero events for at least one quarter. For the entire cohort, the decrease in the estimated number of *C. difficile* LabID events per 10,000 patient-days was statistically significant from Q1 to Q2 by 17.3 percent (95% CI: -29.8% to -2.6%, p=0.023), and from Q1 to Q4 by 19.5% (95% CI: -33.5% to -2.4%, p=0.027).

3.5.2. Characteristics of Participating Units

Of the 402 participating hospitals, about 40 percent had fewer than 100 beds, one-third had 100–299 beds, and one-quarter had at least 300 beds. Seven percent of the hospitals were AMCs, one-quarter were non-AMC teaching hospitals, and two-thirds were nonteaching hospitals, which included nonteaching community hospitals, critical access hospitals, and other hospital types. Of the 476 participating units, 35 percent were ICUs, and over 60 percent were medical or surgical or medical/surgical floor. Exhibit 29 shows select hospital-level and Exhibit 30 shows unit-level characteristics for these units. Appendix Exhibit B-2.1 and Appendix Exhibit B-2.2 present the distribution of unit type and hospital type for participating units across the country.

EXHIBIT 29: HOSPITAL CHARACTERISTICS OF PARTICIPATING UNITS

Hospital Characteristics (402 hospitals in total)	# Participating Hospitals (%)
# hospital beds in facility, mean (standard deviation SD), range	204.7 (199.7), 4–-1,100
Hospital with <100 beds	165 (41.0%)
Hospital with 100–-299 beds	136 (33.8%)
Hospital with 300+ beds	101 (25.1%)
Academic medical centers (AMCs)	28 (7.0%)
Non-AMC hospital	374 (93.0%)
Non-AMC teaching hospital	104 (25.9%)
Non-AMC teaching hospital with <100 beds	7 (1.7%)
Non-AMC teaching hospital with 100–-299 beds	50 (12.4%)
Non-AMC teaching hospital with 300+ beds	47 (11.7%)
Non-teaching hospital	270 (67.2%)
Non-teaching hospital with <100 beds	156 (38.8%)
Non-teaching hospital with 100–-299 beds	83 (20.6%)
Non-teaching hospital with 300+ beds	31 (7.7%)
Critical access hospital	85 (21.1%)

EXHIBIT 30: UNIT CHARACTERISTICS OF PARTICIPATING UNITS

Unit Characteristics (476 units in total)	# Participating Units (%)
# hospital beds in unit, mean (standard deviation), range*	29.9 (30.4), 2-354
Intensive care unit	165 (34.7%)
Medical/surgical floor	195 (41.0%)
Medical floor	94 (19.7%)

Unit Characteristics (476 units in total)	# Participating Units (%)
Surgical floor	11 (2.3%)
Other	11 (2.3%)

*Number of hospital beds in unit was collected in the baseline structural assessment and available for 450 units only (25 units did not respond to the baseline Structural Assessment and one unit had this value missing).

The Premier sample included 1,711 units from 614 hospitals. Among these units, 29 percent were from teaching hospitals, 74 percent were from hospitals in urban area, and 30 percent were ICUs. The weighted Premier sample was similar to Safety Program participating units in terms of hospital teaching status, urban/rural location, census division, unit type, and baseline patient-days. Appendix Exhibit B-2.3 presents the characteristics for the Premier sample.

The structural assessment consisted of seven questions to understand the general infrastructure, local stewardship practices (if any), and experience with quality improvement initiatives at each participating hospital, and how responses changed over the course of the Safety Program.

Among the 402 participating hospitals, 384 responded to the baseline structural assessment. Of those 384 participating hospitals, 317 also responded to the endline assessment. Hospitals that responded to both the baseline and endline assessments were similar to hospitals that responded only to the baseline assessment.

Prior to the start of the formal 1-year AHRQ Safety Program for Improving Antibiotic Use, an environmental scan of the published literature was conducted. First, the evidence compiled in "Implementing an Antibiotic Stewardship Program: Guidelines by the Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America was reviewed."[10] These guidelines were developed by an expert panel using the GRADE methodology that included a PubMed search of articles in the English language published between 1946 and July 2013. To ensure that the most current body of evidence was used to guide the AHRQ Safety Program and to limit redundancy between the environmental scan and the previously published guidelines, an additional PubMed search utilizing identical search parameters to the prior search was conducted, but limited to the time period between August 2013 and October 2018. The search yielded 1,747 results, of which 64 studies were selected for full text review. Articles were excluded if they described ASPs or interventions outside of the acute care setting.

Four key components of successful ASPs in the acute care setting that were identified including: (1) interventions before and after prescription of select antibiotics, (2) development of local guidelines at a minimum for urinary tract infections and community-acquired pneumonia, (3) physician and pharmacist ASP leads with dedicated salary support, and (4) quarterly tracking and reporting of antibiotic use. The importance of each component was underscored throughout the course of the Safety Program. Compliance with the four key components were compared for the 402 participating sites at the beginning (January–February 2018) and end (November–December 2018) of the Safety Program based on self-reporting provided through the Structural Assessment and qualitative data obtained through the Implementation Advisers during their exit interviews, and monthly qualitative data reported to the quality improvement expert assigned to each site.

After program implementation, compliance with four key components of ASPs (i.e., interventions before and after prescription of select antibiotics, existence of local antibiotic guidelines, physician and pharmacist ASP leads with dedicated salary support, and quarterly tracking and reporting of antibiotic use) improved from 8 percent to 74 percent over the one-year period ($p<0.01$).

3.5.3. Hospital Survey on Patient Safety Culture (HSOPS)

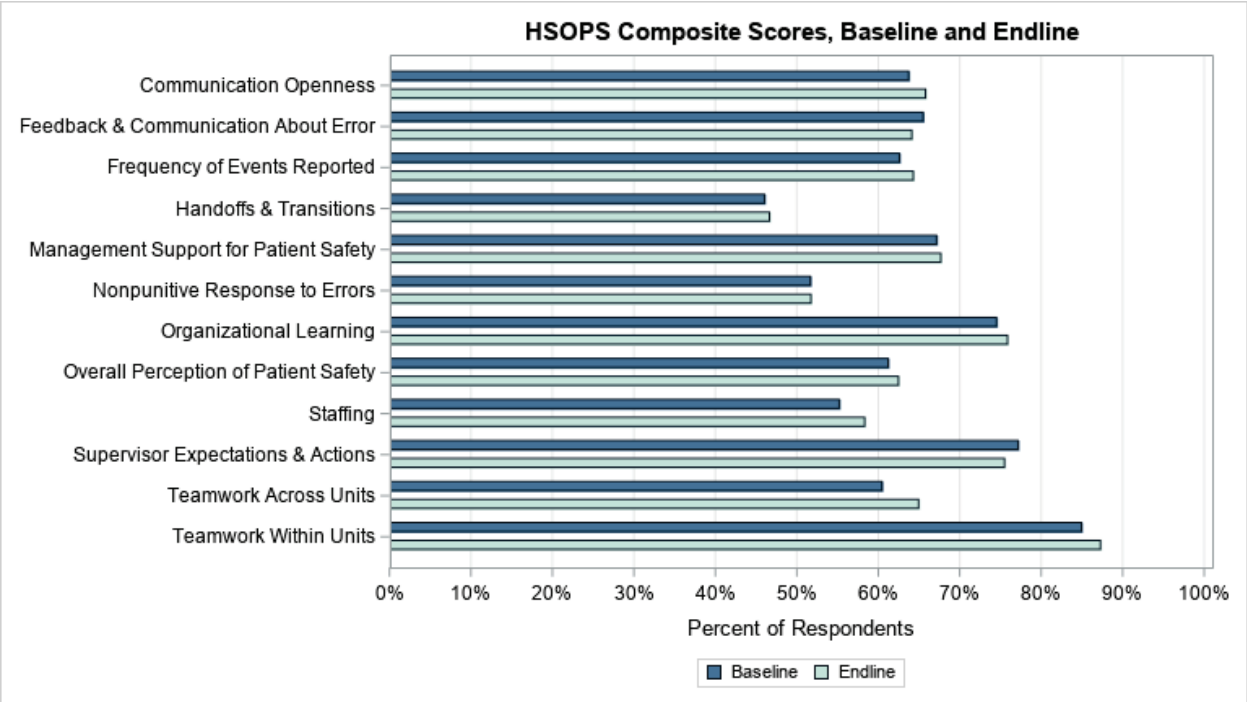
As mentioned earlier, participating units were given the flexibility to choose one of three data collection options for the HSOPS. We evaluated data usability after data submission and excluded units from the analysis if they met any of the following conditions: (1) previously collected HSOPS data were not collected during the designated time period (August 2017–March 2018 for the baseline survey and October 2018–January 2019 for the endline survey); (2) data were not specific to the participating unit; and (3) fewer than five individuals responded to the survey.

The analysis included 162 units for baseline HSOPS and 68 units for endline HSOPS with usable data. Among them, 48 units responded to both baseline and endline HSOPS. Hospital and unit characteristics were comparable between respondents and non-respondents for baseline HSOPS; for the endline survey, respondents were less likely to come from AMCs, nonteaching hospitals, or large hospitals.

At baseline, teamwork within units[k] received the highest composite score (87%), followed by supervisor/manager expectations and actions promoting patient safety (77%), and organizational learning for continuous improvement (75%). Dimensions that received the lowest composite scores were hand-offs and transitions (47%), nonpunitive response to errors (52%), and staffing (58%). Other dimensions received composite scores between 60 percent and 67 percent. After program implementation, teamwork across units improved by 4.5 percentage points (95% CI: 1.0% to 8.0%, $p=0.012$). Composite scores for other domains did not change significantly from baseline to endline. Exhibit 31 displays the HSOPS composite scores for each domain at baseline and endline.

[k] HSOPS composite scores were calculated based on AHRQ User's Guide, which can be retrieved from https://www.ahrq.gov/sites/default/files/wysiwyg/professionals/quality-patient-safety/patientsafetyculture/hospital/userguide/hospcult.pdf.

EXHIBIT 31: HSOPS COMPOSITE SCORES FOR PARTICIPATING UNITS BEFORE AND AFTER THE PROGRAM



Sensitivity analysis including only units who submitted both usable baseline and endline data (n=48) showed a similar pattern of HSOPS composite scores before and after the program. Teamwork across units was still the only domain with a significant increase from baseline to endline (5.2%, 95% CI: 1.2% to 9.2%, p=0.011).

3.5.4. Team Antibiotic Review Form

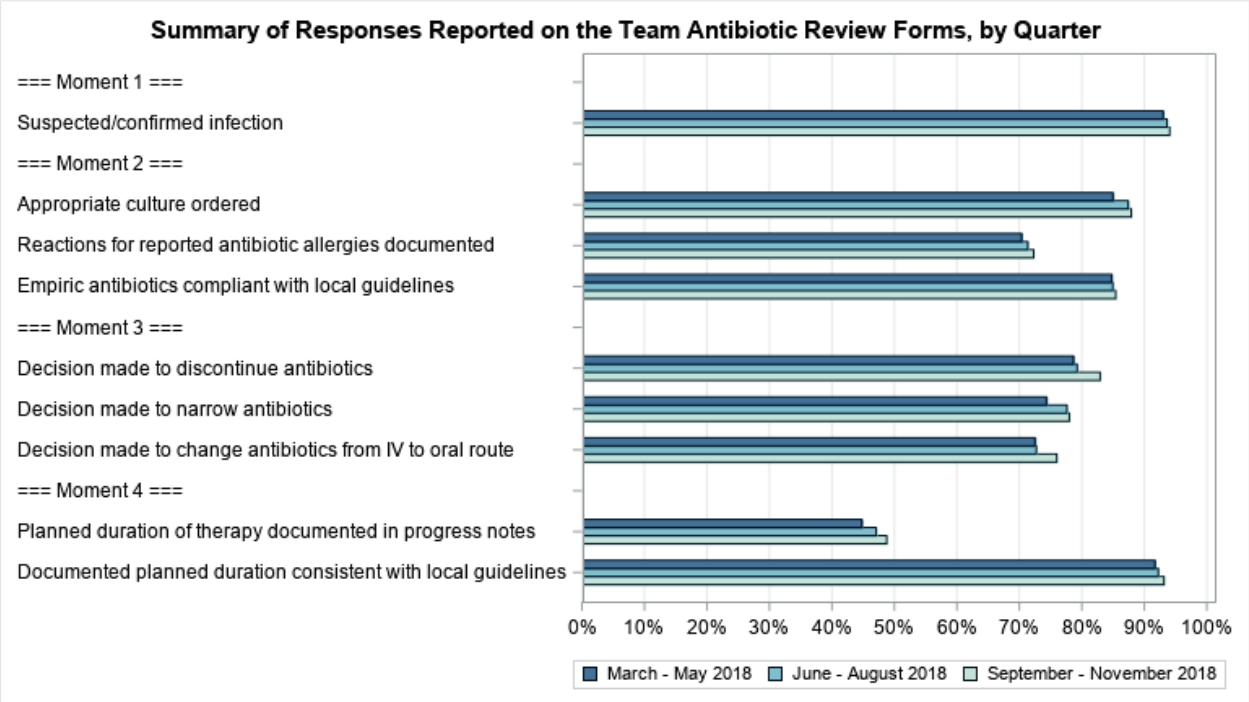
As noted, units were required to review antibiotic use for at least 10 patients and fill out the Team Antibiotic Review Form for each patient every month from March to November 2018. The analysis included 450 units (95%) from 385 hospitals who submitted at least five forms for at least one intervention quarter (March–May, June–August, and September–November).

The average percentage of reviewed forms that correctly self-assessed incorporation of the Four Moments for each unit improved over the course of the Acute Care Cohort. At beginning of intervention periods (March–May), the administration of antibiotics in participating units correctly reflected the Four Moments for most of the reviewed items (>70%), except for the "planned duration of therapy documented in progress," which was only reported by 45 percent of the reviewed forms on average across units. Exhibit 32 shows the percentages of positive responses reported in the Team Antibiotic Review Form for each quarter. Percentages of positive responses continuously increased for all reviewed items from March–May to September–November, and the increase was statistically significant for "decision made to discontinue antibiotics" (4.3 percentage point increase, p=0.019), "planned duration of therapy documented in progress notes" (4.0 percentage point increase, p<0.001), "decision made to narrow antibiotics" (3.7 percentage point increase, p=0.036), "appropriate culture ordered" (2.9

percentage point increase, p<0.001), and "suspected/confirmed infection" (1.1 percentage point increase, p=0.007).

Appendix Exhibit B-3.1 summarizes the estimated percentage of positive responses for each intervention quarter, as well as the changes between quarters, for each reviewed item.

EXHIBIT 32: PERCENT OF POSITIVE RESPONSES REPORTED ON TEAM ANTIBIOTIC FORM BY INTERVENTION QUARTER

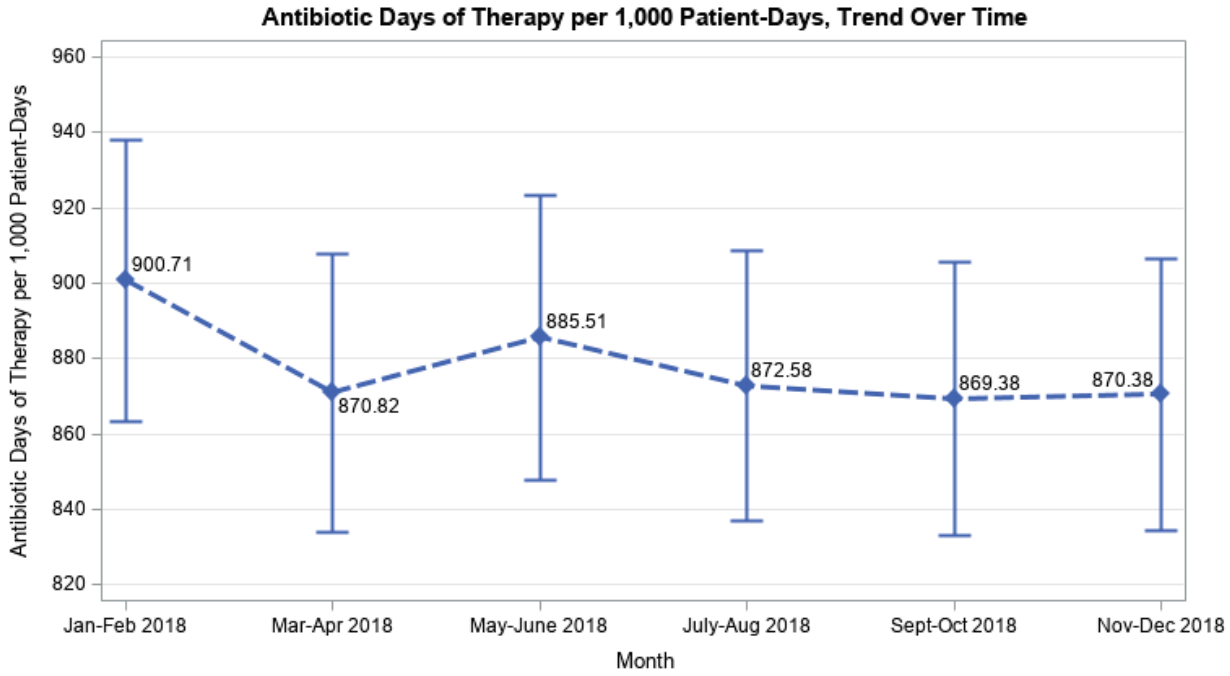


In a sensitivity analysis with 131 units from 117 hospitals that submitted at least 10 forms for all 9 months, the percentage of positive responses increased from March–May to September–November for "decision made to discontinue antibiotics" (9.9 percentage point change, p=0.001), and for "appropriate culture ordered" (4.0 percentage point increase, p<0.001). Appendix Exhibit B-3.2 summarizes the detailed findings from the sensitivity analysis.

3.5.5. Antibiotic Use

For the entire cohort, antibiotic DOT per 1,000 patient-days decreased by 30.3 (95% CI: -52.6 to -8.0, p=0.008), from 900.7 at baseline (January–February 2018) to 870.4 at end of intervention (November–December 2018). Exhibit 33 presents the bimonthly total DOT per 1,000 patient-days over time for all 50 antibiotics.

EXHIBIT 33: BIMONTHLY ANTIBIOTIC DAYS OF THERAPY PER 1,000 PATIENT-DAYS



- The reduction in total DOT per 1,000 patient-days from baseline was also statistically significant for other intervention periods:
    - March–April: -29.9 (95% CI: -45.4 to -14.3, p<0.001)
    - July–August: -28.1 (95% CI: -50.3 to -5.9, p=0.013)
    - September–October: -31.3 (-54.5 to -8.2, p=0.008)

When examining use by selected antibiotic class over time, we found a statistically significant reduction only among Fluoroquinolone (including ciprofloxacin, levofloxacin, moxifloxacin) use. Compared with baseline, DOT for fluoroquinolones per 1,000 patient-days decreased by 14.5 for March–April, 13.4 for May–June, 20.8 for July–August, 18.7 for September–October, and 20.4 for November–December, with all of these reductions statistically significant. Exhibits 34 and 35 present antibiotic use over time by select antibiotic subclass.

EXHIBIT 34: BIMONTHLY ANTIBIOTIC DAYS OF THERAPY PER 1,000 PATIENT-DAYS BY ANTIBIOTIC CLASS

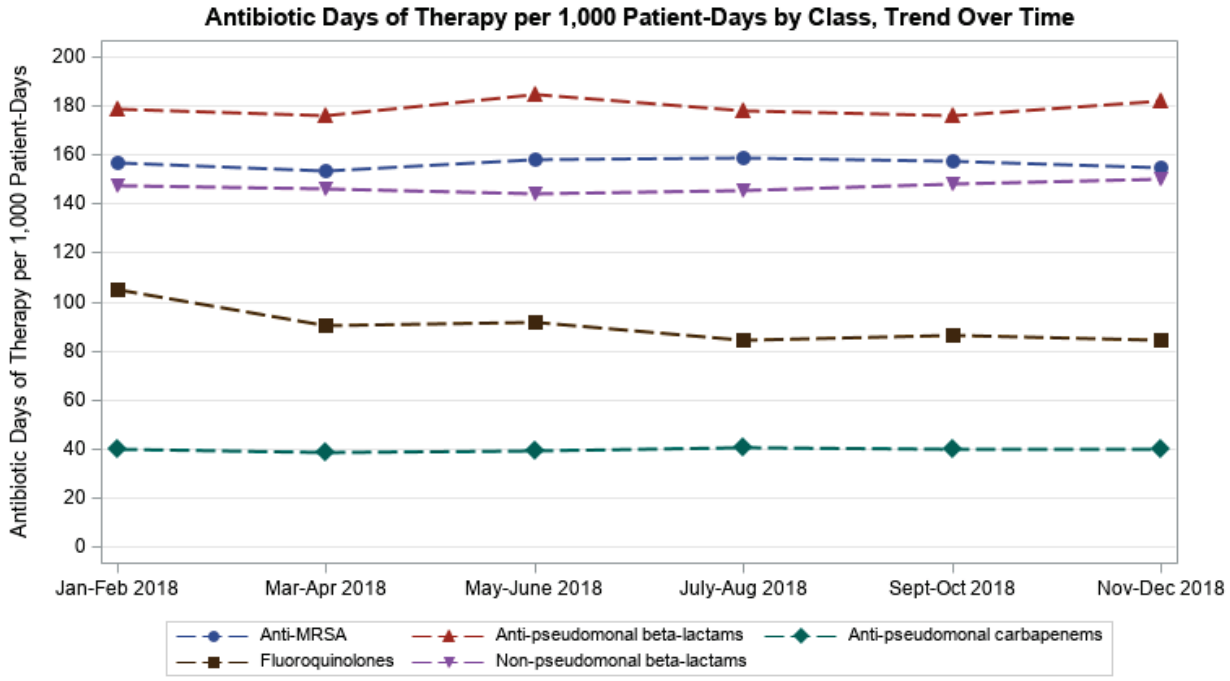


EXHIBIT 35: CHANGE IN DOT PER 1,000 PATIENT-DAYS BY ANTIBIOTIC CLASS COMPARED WITH JAN-FEB 2018

Antibiotic Class	Mar–Apr	May–June	July–Aug	Sept–Oct	Nov–Dec
Total for all 50 antibiotics	-29.9 ***	-15.2	-28.1 *	-31.3 **	-30.3 **
Total for 14 antibiotics in shortlist	-23.3 ***	-10.1	-21.4 *	-21.6 *	-18.5 *
Anti-MRSA (4 antibiotics)	-3.3	0.8	1.6	0.4	-2.2
Anti-pseudomonal beta-lactams (4 antibiotics)	-3.2	6	-1.1	-2.7	3.2
Anti-pseudomonal carbapenems (2 antibiotics)	-1.3	-0.9	0.5	-0.1	-0.2
Fluoroquinolones (3 antibiotics)	-14.5 ***	-13.4 ***	-20.8 ***	-18.7 ***	-20.4 ***
Non-pseudomonal beta-lactams (3 antibiotics)	-1.2	-2.9	-1.7	0.9	3.1

Note: 389 units from 329 hospitals contributed to the antibiotic class analysis. Antibiotic class analysis included all 14 antibiotics collected in the shortlist template and another two antibiotics collected in the full template only. Linear mixed model was used to generate the estimate, with random hospital unit effect and repeated measurement over time; and bimonth as the independent variable.

* denotes p-value<0.05; ** denotes p-value<0.01; *** denotes p-value<0.001.

Change in antibiotic use over time varied by hospital and unit type. Exhibit 36 presents changes from baseline (January–February 2018) to each bimonth period during the intervention (March–December 2018) for each hospital and unit characteristics.

- Total DOT per 1,000 patient-days reduced significantly from baseline to end of intervention for:
  - Units from non-AMC hospitals: -28.1 (95% CI: -52.2 to -3.9, p=0.023)
  - Units from nonteaching hospitals: -39.2 (95% CI: -69.6 to -8.8, p=0.011)
  - Units from noncritical-access hospitals (CAHs): -26.0 (95% CI: -49.1 to -2.9, p=0.028)
  - Units from hospitals with at least 300 beds: -42.8 (95% CI: -78.0 to -7.6, p=0.017)
  - Units from hospitals not compliant with four key components of ASPs at baseline: -28.0 (95% CI: -52.0 to -3.9, p=0.023)

- The reductions in DOT per 1,000 patient-days were significantly significant from baseline to at least two other intervention periods among:
    - Units from non-AMC hospitals: March–April (-28.3), July–August (-30.6), and September–October (-31.7)
    - Units from nonteaching hospitals: March–April (-24.2), July–August (-41.4), and September–October (-39.6)
    - Units from non-CAHs: March–April (-33.7), and September–October (-28.1)
    - Units from hospitals not compliant with four key components of ASPs at baseline: March–April (-29.4), July–August (-26.0), September–October (-29.9)
    - ICUs: March–April (-48.4), May–June (-52.4), and September–October (-57.4)

EXHIBIT 36: CHANGE IN DOT PER 1,000 PATIENT-DAYS COMPARED WITH JAN-FEB 2018

Hospital and Unit Characteristic	# Units	Mar–Apr	May–June	July–Aug	Sept–Oct	Nov–Dec
Overall	(n=352)	-29.9 ***	-15.2	-28.1 *	-31.3 **	-30.3 **
Hospital type						
AMC	(n=41)	-41.8 *	6.5	-9.5	-27.6	-46
Non-AMC	(n=311)	-28.3 **	-18.1	-30.6 *	-31.7 *	-28.1 *
Non-AMC teaching hospital	(n=102)	-36.3 **	-22	-8.4	-15.7	-5.8
100–299 beds	(n=46)	-59.6 ***	-12.9	-22	-2.1	-20.1
300 or more beds	(n=51)	-26.4	-43	-8.5	-39.8	-12.4
Non-teaching hospital	(n=209)	-24.2 *	-15.9	-41.4 **	-39.6 *	-39.2 *
Less than 100 beds	(n=122)	-33.4	-12.1	-50.5 *	-41.8	-36.3
100–299 beds	(n=57)	-39.3 **	-30	-18.8	-42.2	-37.3
300 or more beds	(n=30)	12.6	-9.9	-42	-27.4	-62.1
Critical access hospital (CAH)	(n=58)	-10.7	11	-60.3	-47.4	-51.2
Non-CAH	(n=294)	-33.7 ***	-20.3	-21.8	-28.1 *	-26.0 *
Hospital bed size						
Less than 100 beds	(n=133)	-25.5	-3	-42.4 *	-31.4	-24.5
100–299 beds	(n=107)	-45.8 ***	-17	-19.5	-23.2	-24.7
300 or more beds	(n=112)	-19.9	-28.2	-19.5	-39.1 *	-42.8 *
Hospital compliance with 4 key components of ASPs						
Yes	(n=40)	-33.9	-36.7	-44.8	-43.0	-49.6
No	(n=312)	-29.4 ***	-12.5	-26.0 *	-29.9 **	-28.0 *
Unit type						
ICU	(n=122)	-48.4 ***	-52.4 **	-33.3	-57.4 *	-39.2
Med or surg or med/surg floor	(n=220)	-19.8	4.3	-24.7	-16.6	-22.9

Note: 352 units from 295 hospitals contributed to this analysis. A linear mixed model was used to generate the estimate, with a random hospital unit effect and repeated measurement over time. The entire cohort model includes bimonth as the independent variable; each stratified model includes bimonth variable, stratified variable, and their interaction terms as the independent variables. Findings were not presented for units from non-AMC teaching hospitals with less than 100 beds due to small subgroup sample size (n=5), or for units in other types due to heterogeneity within the subgroup and small sample size (n=10).
* denotes p-value<0.05; ** denotes p-value<0.01; *** denotes p-value<0.001.

Exhibits 37-A and 37-B present the variation in antibiotic use by hospital type, hospital bed size, and unit type.

EXHIBIT 37-A: BIMONTHLY ANTIBIOTIC DAYS OF THERAPY PER 1,000 PATIENT-DAYS BY HOSPITAL TYPE

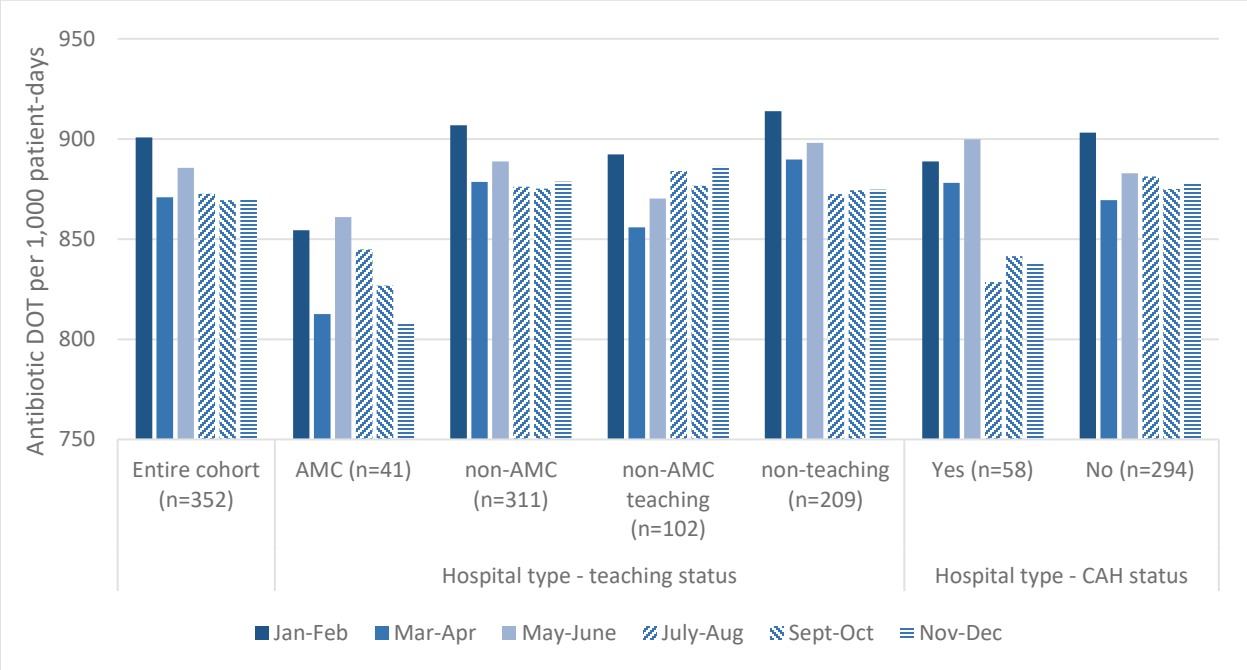
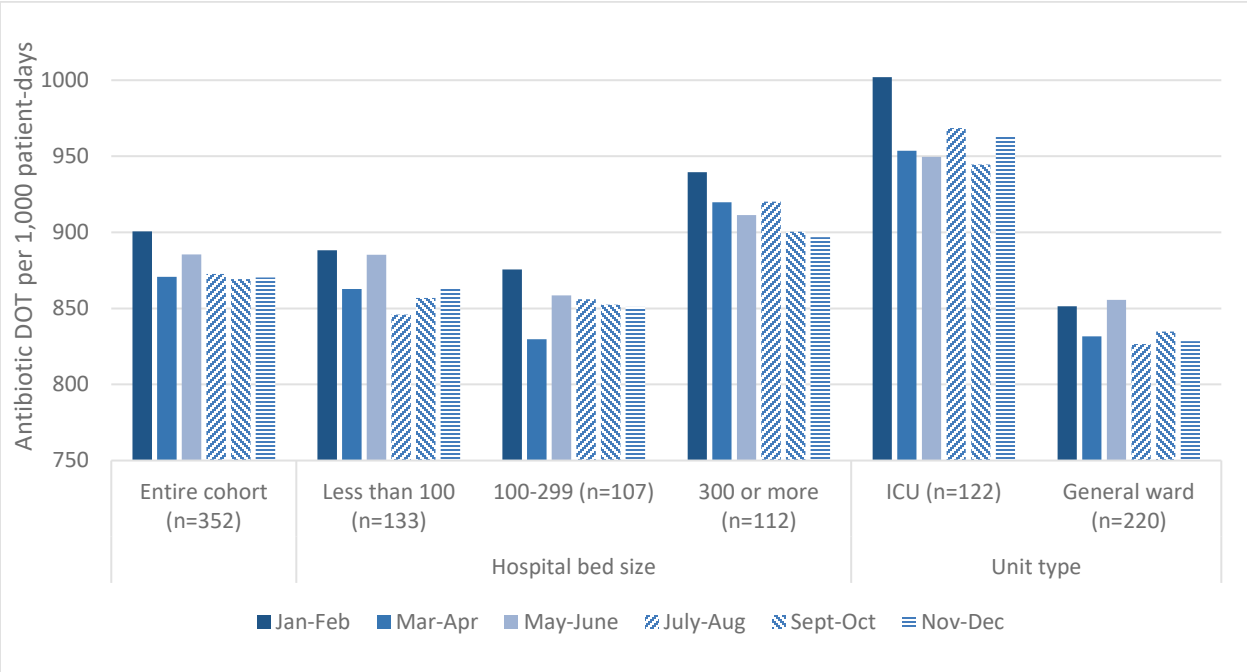


EXHIBIT 37-B: BIMONTHLY ANTIBIOTIC DAYS OF THERAPY PER 1,000 PATIENT-DAYS BY HOSPITAL BED SIZE AND UNIT TYPE



Sensitivity analysis showed a similar antibiotic use pattern as the main analysis:

- DOT per 1,000 patient-days for the 14 antibiotics on the shortlist: The total DOT per 1,000 patient-days for antibiotics on the shortlist decreased by 18.5 (95% CI: -36.2 to -0.8, p=0.041)

from 624.2 at baseline (January–February) to 605.7 at end of intervention (November–December). The reductions in antibiotic use were also significant from baseline to three other intervention periods March–April (-23.3, p<0.001), July–August (-21.4, p=0.010) and September-October (-21.6, p=0.017).

- Units with valid data for all 12 months: The total DOT per 1,000 patient-days fell by -29.2 (95% CI: -52.6 to -5.9, p=0.014) from 891.5 at baseline (January–February) to 862.3 at end of intervention (November–December). The reductions in antibiotic use were also statistically significant from baseline to March–April (-31.8, p<0.001), and September–October (-26.7, p=0.031).

Appendix Exhibits B-4.1 and B-4.2 summarize the detailed findings from the sensitivity analysis.

Unlike the Safety Program, analysis of the weighted Premier data showed no significant changes in overall antibiotic use among Premier hospital units during any bimonth intervention period compared to the January–February baseline period. Total DOT per 1,000 patient-days decreased by -9.0 (95% CI: -44.4 to 26.4, p=0.62) from 648.3 in January–February to 639.3 in November–December for the Premier sample. Appendix Exhibits B-4.3 and B-4.4 summarize the detailed findings from the analysis with Premier data.

3.5.6. C. difficile LabID Events

Many participating units reported zero *C. difficile* LabID events. For the entire cohort, the estimated number of *C. difficile* LabID events per 10,000 patient-days were 6.3 for Q1, 5.2 for Q2, 6.0 for Q3, and 5.1 for Q4. The decrease in the incidence rate was statistically significant from Q1 to Q2 (17.3%, 95% CI: -29.8% to -2.6%, p=0.023), and from Q1 to Q4 (19.5%, 95% CI: -33.5% to -2.4%, p=0.027). However, the incidence rate did not decrease from Q1 to Q3.

Our sensitivity analysis included 296 units from 244 hospitals who submitted data for all four quarters showed similar patterns as the main analysis. The estimated numbers of *C. difficile* LabID events per 10,000 patient-days were 6.5 for Q1, 5.2 for Q2, 6.1 for Q3, and 5.2 for Q4. The decrease in the incidence rate was statistically significant from Q1 to Q2 (20.3%, 95% CI: -32.8% to -5.5%, p=0.009), and from Q1 to Q4 (20.9%, 95% CI: -35.4% to 3.2%, p=0.023).

3.6 Limitations

The Acute Care Safety Program had several limitations:

A reduction in overall antibiotic use was observed in the first 2 months of the Safety Program and it was sustained throughout the subsequent 10 months. The reduction in antibiotic use was also observed for all subgroups (i.e., by hospital type, size, baseline AS infrastructure, and unit type), though some of them were not statistically significant. This may be partially due to the reduced sample size in the subgroups (e.g., CAHs).

Although we would like to fully attribute the decrease in antibiotic use to the success of the Safety Program, there are other possible explanations for this observation including the following: (1) the

influence of seasonal trends, (2) expected secular trends, or (3) inaccuracies with submitted antibiotic use data, each of which is described in further detail below. As the Safety Program was a quality improvement initiative and not a research study, we limited data collection to information that would directly be useful in improving local antibiotic prescribing practices. We did not want to discourage resource-limited hospitals (e.g., rural hospitals, critical access hospitals) that are traditionally excluded from large quality improvement initiatives from participating by requesting data that would be overly onerous to obtain. As such, we did not collect antibiotic use data in the year prior to the Safety Program to serve as a comparison.

Seasonal trends have been shown to be an important determinant of rates of antibiotic prescribing. More specifically, antibiotic use increases in the winter months. Suda and colleagues investigated antibiotic prescriptions in the United States over a 5-year period and found that they were almost 25 percent higher in winter months (defined as the first and last quarters of each year) compared with summer months.[11] Similarly, an evaluation of antibiotic consumption in British Columbia over a 4-year period revealed that antibiotic use during quarters 1 and 4 were 22 percent greater than quarters 2 and 3.[12] Although seasonal trends may have influenced the high antibiotic prescribing rate observed in January-February in the Safety Program, as both the beginning (i.e., January–February) and the end (i.e., November–December) of the Safety Program occurred in winter months, seasonality was unlikely to have factored prominently into our findings. Moreover, we do not have evidence from the published literature suggesting that antibiotic use in January–February is expected to be higher than November–December.[13,14,15,16,17]

Because of the ecological study design, it remains unknown if the significant decreases in overall antibiotic usage during the course of the Safety Program were reflective of secular trends. With a growing understanding of the need for judicious antibiotic prescribing due to public health campaigns emphasizing increasing rates of antibiotic resistance, an upsurge in both the lay and scientific literature focusing on antibiotic-associated harm, a broadening of the evidence base indicating shorter durations of therapy than historically prescribed are safe and effective, and increased recommendations for judicious antibiotic prescribing for common indications, it is possible that antibiotic use would have naturally decreased in the participating hospitals independent of implementation of the Safety Program. Therefore, we acquired antibiotic use data from Premier Healthcare Database to construct a comparison group with similar characteristics to the hospitals in the Safety Program acute care cohort; however, major methodological issues with Premier data precluded an apples-to-apples comparison with the Safety Program participating units. For example, data for the Safety Program Acute Care Cohort were extracted from their EHR systems or downloaded from their NHSN portal by each site, while data for Premier Hospitals were extracted from their claims database. Also, the Premier data extract we received contained limited information on hospital (and hospital unit) characteristics. In addition, comparing units from the Premier data with those participating in the Safety Program revealed substantial differences between the two samples in the limited number of observed characteristics—a comparison that was further constrained by the limited baseline observations available for the Safety Program sample.

As we were unable to identify a suitable control group to investigate this hypothesis further, we explored studies in the literature to understand if antibiotic use has followed a decreasing trend over the past several years. Baggs and colleagues evaluated antibiotic use across over 300 U.S. hospitals using the Truven Health MarketScan Hospital Drug Database from January 2006 to December 2012 and did not observe decreases in overall antibiotic use during this 7-year period.[18] Goodman and colleagues performed an almost identical analytic approach as Baggs et al. using the Premier Healthcare Database between January 2016 and December 2017 to investigate antibiotic usage data across 576 U.S. hospitals.[19] They found that total antibiotic consumption was no different from antibiotic use data published almost a decade earlier by Baggs and colleagues. Although these data do not negate the possibility of secular trends influencing our outcomes, they do not provide strong support for the narrative that antibiotic use was expected to naturally decline over the 2018 calendar year. And, perhaps to the contrary, with the recommendation of The Surviving Sepsis Campaign Bundle: 2018 Update that all elements of the Severe Sepsis/Septic Shock Early Management Bundle (i.e., SEP-1) be initiated within 1 hour of emergency department presentation, it is plausible that antibiotic use would be anticipated to gradually increase over the 2018 year.[20]

Finally, we cannot discount the possibility of inaccuracies with antibiotic data collected and submitted by participating sites. The number of hospitals enrolled and our lack of access to protected health information precluded our ability to ensure the integrity of antibiotic use data submitted from hospitals or an evaluation of "appropriate" antibiotic use. Nonetheless, several rigorous steps were followed to maximize the likelihood of valid data submission. At the beginning of the Safety Program an informational Webinar was held to assist sites with step-by-step instructions regarding antibiotic data collection. Only antibiotic administration data and not purchasing data were allowed to be submitted. For sites with electronic health records who were unfamiliar with how to extract antibiotic use data, they were connected to other sites enrolled in the Safety Program who had successfully navigated the same electronic health record system to access their antibiotic use data. Furthermore, a standardized template (that could not be modified) with detailed instructions was distributed to sites for collecting and uploading data. The quality improvement expert assigned to each hospital worked closely with each site through at least monthly contact to trouble shoot any data collection issues. Finally, if sites reported antibiotic use rates that were either much higher or lower than would be expected, suggesting an error in collection of the numerator or denominator, they were contacted to confirm that standardized practices were used to obtain data collection and sites were requested to re-extract data if necessary.

Other evaluation limitations include variation in the accuracy of self-assessments of antibiotic stewardship infrastructure and the representativeness of respondents to the HSOPS surveys. A potential limitation of using generalized mixed models for *C. difficile* outcome is that the conclusion depends in part on the distributional assumption for the outcome, which increases the risk in mis-specifying the model and hence introducing bias to the parameter estimates. The overdispersion in Poisson model would not affect the conditional mean or contrast, but would affect the estimated standard error. The random effects in the model were able to take the overdispersion into account to some extent. A sensitivity test using a negative binomial model without random hospital unit effects showed similar findings: 18.7 percent and 17.0 percent statistically significant reductions in *C. difficile* incidence rate for Q2 and Q4 compared with Q1.

CHAPTER 4: CONCLUSION

Chapter Summary

Strong recommendations for antibiotic stewardship programs (ASPs) in the acute care setting have expanded to include the Veterans Health Administration, The Joint Commission, the Office of Rural Health Policy, and the President's Council of Advisors on Science and Technology. The Centers for Medicare & Medicaid Services required hospitals—including critical access hospitals—to implement antibiotic stewardship programs by March 30, 2020, as a condition of participation. Hospitals that have not yet established ASPs will likely include large numbers of resource-limited hospitals, similarly to many that participated in the Safety Program. The Safety Program was able to demonstrate that establishing ASPs and training frontline clinicians can improve antibiotic use—even in hospitals without electronic health record software or without infectious diseases–trained physicians or pharmacists. In fact, we were able to train clinicians—often staff pharmacists—with becoming stewardship leaders in their facilities and with successfully implementing practices that improved antibiotic prescribing and reduced patient harm. As all content from the Safety Program is publicly available, we believe that utilizing Safety Program resources provides exciting opportunities for hospitals across the United States seeking to establish or strengthen existing ASPs and to teach frontline clinicians to become "self-stewards" of their own antibiotic use.

4.1. Sustainability

During the Acute Care Cohort, Johns Hopkins Medicine/NORC at the University of Chicago (JHM/NORC) developed a range of strategies to help participating sites develop plans to sustain the Stewardship Program they established beyond the formal 1-year Safety Program. Specific content developed includes a Webinar titled "Sustaining Stewardship Activities" and a Gap Analysis Tool to assist sites with internal determining what resources they currently have and what additional resources might be of benefit to them to continue to see positive results with their local ASP.

The Safety Program materials remain available to the sites through the project Web site through August 2019; thereafter, the materials will be posted and available to the public on the AHRQ Web site with release of the Acute Care Safety Program Toolkit.

4.2. Lessons Learned

The AHRQ Safety Program for Improving Antibiotic Use is a complex, national quality improvement collaborative. The goals for the Acute Care Cohort were twofold. The first goal was to develop or improve ASPs in hospitals across the country. The second goal was to improve the use of antibiotics at the provider level—to ascertain whether a bacterial infection requiring antibiotics is present, collect appropriate cultures as needed, choose appropriate empiric therapy, re-evaluate the need for antibiotics on a regular basis, and choose the appropriate duration of therapy, all while fostering teamwork and communication among health-care workers.

The Acute Care Cohort demonstrated the efficacy of a large-scale, national program on AS for acute care hospitals. From hospital recruitment to curriculum refinement, the AHRQ Safety Program for Improving Antibiotic Use provided hospital units with novel training opportunities and a platform to implement the Four Moments of Antibiotic Decision Making framework. As with any large, complex initiative, implementation of the Acute Care Cohort yielded numerous lessons for the field. The Safety Program highlights the following challenges faced during the execution of the Acute Care Cohort, and ways to mitigate these implementation issues going forward:

- Recruitment – While the Acute Care Cohort was successful in meeting the target enrollment goals (476 hospitals), enrollment took time to ramp up. We employed a multipronged approach in the recruitment process, including eight Informational Webinars open to all comers, and engaging with Hospital Improvement Innovation Networks (HIINs), hospital associations, The Joint Commission, the Institute for Healthcare Improvement, and others to assist with recruitment efforts. JHM/NORC also reached out to the three health-care systems that had participated in the pilot—Geisinger Health System, Johns Hopkins Health System, and Atrium Health—as well as other health-care systems that had not been part of the pilot. In addition, JHM/NORC leveraged the free social media of AHRQ, Centers for Medicare & Medicaid Services' HIINs, and Johns Hopkins Medicine to recruit acute care hospitals (e.g., via LinkedIn, Twitter, and Facebook).
- Site selection and organizational capacity – We recruited and enrolled a wide spectrum of hospital sizes for the Acute Care Cohort, ranging from large, academic hospitals to small critical access hospitals. Many of the smaller hospitals struggled with implementation due to small staff size. Leaders of the program at some sites also had difficulty obtaining staff buy-in. These issues were addressed during several of the Informational Webinars and at Office Hours. In addition, the Implementation Advisers worked with sites to help them problem solve and overcome barriers.
- Data collection burden, Days of therapy (DOT) and *Clostridioides Difficile* (*C. difficile*) laboratory-identified events – There were two primary issues around collecting these data. Some smaller hospitals lacked capacity to complete antibiotic DOT data collection due to the large number of antibiotics requested by the JHM/NORC team. To ease the burden on these smaller sites, the Safety Program provided a truncated list of antibiotics. Additionally, some sites had difficulty extracting data from their EHR system. Fortunately, JHM/NORC discovered that several sites used the same EHR vendor, and these peer organizations were able to share the appropriate extraction codes needed to obtain the necessary data.

Despite those implementation challenges, the Acute Care Cohort engaged acute care hospitals and demonstrated meaningful changes in safety culture. This strategy led, in turn, to promising outcomes in terms of antibiotic use and *C. difficile* rates, among other key outcomes.

APPENDIXES

Appendix A-1. Technical Expert Panel Members

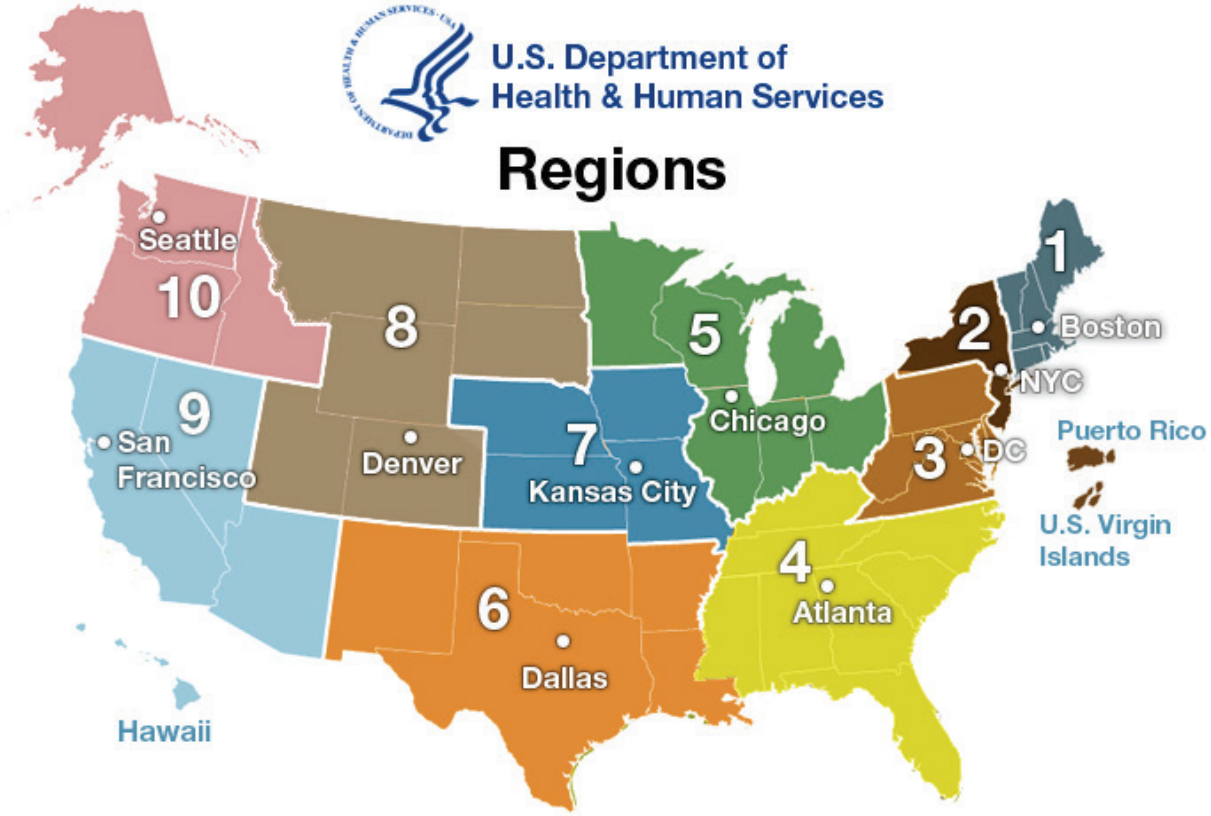
Name	Title	Affiliation	Representation
Elizabeth Dodds-Ashley, Pharm.D.	Antibiotic Stewardship Pharmacist	Duke Antimicrobial Stewardship Outreach Network	Acute Care Setting
Neil Fishman, M.D.	Associate Chief Medical Officer, Chief Patient Safety Officer	University of Pennsylvania	Acute Care Setting
Kristi Kuper, Pharm.D.	Antibiotic Stewardship Pharmacist	Vizient, Inc.	Acute Care Setting
Andrew Morris, M.D., SM(Epi), FRCPC	Medical Director, Antimicrobial Stewardship Program	Sinai Health System/University Health Network	Acute Care Setting
Jeffrey Gerber, M.D., Ph.D.	Assistant Professor of Pediatrics, Director of Antimicrobial Stewardship	Children's Hospital of Philadelphia	Ambulatory Care Setting
Daniella Meeker, Ph.D.	Assistant Professor of Preventative Medicine	University of Southern California	Ambulatory Care Setting
Julia Szymczak, Ph.D.	Medical Sociologist	Dept. of Epidemiology and Biostatistics, University of Pennsylvania	Ambulatory Care Setting
Marjory Cannon, M.D.	Medical Director, Quality Improvement Group Centers for Clinical Standards and Quality	Centers for Medicare & Medicaid Services	Ex-Officio
James Cleeman, M.D.	Director, Division of Healthcare-Associated Infections	AHRQ Center for Quality Improvement and Patient Safety	Ex-Officio
Shelly Coyle, R.N., M.S., M.B.A.		CMS/Center for Clinical Standards and Quality (CCSQ)	Ex-Officio
Kali Crosby, M.S.N., R.N., CIC	Nurse Consultant	AHRQ Center for Quality Improvement and Patient Safety	Ex-Officio
Lauri Hicks, D.O.	Director, Office of Antibiotic Stewardship	Centers for Disease Control and Prevention	Ex-Officio
Melissa Miller, M.D., M.S.	Medical Officer	AH/RQ Center for Quality Improvement and Patient Safety	Ex-Officio
Arjun Srinivasan, M.D.	Associate Director of HAI Prevention Programs	Centers for Disease Control and Prevention	Ex-Officio
Nimalie Stone, M.D., M.S.	Medical Epidemiologist for Long-Term Care	Centers for Disease Control and Prevention	Ex-Officio
Anita Thomas, Pharm.D.		CMS/Center for Clinical Standards and Quality (CCSQ)	Ex-Officio

Name	Title	Affiliation	Representation
Whitney Buckel, Pharm.D.	Infectious Disease Specialist	Intermountain Healthcare	Integrated Healthcare Delivery Systems
Lisa Davidson, M.D.	Medical Director, Antimicrobial Stewardship Network	Atrium Health	Integrated Healthcare Delivery Systems
Stanley Martin, M.D.	Director of Infectious Diseases	Geisinger Health System	Integrated Healthcare Delivery Systems
Edward Septimus, M.D., FACP, FIDSA, FSHEA	Infectious Disease Specialist	Memorial Hermann Southwest Hospital	Integrated Healthcare Delivery Systems
Linda Behan, B.S.N., R.N., CWCN, CIC	Corporate Director of Infection Prevention and Control	Genesis Health	LTC Setting
Joseph Marek, R.Ph., CGP, FASCP	Director of Pharmacy Services	CommuniCare Health Services, American Society of Consultant Pharmacists (ASCP)	LTC Setting
David Nace, M.D., M.P.H.	Director, Long-Term Care Program	University of Pittsburgh Medical Center	LTC Setting
Rita Olans, D.N.P., R.N., CPNP, APRN-BC	Assistant Professor, School of Nursing	MGH Institute of Health Professions	Nursing/Nurse Practitioner
Christian Lillis	Patient Advocacy Group	Peggy Lillis Foundation	Patient Representative

Appendix A-2. Stakeholder/Train-the-Trainer Meeting Attendees

Attendees	Organization
Melissa Miller	Agency for Healthcare Research and Quality
Deborah Smith	Health Quality Innovators
Jenni Brockman	
Katie Richards	
Sheila McLean	
Thelma Baker	
Andrea Silvey	Health Services Advisory Group, Inc.
Charlie Chapin	
Mary Andrawis	
Renee Rush	
Kathleen Speck	Johns Hopkins Medicine
Pranita Tamma	
Sara Cosgrove	
Prashila Dullabh	NORC at the University of Chicago
Roy Ahn	
Betsy Jeppesen	Stratis Health
Candy Hanson	
Jerri Hiniker	
Kristi Wergin	
Lisa Gall	
Marilyn Reierson	
Nancy Miller	

Appendix A-3. 10 HHS Regions and Number of Participating Hospitals by Region



HHS Region	States & Territories	Total Number of Participating Hospitals (after withdrawals)
1	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont	25
2	New Jersey, New York, Puerto Rico, and the Virgin Islands	24
3	Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, and West Virginia	31
4	Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee	56
5	Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin	62
6	Arkansas, Louisiana, New Mexico, Oklahoma, and Texas	80
7	Iowa, Kansas, Missouri, and Nebraska	45
8	Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming	29
9	Arizona, California, Hawaii, Nevada, U.S.-Affiliated Pacific Islands (American Samoa, Commonwealth of the Northern Mariana Islands, Federated States of Micronesia, Guam, Marshall Islands, and Republic of Palau)	29
10	Alaska, Idaho, Oregon, and Washington	21
	TOTAL	402

Appendix A-4. Online Application

Online Application Page One

AHRQ Safety Program for Improving Antibiotic Use

The Agency for Healthcare Research and Quality (AHRQ) created the AHRQ Safety Program for Improving Antibiotic Use in conjunction with Johns Hopkins University and NORC at The University of Chicago to develop and implement a bundle of technical and adaptive interventions designed to improve the use of antibiotics in acute care hospitals across the United States.

Antibiotics are a precious resource and can be critical for improving the outcomes of patients with serious infections. However, antibiotics also have the potential to cause patient harm including allergic reactions, *Clostridium difficile* infections, and antibiotic resistance both at the individual patient level and for society as a whole. It is important that antibiotics are available and effective for future generations and that is only possible through the judicious use of antibiotics.

Online Application Page Two

Potential Benefits of Participation
There are a number of benefits associated with participating in this program. Some of these include improved antibiotic usage and antibiotic decision-making. Expected outcomes include:

- Clinician teams trained to make wise antibiotic decisions
- A reduction in antibiotic usage
- An improved safety culture
- Enhanced teamwork and communication
- Improved patient, family, provider, and staff satisfaction
- Improved compliance with The Joint Commission Antimicrobial Stewardship Standard

Expectations From Participating Facilities

Identify team leaders at participating units to assist with overseeing work. For example, if a MICU is selected, team leaders may include a medical director, nurse leader, and pharmacist. If an Antibiotic Stewardship Team already exists at an acute care facility, the Antibiotic Stewardship Team will work closely with training the team leaders. If there is no existing Antibiotic Stewardship Team, we ask that the participating unit select a physician and/or pharmacist leader who would like to be trained in becoming an antibiotic stewardship leader.

Throughout the 12 months, the Antibiotic Stewardship Team, team leaders, and available frontline staff will participate in bimonthly or monthly calls that will include both content and coaching. These calls will include a formal discussion of technical or adaptive work to improve antibiotic prescribing and will also include open dialogue about successes and failures related to improving antibiotic use.

During both the 3-month base period and the 9-month intervention period, we will use data submitted from your electronic health record to collect monthly data on days of antibiotic therapy per 1,000 days present and quarterly data on rates of *Clostridium difficile* lab-events per 10,000 patient-days. During the 9-month intervention period, the Antibiotic Stewardship Team will review data on at least 10 patients receiving antibiotics with team leaders and/or frontline staff to determine if antibiotic use was appropriate.

Online Application Page Three

Please provide the following information about your facility (mandatory):

Legal Name of Facility
Street Address Line 1
Street Address Line 2
City
State
Zip Code
Hospital Web site URL address (optional):
Federal Provider ID number (mandatory):

In which Department of Health & Human Services region is your facility located:

_Region 1 (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont)
_Region 2 (New Jersey, New York, Puerto Rico, the Virgin Islands)
_Region 3 (Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, West Virginia)
_Region 4 (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee)
_Region 5 (Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin)
_Region 6 (Arkansas, Louisiana, New Mexico, Oklahoma, Texas)
_Region 7 (Iowa, Kansas, Missouri, Nebraska)
_Region 8 (Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming)
_Region 9 (Arizona, California, Hawaii, Nevada, American Samoa, Commonwealth of the Northern Mariana Islands, Federated States of Micronesia, Guam, Marshall Islands, Republic of Palau)
_Region 10 (Alaska, Idaho, Oregon, Washington)

Representative Contact Information (mandatory):
Representative Name:
Representative Title:
Representative Phone Number:
Representative Email:
Is your facility part of a larger health system? Y/N

If yes: What is the name of the health system?

If yes: We will ask you to sign a participation agreement and a data use agreement before starting the project. This will be signed by the primary facility contact person and the facility administrator. If there is another level of approval that is required by your facility to participate, e.g. a corporate officer, please provide that contact information:

Contact Name:

Contact Title:
Contact Email Address:
Contact Telephone Number:

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Do you have an electronic health record (EHR) in your facility? Y/N
If your facility does not have an electronic health record, we are happy to discuss ways we can work with your organization to collect data.

Who is your electronic health records vendor?
- Epic
- Cerner
- Meditech
- Siemens
- Allscripts
- Other (please describe)

How long have you been using this electronic health record?
Drop down menu:
< 6 months
6-12 months
> 12 months

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In a few sentences or paragraphs, please explain why you would like to participate in this project.

For more information on the AHRQ Safety Program for Improving Antibiotic Use, please visit:
https://safetyprogram4antibioticstewardship.org

If you have any questions about the project, please contact:
antibioticsafety@norc.org
https://safetyprogram4antibioticstewardship.org

SUBMIT APPLICATION

Appendix A-5. Sample Quarterly Benchmarking Report

Quarterly Benchmarking Report, 4th Quarter, October–December 2018

Facility: ABC Medical Center

Unit: Medical Unit

Hospital Benchmark: all participating units from Academic Medical Centers or Cancer Hospitals

Unit Benchmark: all participating Medical units/wards from all participating hospitals

As part of participation in the AHRQ Safety Program for Improving Antibiotic Use, your unit will receive quarterly benchmarking reports to compare your unit's progress to those of units in similar facilities.

This report contains individualized results from all the data submitted by your unit for the 1st, 2nd, 3rd, and 4th quarters (January–December 2018). It includes the following results for your unit:

- Baseline Structural Assessment (SA)
- Endline Structural Assessment (SA)
- 1st quarter antibiotic days of therapy (DOT)
- 2nd quarter antibiotic days of therapy (DOT)
- 3rd quarter antibiotic days of therapy (DOT)
- 4th quarter antibiotic days of therapy (DOT)
- 1st quarter C. difficile LabID events
- 2nd quarter C. difficile LabID events
- 3rd quarter C. difficile LabID events
- 4th quarter C. difficile LabID events
- March - May 2018 Team Antibiotic Review Forms
- June - August 2018 Team Antibiotic Review Forms
- September - November 2018 Team Antibiotic Review Forms

The report also includes aggregate data results from all participating units in similar facilities (Hospital Benchmark) and from similar units in all participating hospitals (Unit Benchmark). Both benchmarks include data available at the time of production of this report. The benchmarks and your unit's relation to these benchmarks may have changed from previous quarterly reports as more data from participating facilities has been included.

If your unit submitted: data that are not specific to your registered unit, incomplete quarterly data (e.g., missing data for one month), a denominator other than patient-days (e.g., days-present), and/or out-of-range data (low or high patient-days/rates in comparison to the benchmark), your unit's data will be excluded from the benchmark calculation as they are not directly comparable to benchmark data. Please see individual results below for more detail.

Please note that results from individual units will not be shared with other participating hospitals; the report only includes aggregate benchmark data from other hospitals. We welcome your feedback on the report. If you have any questions about the report, or the individual results from your unit, please contact your implementation adviser.

Structural Assessment

See program Web site for Structural Assessment Form.

The table below summarizes the data from the Baseline and Endline Structural Assessment forms submitted by your unit, as well as the data from all participating units from Academic Medical Centers or Cancer Hospitals, and Medical units/wards from all participating hospitals.

Assessment Items	Baseline Your Unit	Baseline Hospital Benchmark	Baseline Unit Benchmark	Endline Your Unit	Endline Hospital Benchmark	Endline Unit Benchmark
Number of hospital beds						
Number of unit beds						
Have experience using the CUSP approach before						
Have an existing antibiotic stewardship (AS) program						
Development of antibiograms						
Developed antibiotic-related educational modules						
Developed local antibiotic treatment guidelines						
Prior-approval of select antibiotics						
Post-prescription review for selected antibiotics						
Days of antibiotic therapy reported periodically to track antibiotic usage						
Have an antibiotic stewardship committee						

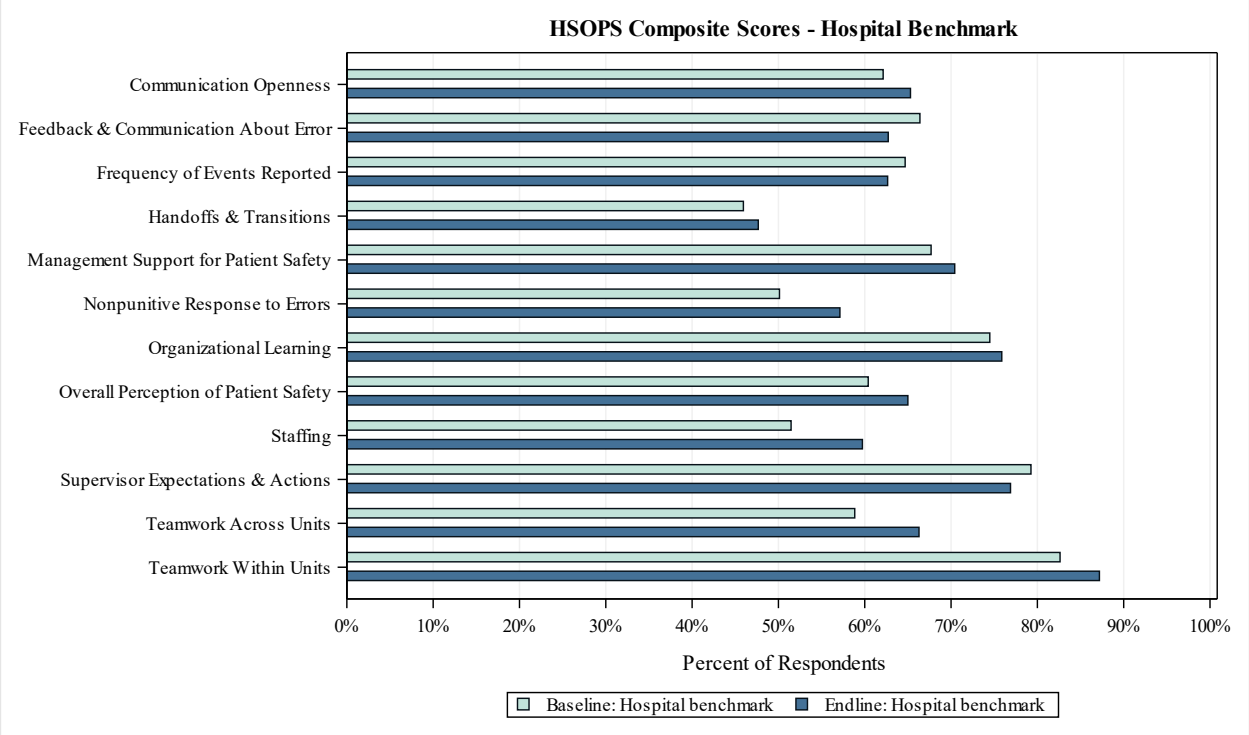
Hospital Survey on Patient Safety Culture (HSOPS)

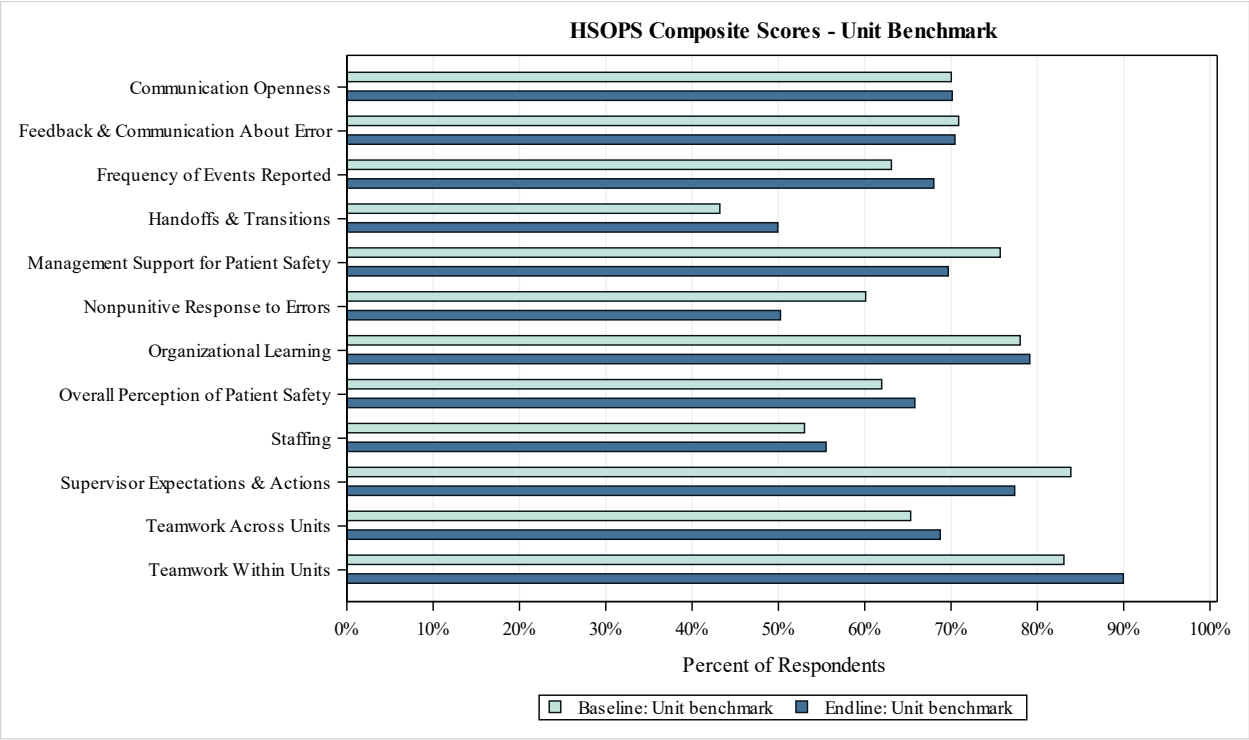
See program website for HSOPS questionnaire

The charts below provide the average composite Endline and Baseline scores among units in the hospital benchmark as well as units in the unit benchmark.

Please note that individual HSOPS results may not be displayed for the following reasons:

- If 5 or fewer respondents from your unit completed the survey, we are unable to present results
- The data submitted did not follow the AHRQ HSOPS data file specifications
- The HSOPS data submitted was hospital-level instead of unit-level

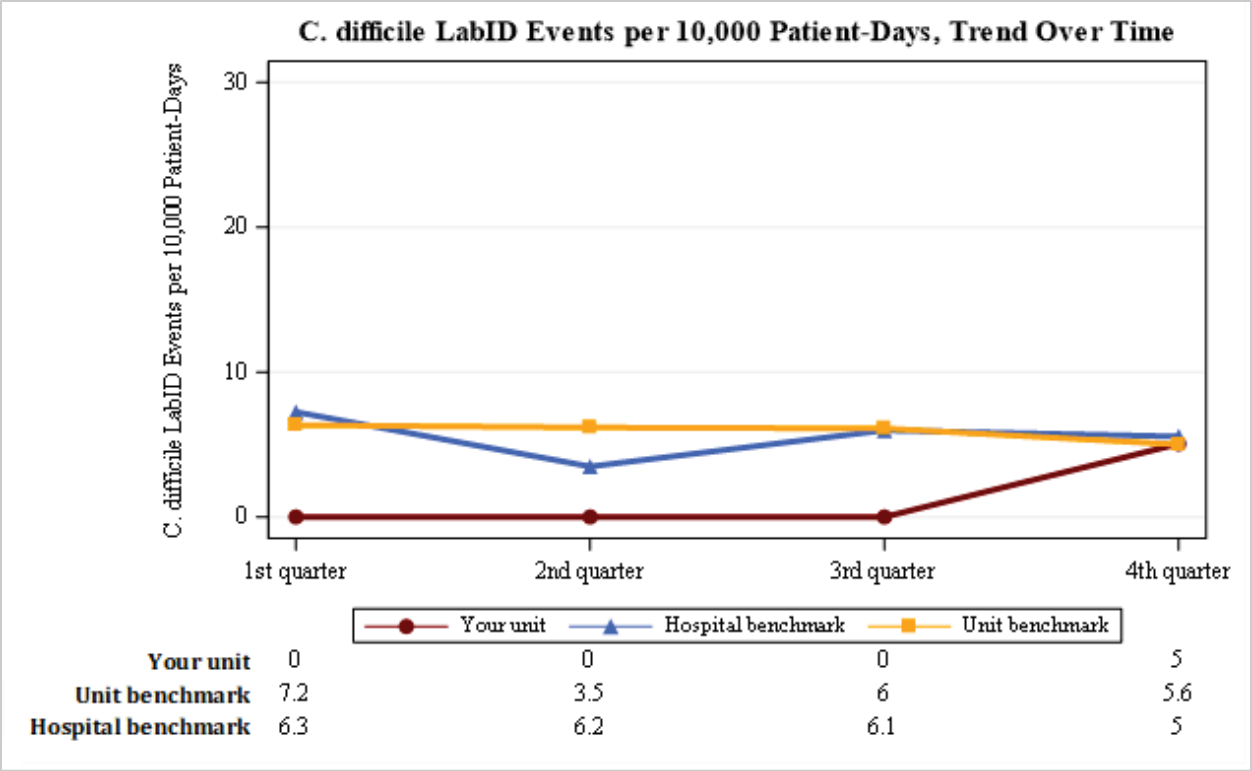




C. difficile LabID Events

C. difficile LabID events per 10,000 patient-days

The following figure shows the trend of number of C. difficile LabID events per 10,000 patient-days in your unit, all participating units from Academic Medical Centers or Cancer Hospitals, and Medical units/wards from all participating hospitals. The benchmark rates represent average rates across all included units.



The number of units submitting Q4 data for your unit's benchmarking cohorts are as follows:

- Hospital Benchmark: 160 units from 119 hospitals
- Unit Benchmark: 64 units from 59 hospitals

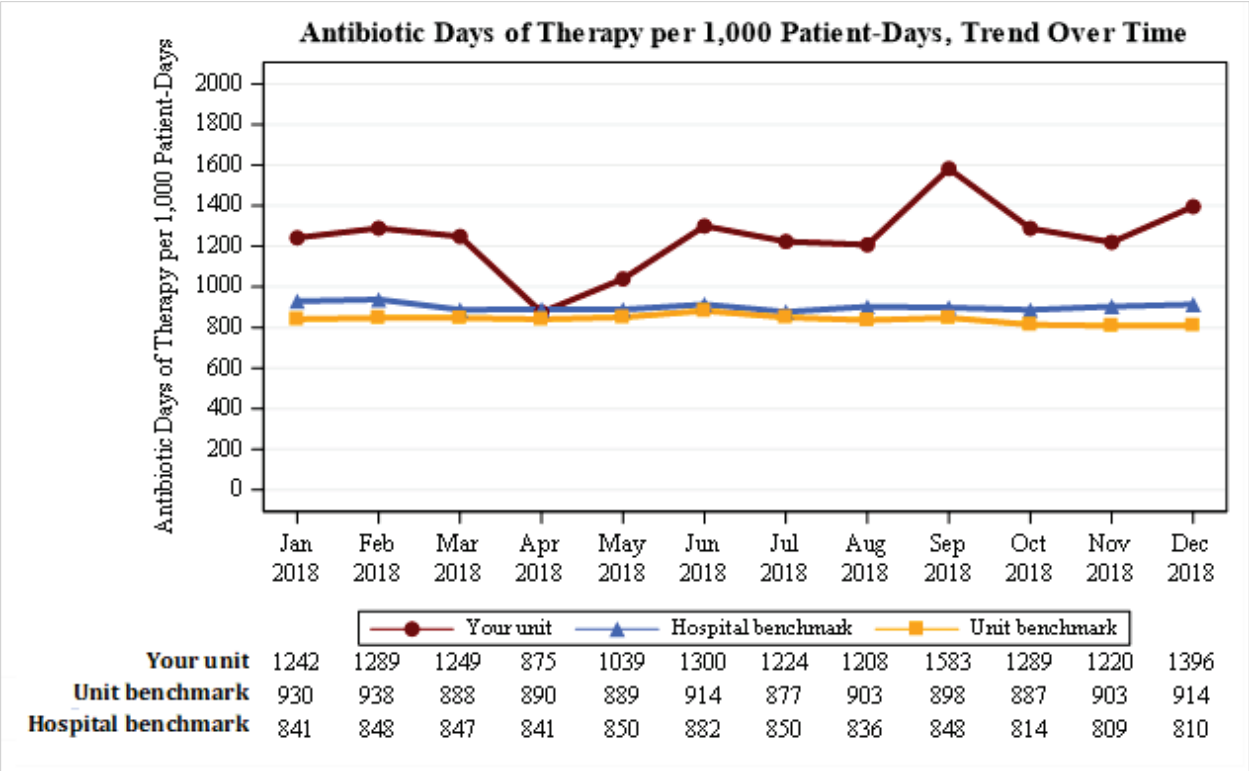
The following results compare your unit's rate to all rates in your unit's benchmark cohorts:

- Compared to individual units in your hospital benchmark, your unit's rate of C. difficile LabID events is lower than at least 750% percent of similar units.
- Compared to individual units in your unit benchmark, your unit's rate of C. difficile LabID events is lower than at least 750% percent of similar units.

Antibiotic Use Data

Antibiotic days of therapy (DOT) per 1,000 patient-days

The following figure shows the trend of monthly days of therapy per 1,000 patient-days in your unit, all participating units from Academic Medical Centers or Cancer Hospitals, and Medical units/wards from all participating hospitals. It includes data for all antibiotics reported by your unit. The benchmark rates represent an average rate across all included units.



	Jan 2018	Feb 2018	Mar 2018	Apr 2018	May 2018	Jun 2018	Jul 2018	Aug 2018	Sep 2018	Oct 2018	Nov 2018	Dec 2018
Your unit	1242	1289	1249	875	1039	1300	1224	1208	1583	1289	1220	1396
Unit benchmark	930	938	888	890	889	914	877	903	898	887	903	914
Hospital benchmark	841	848	847	841	850	882	850	836	848	814	809	810

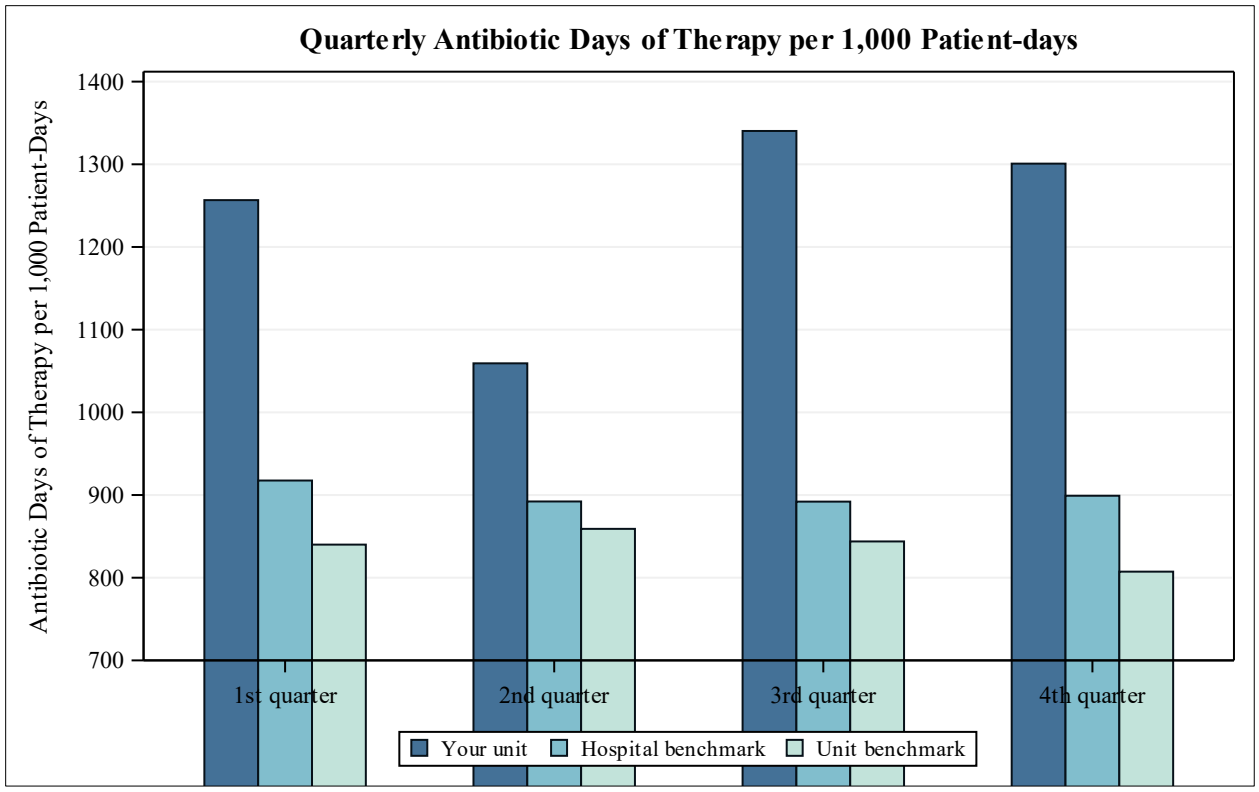
The number of units submitting Q4 data for your unit's benchmarking cohorts are as follows:

- Hospital Benchmark: 158 units from 122 hospitals
- Unit Benchmark: 66 units from 62 hospitals

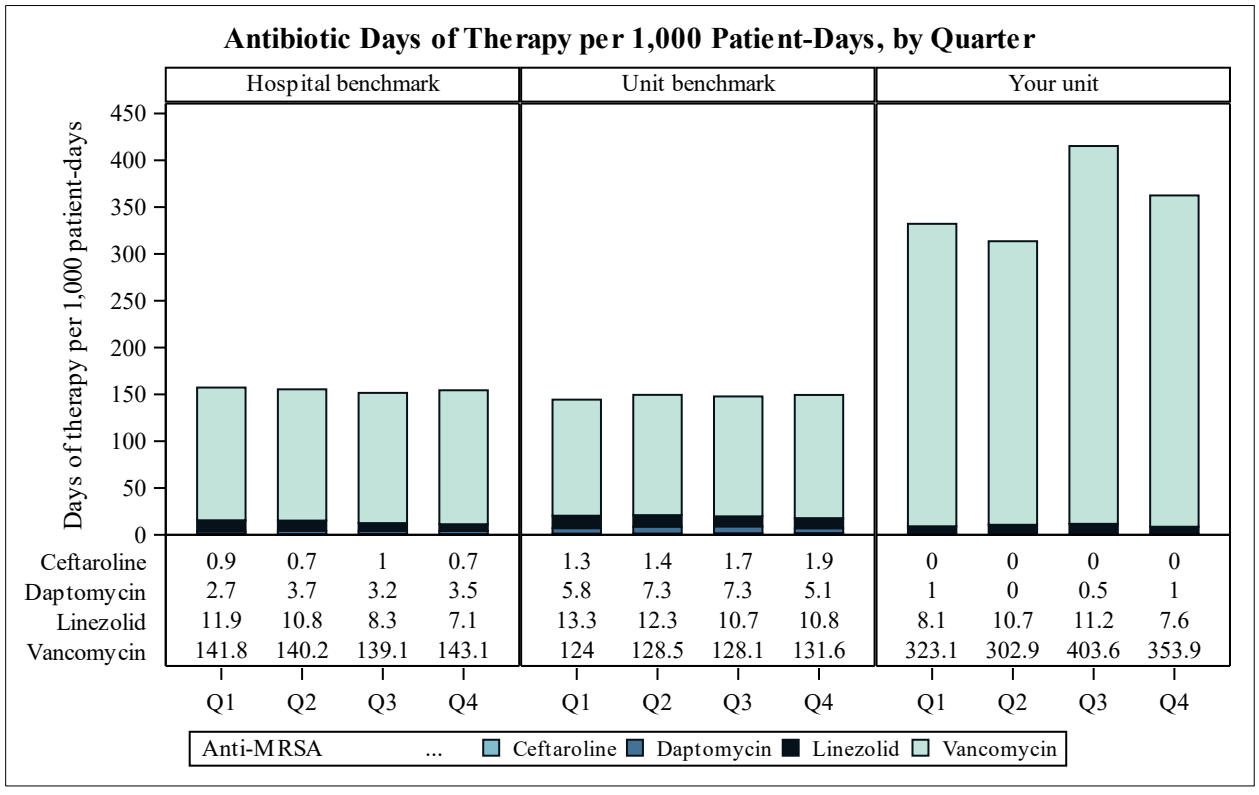
The following results compare your unit's rate to all rates in your unit's benchmark cohort:

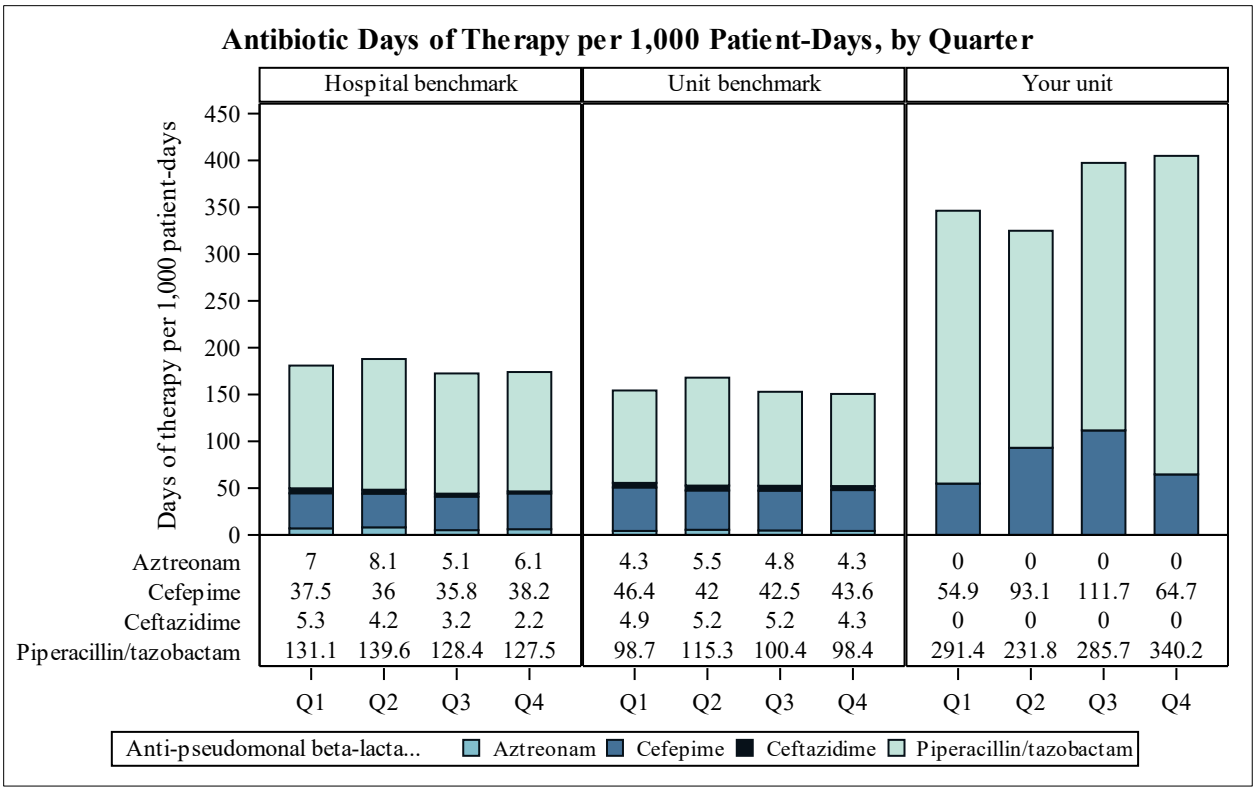
- Compared to individual units in your hospital benchmark, your unit's rate of days of therapy is higher than at least 75 percent of similar units.
- Compared to individual units in your unit benchmark, your unit's rate of days of therapy is higher than at least 75 percent of similar units.

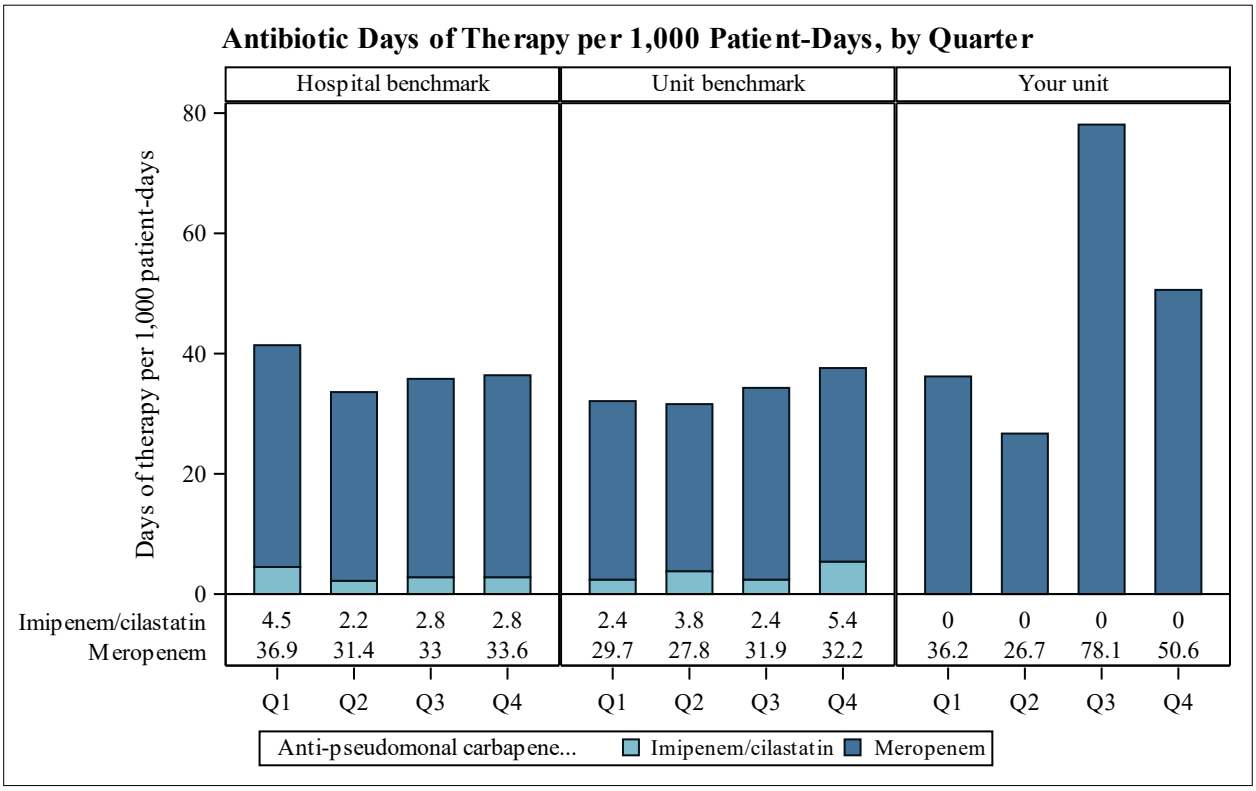
The figure below shows the quarterly antibiotic days of therapy per 1,000 patient-days from Q1 to each subsequent program quarter, for your unit and for the hospital and unit benchmarks, respectively. The benchmark rates represent an average rate across all included units.

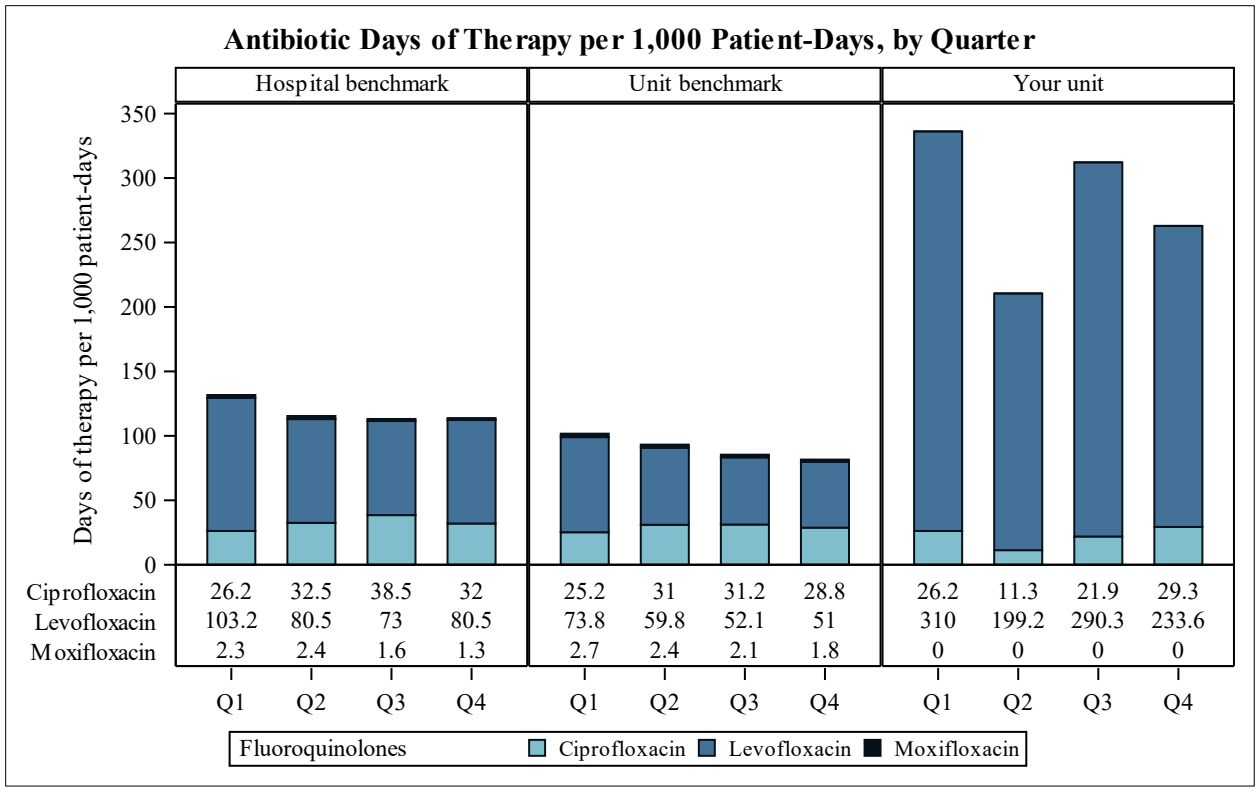


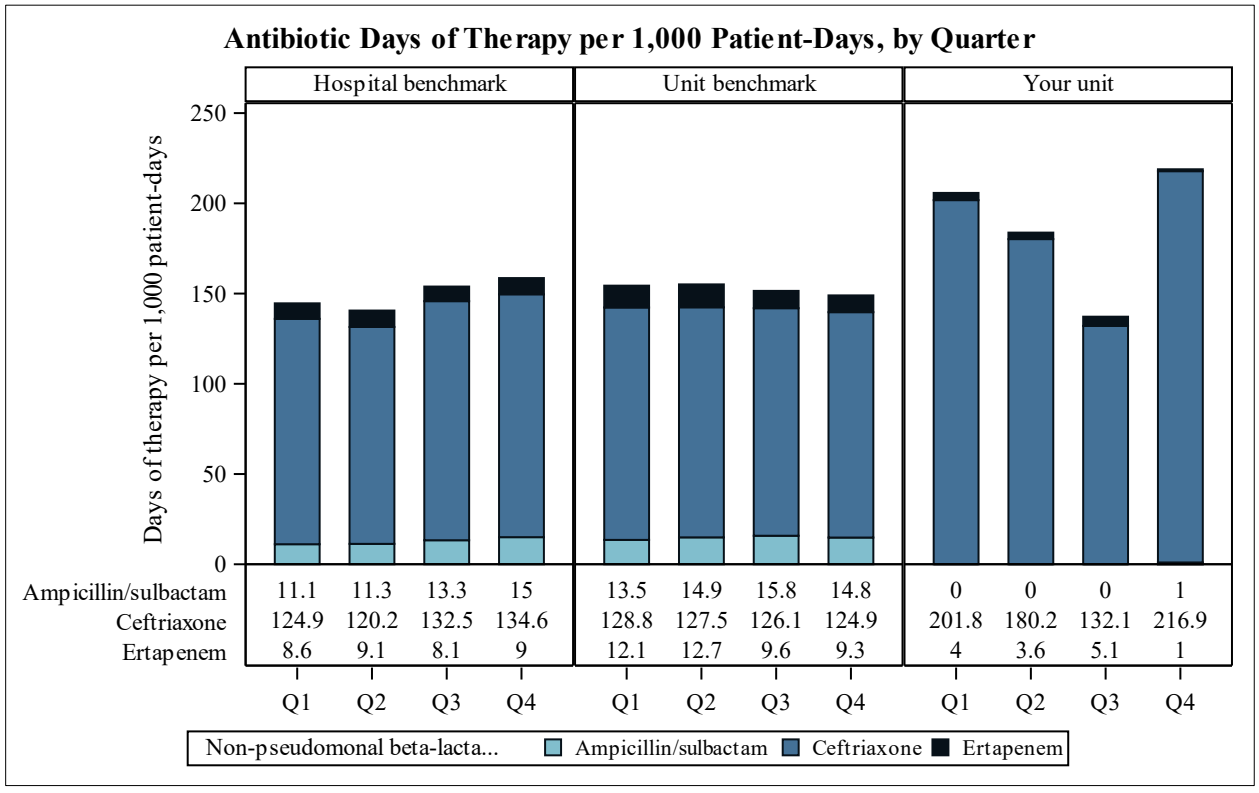
The following figures show the quarterly days of therapy per 1,000 patient-days for antibiotics in each of five drug classes of interest. Data are shown for the hospital benchmark, unit benchmark, and your unit.




Antibiotic Days of Therapy per 1,000 Patient-Days, by Quarter
Hospital benchmark
Unit benchmark
Your unit
Days of therapy per 1,000 patient-days
450
400
350
300
250
200
150
100
50
0
Aztreonam 7 8.1 5.1 6.1 4.3 5.5 4.8 4.3 0 0 0 0
Cefepime 37.5 36 35.8 38.2 46.4 42 42.5 43.6 54.9 93.1 111.7 64.7
Ceftazidime 5.3 4.2 3.2 2.2 4.9 5.2 5.2 4.3 0 0 0 0
Piperacillin/tazobactam 131.1 139.6 128.4 127.5 98.7 115.3 100.4 98.4 291.4 231.8 285.7 340.2
Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4
Anti-pseudomonal beta-lacta...
Aztreonam
Cefepime
Ceftazidime
Piperacillin/tazobactam


Antibiotic Days of Therapy per 1,000 Patient-Days, by Quarter
Hospital benchmark
Unit benchmark
Your unit
Days of therapy per 1,000 patient-days
80
60
40
20
0
Imipenem/cilastatin 4.5 2.2 2.8 2.8 2.4 3.8 2.4 5.4 0 0 0 0
Meropenem 36.9 31.4 33 33.6 29.7 27.8 31.9 32.2 36.2 26.7 78.1 50.6
Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4
Anti-pseudomonal carbapene...
Imipenem/cilastatin
Meropenem

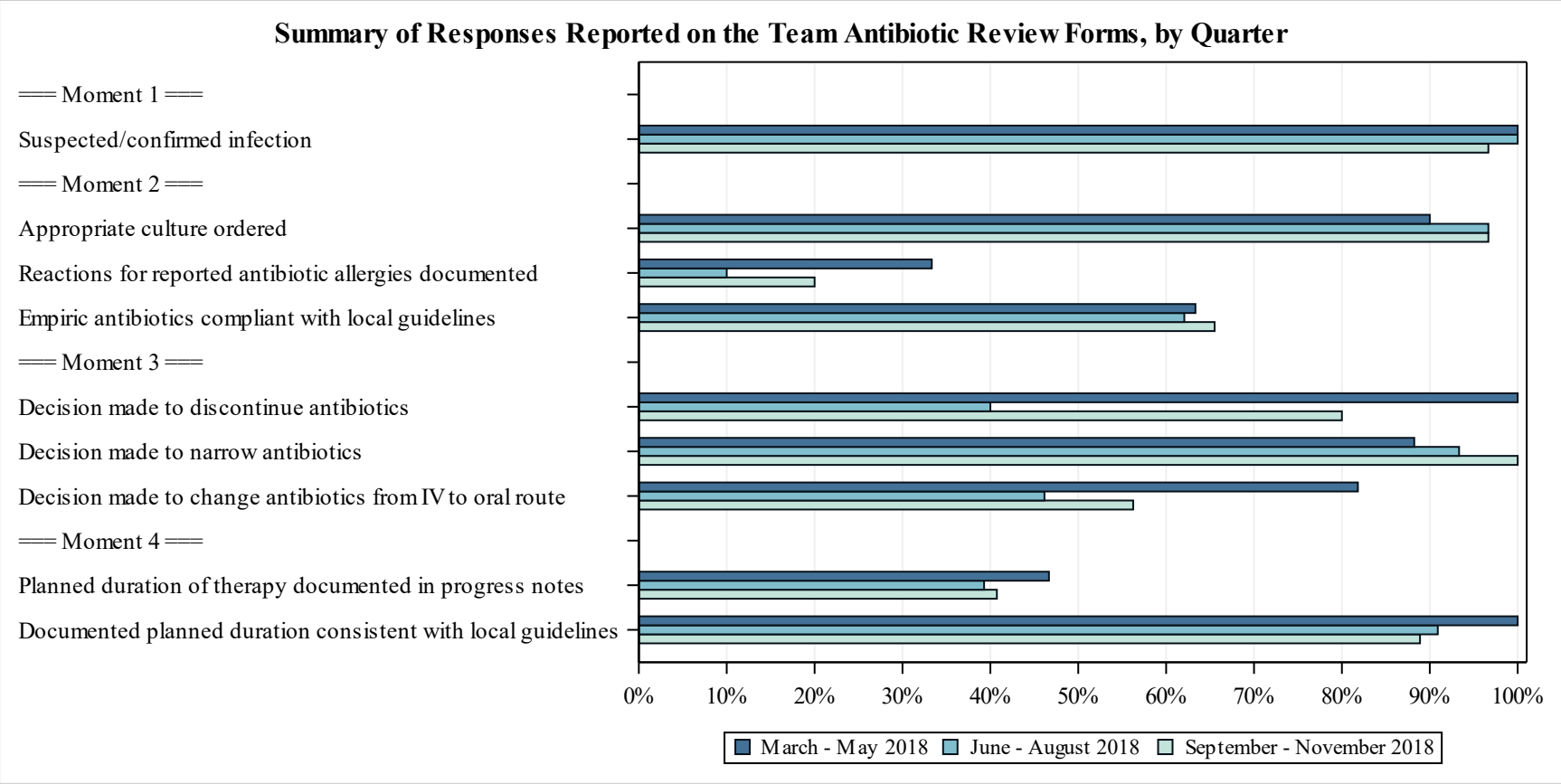

Antibiotic Days of Therapy per 1,000 Patient-Days, by Quarter
Hospital benchmark
Unit benchmark
Your unit
Days of therapy per 1,000 patient-days
350
300
250
200
150
100
50
0
Ciprofloxacin 26.2 32.5 38.5 32 25.2 31 31.2 28.8 26.2 11.3 21.9 29.3
Levofloxacin 103.2 80.5 73 80.5 73.8 59.8 52.1 51 310 199.2 290.3 233.6
Moxifloxacin 2.3 2.4 1.6 1.3 2.7 2.4 2.1 1.8 0 0 0 0
Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4
Fluoroquinolones
Ciprofloxacin
Levofloxacin
Moxifloxacin


Antibiotic Days of Therapy per 1,000 Patient-Days, by Quarter
Hospital benchmark
Unit benchmark
Your unit
Days of therapy per 1,000 patient-days
250
200
150
100
50
0
Ampicillin/sulbactam 11.1 11.3 13.3 15 13.5 14.9 15.8 14.8 0 0 0 1
Ceftriaxone 124.9 120.2 132.5 134.6 128.8 127.5 126.1 124.9 201.8 180.2 132.1 216.9
Ertapenem 8.6 9.1 8.1 9 12.1 12.7 9.6 9.3 4 3.6 5.1 1
Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4
Non-pseudomonal beta-lacta...
Ampicillin/sulbactam
Ceftriaxone
Ertapenem

Team Antibiotic Review Form

See program Web site for team antibiotic use review form

Your unit submitted Team Antibiotic Review Forms for 9 months, with an average of 10 antibiotic use review forms per month from March to November 2018. The graph below shows the summary of responses reported on the Team Antibiotic Review Forms, by quarter, for your unit. Each bar represents the percentage of submitted forms answering "yes" to a particular question or set of questions related to the patients on antibiotics that were evaluated. Responses of "not applicable" are not included in the graph.



Appendix A-6. Structural Assessment

STRUCTURAL ASSESSMENT

Form Approved
OMB No. 0935-0238
Exp. Date 9/30/2020

1. How many hospital beds are in your institution?
2. How many hospital beds are in your unit?
3. Has your unit used the comprehensive unit-based safety program (CUSP) for other quality improvement initiatives before? ◯ Yes ◯ No

   3a. If yes, please describe previous initiatives that have used the CUSP approach.

4. Does your institution have an existing Antibiotic Stewardship Program (ASP)? ◯ Yes ◯ No

   If you answered N0 in the last question, you can stop here. If you answered Yes, please continue.

   4a. Does your ASP have a physician lead? ◯ Yes ◯ No
   - What percent FTE does the physician lead receive for stewardship activities?_____

   4b. Does your ASP have a pharmacist lead? ◯ Yes ◯ No
   - What percent FTE of pharmacist time is devoted towards your ASP?

   _____

   4c. What are the current activities of your ASP? (Check all that apply)

   ☐ Developing an antibiogram
   ☐ Developing educational modules
   ☐ Developing local antibiotic treatment guidelines
   ☐ Prior-approval of select antibiotics
   ☐ Post-prescription review with feedback of select antibiotics
   ☐ Other (please describe)

   _____

   4d. Do you report antibiotic days of therapy per 1,000 days present periodically to track antibiotic usage? ◯ Yes ◯ No

   4e. Please describe if there are other outcomes your ASP tracks.

   _____

   5. Does your hospital have an Antibiotic Stewardship Committee? ◯ Yes ◯ No
   6. What is the title of the person to whom your ASP reports? _____

Appendix A-7. Quarterly Template for Antibiotic Days of Therapy

Monthly DOT

General Instructions:

* We are requesting two spreadsheets per quarter for each unit participating in the AHRQ Safety Program for Improving Antibiotic Use, one is monthly antibiotic use data, the other is quarterly CDI event data. Separate spreadsheets will be available for each quarter. This spreadsheet is for data collected during Quarter 4 (10/1/2018- 12/31/2018).
* Please make sure the hospital and unit names are consistent across the two sheets (Monthly DOT, Quarterly C. difficile) and different cycles of submissions.
* The predefined cells of this worksheet are locked and protected (Column A, B4--D6). Please avoid editing these cells or changing their orders. If no patient is administered for an antibiotics across all three months, please leave the cells empty or fill in zeros.
* Before uploading this to the website, save it as "CDIFF Q4_Hospital Name_Unit Name." Insert your own hospital and unit name.

Instructions for Reporting Antibiotic Data:

* Total number of patient-days (B7, C7, D7) are the monthly totals of number of patients present in the unit at the same time (e.g. at midnight) of each day, summed across all days in the month. Please see Appendix “Calculate Pt-Days” for examples.
* B8-B57, C8-C57, and D8-D57 reflect the aggregate number of days patients were administered each of the antibiotics in Column A within the timeframe specified in B5-B6, C5-C6, and D5-D6 respectively. For example, if your unit had 3 patients using Amikacin in January 2018 and they used it for 3, 5, & 7 days, respectively, then days of Amikacin in January 2018 should be counted as 3+5+7=15 days and you should fill 15 in cell B8. If a patient used an antibiotic across months - for example, from 1/31/2017 to 2/2/2018 - then 1 day should be counted to January 2018 and 2 days should be counted towards February 2018.
* Please see NDC codes for corresponding antibiotics in Appendix 2.
* If you anticipate difficulties in collecting antibiotic usage data for the antibiotics listed below, please contact your Implementation Advisor for assistance.

Hospital name	[insert hospital name here]		
Unit name	[insert unit name here]		
Month	October	November	December
Time starts	10/1/2018	11/1/2018	12/1/2018
Time ends	10/31/2018	11/30/2018	12/31/2018
Total number of patient-days each month	[insert total # of patient-days for **October** here]	[insert total # of patient-days for **November** here]	[insert total # of patient-days for **December** here]
	[insert aggregate # of days patients were administered Amikacin in participating unit in October here]	[insert aggregate # of days patients were administered Amikacin in participating unit in November here]	[insert aggregate # of days patients were administered Amikacin in participating unit in December here]
AMIKACIN			
AMOXICILLIN			
AMOXICILLIN/CLAVULANATE			
AMPICILLIN			
AMPICILLIN/SULBACTAM			
AZITHROMYCIN			
AZTREONAM			
CEFACLOR			
CEFAZOLIN			
CEFEPIME			
CEFOTAXIME			
CEFOTETAN			
CEFOXITIN			
CEFTAROLINE			
CEFTAZIDIME			
CEFTAZIDIME/AVIBACTAM			
CEFTOLOZANE/TAZOBACTAM			
CEFTRIAXONE			
CEFUROXIME			
CIPROFLOXACIN			
CLARITHROMYCIN			
CLINDAMYCIN			
COLISTIMETHATE			
DAPTOMYCIN			
DORIPENEM			
DOXYCYCLINE			
ERTAPENEM			
FIDAXOMICIN			
FOSFOMYCIN			
GENTAMICIN			
IMIPENEM/CILASTATIN			
LEVOFLOXACIN			
LINEZOLID			
MEROPENEM			

Hospital name	[insert hospital name here]		
Unit name	[insert unit name here]		
Month	October	November	December
Time starts	10/1/2018	11/1/2018	12/1/2018
Time ends	10/31/2018	11/30/2018	12/31/2018
Total number of patient-days each month	[insert total # of patient-days for **October** here]	[insert total # of patient-days for **November** here]	[insert total # of patient-days for **December** here]
	[insert aggregate # of days patients were administered Amikacin in participating unit in October here]	[insert aggregate # of days patients were administered Amikacin in participating unit in November here]	[insert aggregate # of days patients were administered Amikacin in participating unit in December here]
MEROPENEM/VABORBACTAM			
METRONIDAZOLE			
MOXIFLOXACIN			
NAFCILLIN			
NITROFURANTOIN			
OXACILLIN			
PENICILLIN G			
PIPERACILLIN/TAZOBACTAM			
POLYMYXIN B			
RIFAMPIN			
SULFAMETHOXAZOLE/TRIMETHOPRIM			
TEDIZOLID			
TELAVANCIN			
TIGECYCLINE			
TOBRAMYCIN			
VANCOMYCIN			

Calculate Pt-Days

This example illustrates two methods to calculate the number of patient days
The example shows a case of 5 patients and set the timeframe as 1/1/2018-1/5/2018
Both methods calculate the total number of patient days as 18 days among the 5 patients during 1/1/2018-1/5/2018

Patient	Admitted or Transferred Into the Unit	Discharge or Transferred out From the Unit
A	1/1/18 12:00 AM	1/5/18 2:00 PM
B	1/1/18 4:00 PM	1/4/18 12:01 AM
C	1/1/18 8:00 PM	1/7/18 11:59 PM
D	1/2/18 3:00 AM	1/6/18 5:00 AM
E	1/2/18 6:00 AM	1/8/18 6:00 AM

Method 1: Count number of patients in the unit at the same time for each day in the given timeframe and sum across all days

Time	# of Patients in the Unit
1/1/18 12:00 AM	1 (patient A)
1/2/18 12:00 AM	3 (patient A, B, C)
1/3/18 12:00 AM	5 (patient A, B, C, D, E)
1/4/18 12:00 AM	5 (patient A, B, C, D, E)
1/5/18 12:00 AM	4 (patient A, C, D, E)

Method 2: Count days contributed by each patient in a given timeframe and sum across all patients

Patient	Patient-Days Between 1/1/2018 and 1/5/2018
A	5 days (the patient is in the unit at 12:00 AM on 1/1, 1/2, 1/3, 1/4, and 1/5)
B	3 days (the patient is in the unit at 12:00 AM on 1/2, 1/3, and 1/4)
C	4 days (the patient is in the unit at 12:00 AM on 1/2, 1/3, 1/4, and 1/5)
D	3 days (the patient is in the unit at 12:00 AM on 1/3, 1,4 and 1/5)
E	3 days (the patient is in the unit at 12:00 AM on 1/3, 1,4 and 1/5)

Appendix A-8. Quarterly Template for *C. difficile* Lab ID Events

Quarterly C. Diff

Hospital name	Unit name	Time starts	Time ends	Total number of patient-days	Number of unit (or hospital)-onset *Clostridium difficile* laboratory-identifiable (LabID) events
[insert hospital name here]	[insert unit name here]	10/1/2018	12/31/2018		

General Instructions:

* We are requesting two spreadsheets per quarter for each unit participating in the AHRQ Safety Program for Improving Antibiotic Use, one is monthly antibiotic use data, the other is quarterly *C.difficile* LabID event data. Separate spreadsheets will be available for each quarter. This spreadsheet is for data collected during Quarter 4 (10/1/2018- 12/31/2018).
* Please make sure the hospital and unit names are consistent across the two sheets (Monthly DOT, Quarterly *C.difficile*) and different cycles of submissions.
* Save this template as "CDIFF Q4_Hospital Name_Unit Name" before submitting to the website. Insert your hospital and unit name.

Instructions for Measures:

* Total number of patient-days (E2) is the quarterly totals of number of patients present in the unit at the same time (e.g. at midnight) of each day, summed across all days in the quarter. Please see Appendix 1 for examples.
* *C. difficile LabID event* is defined as the number of all non-duplicate *C. difficile* toxin-positive laboratory results in the unit within the timeframe specified in Columns C and D. *C. difficile toxin-positive laboratory result* is a positive laboratory test result for *C.difficile* toxin A and/or B tested on an unformed stool specimen OR a toxin-producing *C. difficile* organism detected by culture or other laboratory means performed on an unformed stool sample. *Duplicate C.difficile positive test* is defined as any *C. difficile* toxin-positive laboratory result from the same patient and location, following a previous *C. difficile* toxin-positive laboratory result within the past two weeks [14 days] (even across quarters and readmissions to the same facility). There should be at least 14 days with no *C. difficile* toxin-positive laboratory result (e.g. negative result or no test is performed) for the patient and location before another *C. difficile* LabID Event is counted for the numerator. The date of specimen collection is considered Day 1. *Unit-onset* includes LabID event collected from the participating unit >3 days after admission to the participating unit (specifically, on or after day 4). If the participating unit has trouble to differentiate 3 days after admission to the hospital and 3 days after admission to the specific unit, please report *hospital-onset C. difficile* LabID events, which reflect event collected from an inpatient location >3 days after admission to the hospital.

This example illustrates two methods to calculate the number of patient days

The example shows a case of 5 patients and set the timeframe as 1/1/2018–1/5/2018

Both methods calculate the total number of patient days as 18 days among the 5 patients during 1/1/2018–1/5/2018

Patient	Admitted or Transferred Into the Unit	Discharge or Transferred out From the Unit
A	1/1/18 12:00 AM	1/5/18 2:00 PM
B	1/1/18 4:00 PM	1/4/18 12:01 AM
C	1/1/18 8:00 PM	1/7/18 11:59 PM
D	1/2/18 3:00 AM	1/6/18 5:00 AM
E	1/2/18 6:00 AM	1/8/18 6:00 AM

Method 1: Count number of patients in the unit at the same time for each day in the given timeframe and sum across all days

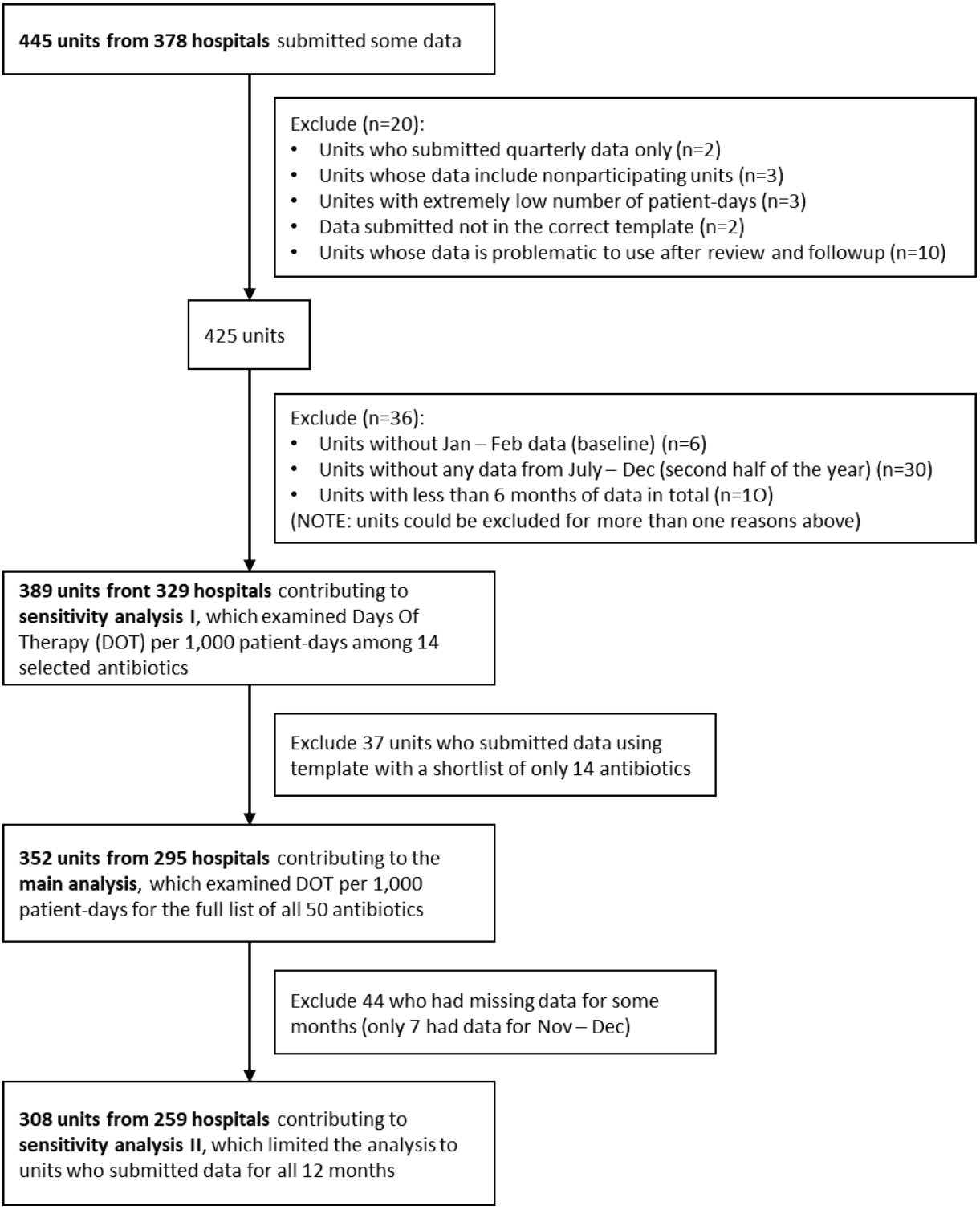
Time	# of Patients in the Unit
1/1/18 12:00 AM	1 (patient A)
1/2/18 12:00 AM	3 (patient A, B, C)
1/3/18 12:00 AM	5 (patient A, B, C, D, E)
1/4/18 12:00 AM	5 (patient A, B, C, D, E)
1/5/18 12:00 AM	4 (patient A, C, D, E)

Method 2: Count days contributed by each patient in a given timeframe and sum across all patients

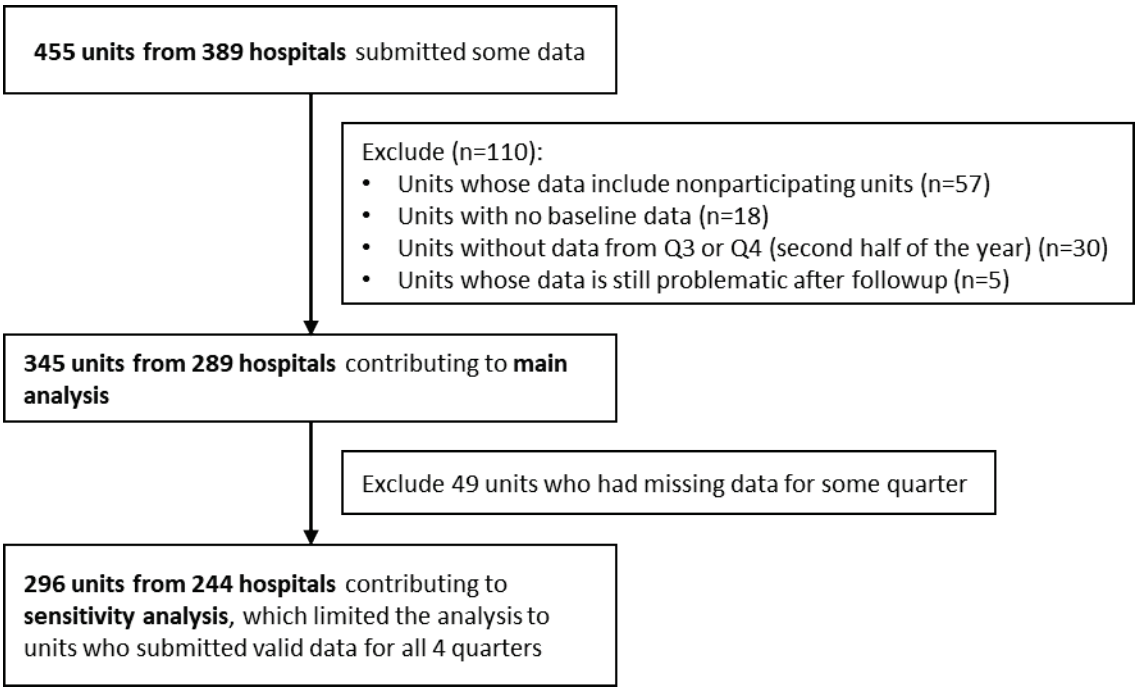
Patient	Patient-Days Between 1/1/2018 and 1/5/2018
A	5 days (the patient is in the unit at 12:00 AM on 1/1, 1/2, 1/3, 1/4, and 1/5)
B	3 days (the patient is in the unit at 12:00 AM on 1/2, 1/3, and 1/4)
C	4 days (the patient is in the unit at 12:00 AM on 1/2, 1/3, 1/4, and 1/5)
D	3 days (the patient is in the unit at 12:00 AM on 1/3, 1,4 and 1/5)
E	3 days (the patient is in the unit at 12:00 AM on 1/3, 1,4 and 1/5)

Appendix B-1. Data Flowcharts

APPENDIX EXHIBIT B-1.1: FLOWCHART FOR UNITS INCLUDED IN THE ANALYSIS OF ANTIBIOTIC USE DATA

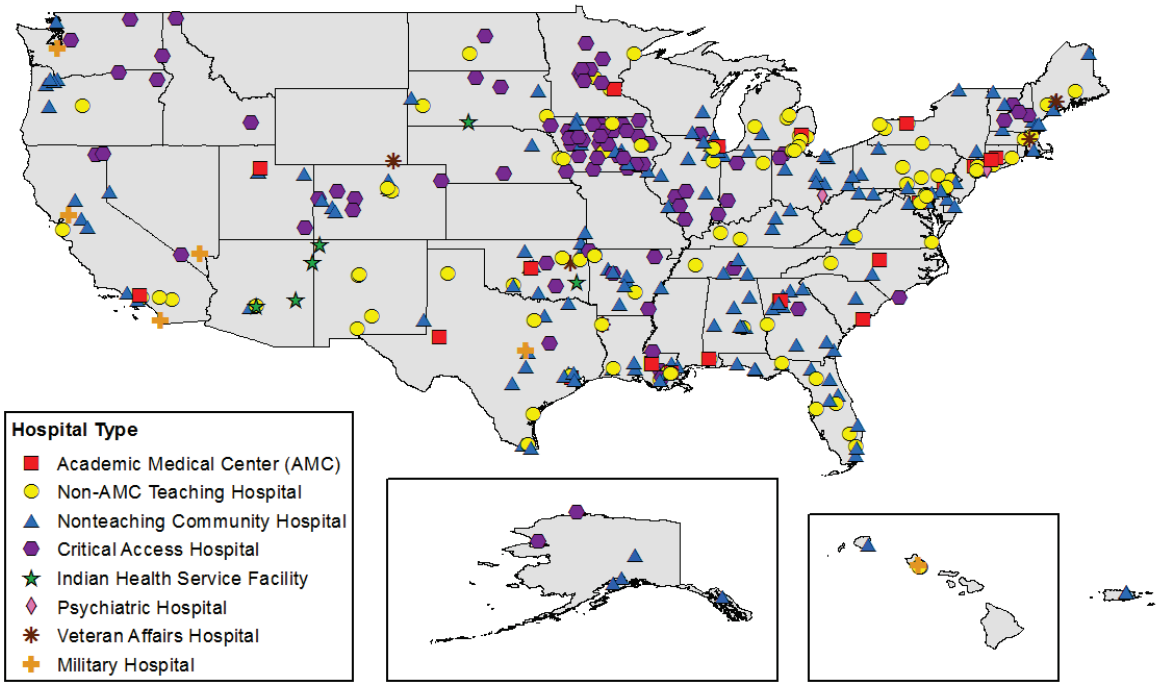


APPENDIX EXHIBIT B-1.2: FLOWCHART FOR UNITS INCLUDED IN THE ANALYSIS OF *C. DIFFICILE* LABID EVENTS DATA

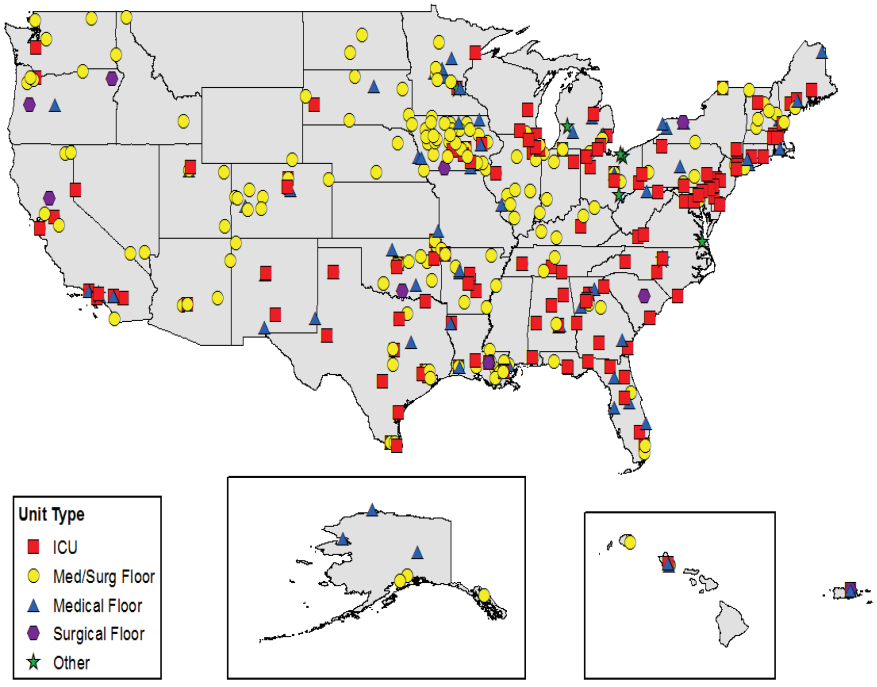


Appendix B-2. Distribution of Participating Units

Appendix Exhibit B-2.1: Distribution of Participating Units by Hospital Type across the United States



Appendix Exhibit B-2.2: Distribution of Participating Unit by Unit Type across the United States



APPENDIX EXHIBIT B-2.3: HOSPITAL AND UNIT CHARACTERISTICS BETWEEN THE SAFETY PROGRAM ACUTE CARE COHORT AND PREMIER SAMPLE

Hospital and Unit Characteristics	AHRQ Safety Program Acute Care Cohort	Premier Sample: Raw	Premier Sample: Weighted
Total number of units	352	1,711	352
Hospital type, %			
Teaching	40.6	28.8	40.7
Nonteaching	59.4	71.2	59.3
Location, %			
Urban	65.3	73.6	65.3
Rural	34.7	26.4	34.7
Census division, %			
New England (CT, ME, MA, NH, RI, VT)	5.7	1.3	5.5
Middle Atlantic (NJ, NY, PA)	7.7	12.4	7.7
East North Central (IN, IL, MI, OH, WI)	13.4	18.4	13.4
West North Central (IA, KS, MN, MO, NE, ND, SD)	13.9	6.8	14.0
South Atlantic (DE, DC, FL, GA, MD, NC, SC, VA, WV)	15.1	28.2	15.1
East South Central (AL, KT, MS, TN)	6.3	7.4	6.3
West South Central (AR, LA, OK, TX)	20.7	10.9	20.8
Mountain (AZ, CO, ID, NM, MT, UT, NV, WY)	6.5	5.0	6.5
Pacific (AK, CA, HI, OR, WA)	10.8	9.7	10.8
Unit type, %			
ICU	35.2	29.8	35.3
Medical	62.8	35.4	62.7
Surgical	2.0	34.8	2.0
Baseline patient-days, mean (standard deviation)	1,410 (1,599)	6,968 (9,788)	1,410 (1,598)

NOTE: Since the difference-in-differences (DID) analysis was conducted to compare antibiotic use among 352 Safety Program participating units who submitted antibiotic use data for the full list of all 50 antibiotics with the Premier sample, we weighted the Premier sample similarly to those units as well (i.e. excluding 37 units who submitted data using template with a shortlist of only 14 antibiotics).

Appendix B-3. Detailed Findings for Team Antibiotic Review Forms

Appendix Exhibit B-3.1: Adjusted Changes in Percent of Positive Responses Reported on the Team Antibiotic Review Form between Quarters, Main Analysis

Reviewed Items	Q2 Versus Q1	Q3 Versus Q1	Q3 Versus Q2
Suspected/confirmed infection	0.6%	1.1% **	0.4%
Appropriate culture ordered	2.4% ***	2.9% ***	0.5%
Reactions for reported antibiotic allergies documented	1.0%	1.9%	1.0%
Empiric antibiotics compliant with local guideline	0.2%	0.7%	0.5%
Decision made to discontinue antibiotics	0.6%	4.3% *	3.7% *
Decision made to narrow antibiotics	3.3% *	3.7% *	0.4%
Decision made to change antibiotics from intravenous to oral routes	0.2%	3.5%	3.3%
Planned duration of therapy documented in progress	2.3% *	4.0% ***	1.7%
Documented planned duration consistent with local guidelines	0.5%	1.5%	0.9%

Note: main analysis included 450 units who submitted at least 5 forms for at least one quarter (March–May, June–August, and September–November). Estimates were generated from linear mixed model with random hospital unit and repeated measurements over time.

* denotes p-value<0.05, ** denotes p-value<0.01, *** denotes p-value<0.001.

Appendix Exhibit B-3.2: Adjusted Changes in Percent of Positive Responses Reported on the Team Antibiotic Review Form between Quarters, Sensitivity Analysis

Reviewed Items	Q2 Versus Q1	Q3 Versus Q1	Q3 Versus Q2
Suspected/confirmed infection	0.8%	1.1%	0.3%
Appropriate culture ordered	3.6% ***	4.0% ***	0.4%
Reactions for reported antibiotic allergies documented	1.7%	0.8%	-1.0%
Empiric antibiotics compliant with local guideline	-0.1%	2.3%	2.5%
Decision made to discontinue antibiotics	2.1%	9.9% **	7.7% *
Decision made to narrow antibiotics	2.4%	5.2%	2.8%
Decision made to change antibiotics from intravenous to oral routes	-3.3%	0.5%	3.8%
Planned duration of therapy documented in progress	1.3%	2.2%	0.9%
Documented planned duration consistent with local guidelines	-0.7%	1.2%	1.9%

Note: sensitivity analysis included 131 units who submitted at least 10 forms for all nine months (March–November). Estimates were generated from linear mixed model with random hospital unit and repeated measurements over time.

* denotes p-value<0.05, ** denotes p-value<0.01, *** denotes p-value<0.001.

Appendix B-4. Detailed Findings for Antibiotic Use

APPENDIX EXHIBIT B-4.1: ADJUSTED CHANGE IN DOT PER 1,000 PATIENT-DAYS, SENSITIVITY ANALYSIS 1

Hospital and Unit Characteristic	# Units, Compared With Jan–Feb 2018	Mar–Apr, Compared With Jan–Feb 2018	May–June, Compared With Jan–Feb 2018	July–Aug, Compared With Jan–Feb 2018	Sept–Oct, Compared With Jan–Feb 2018	Nov–Dec, Compared With Jan–Feb 2018
Overall	(n=389)	-23.3 ***	-10.1	-21.4 *	-21.6 *	-18.5 *
Hospital type						
AMC	(n=42)	-37.3 ***	-2.6	-27.7	-32.6	-41.4 *
Non-AMC	(n=347)	-21.6 ***	-11.0	-20.6 *	-20.2 *	-15.6
Non-AMC teaching hospital	(n=109)	-27.0 **	-17.1	-15.9	-23.3	-7.6
100–299 beds	(n=49)	-55.6 ***	-19.6	-48.6 *	-37.9	-40.4
300 or more beds	(n=55)	-14.6	-29.4	0.7	-17.6	7.2
Nonteaching hospital	(n=238)	-19.1 *	-8.1	-22.7 *	-18.8	-19.4
Less than 100 beds	(n=141)	-17.7	-1.4	-27.2	-17.7	-15.3
100–299 beds	(n=65)	-34.9 **	-25.2	-10.6	-19.5	-12.0
300 or more beds	(n=32)	9.5	-2.4	-26.7	-22.3	-54.2
Critical access hospital (CAH)	(n=69)	-8.2	9.9	-35.9	-21.3	-27.4
Non-CAH	(n=320)	-26.5 ***	-14.3	-18.1 *	-21.7 *	-16.3
Hospital bed size						
Less than 100 beds	(n=152)	-14.5	3.0	-24.6	-14.8	-10.6
100–299 beds	(n=118)	-42.8 ***	-19.3	-27.3	-30.4	-24.1
300 or more beds	(n=119)	-15.1	-17.7	-11.3	-22.1	-23.1
Compliance with 4 key components of ASPs						
Yes	(n=40)	-28.6	-28.0	-29.4	-26.7	-33.9
No	(n=349)	-22.6 ***	-8.0	-20.5 *	-21.0 *	-16.8
Unit type						
ICU	(n=129)	-42.0 ***	-45.2 **	-30.2	-52.3 **	-33.0
Med or surg or med/surg Floor	(n=249)	-13.0	7.3	-15.9	-5.7	-8.9

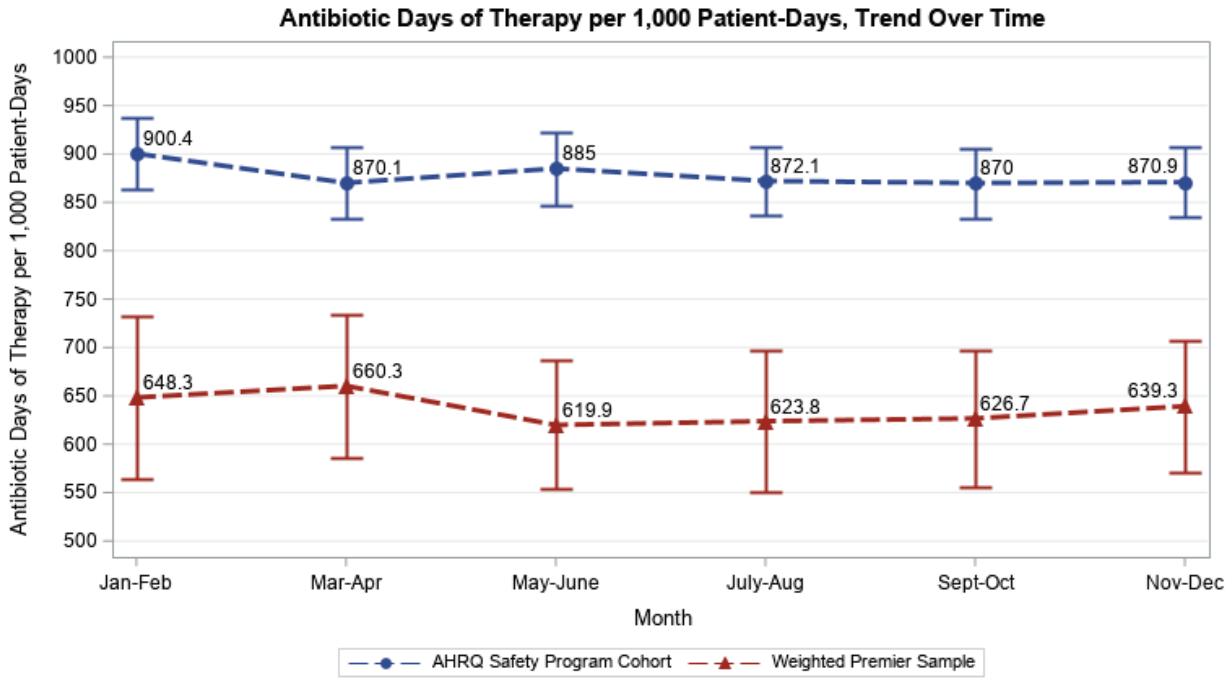
Note: 389 units from 329 hospitals contributed to this analysis. Linear mixed model was used to generate the estimate, with random hospital unit effect and repeated measurement over time. The entire cohort model includes bimonth variable as the independent variable; each stratified model includes bimonth variable, stratified variable, and their interaction terms as the independent variables. Findings were not presented for units from non-AMC teaching hospitals with less than 100 beds due to small subgroup sample size (n=5) and for units in other types due to heterogeneity within the subgroup and the small sample size (n=10). * denotes p-value<0.05; ** denotes p-value<0.01; *** denotes p-value<0.001.

APPENDIX EXHIBIT B-4.2: ADJUSTED CHANGE IN DOT PER 1,000 PATIENT-DAYS, SENSITIVITY ANALYSIS 2

Hospital and Unit Characteristic	# Units, Compared With Jan–Feb 2018	Mar–Apr, Compared With Jan–Feb 2018	May–June, Compared With Jan–Feb 2018	July–Aug, Compared With Jan–Feb 2018	Sept–Oct, Compared With Jan–Feb 2018	Nov–Dec, Compared With Jan–Feb 2018
Overall	(n=308)	-31.8 ***	-15.2	-23.7	-26.7 *	-29.3 *
Hospital type						
AMC	(n=37)	-51.6 **	-4.8	-14.8	-19.6	-47.0
Non-AMC	(n=271)	-29.1 **	-16.6	-24.9	-27.6 *	-26.8 *
Non-AMC teaching hospital	(n=92)	-34.4 **	-14	5.3	-6.8	1.2
100–299 beds	(n=41)	-57.0 **	4.0	-2.0	12.8	-7.4
300 or more beds	(n=46)	-28.8	-42.2	1.4	-35.8	-9.1
Nonteaching hospital	(n=179)	-26.3 *	-17.9	-40.4 *	-38.4 *	-41.2 *
Less than 100 beds	(n=113)	-34.4 *	-18.6	-54.6 *	-47.7 *	-41.9
100–299 beds	(n=44)	-35.7 **	-25.9	-0.8	-28.5	-31.3
300 or more beds	(n=22)	33.6	2.1	-47.1	-9.9	-58.6
Critical access hospital (CAH)	(n=54)	-16.9	4.5	-61.5	-47.7	-54.1
Non-CAH	(n=254)	-35.0 ***	-19.4	-15.7	-22.3	-24.0
Hospital bed size						
Less than 100 beds	(n=124)	-29.3	-9.5	-45.6 *	-34.1	-28.2
100–299 beds	(n=87)	-44.5 ***	-8.6	0.05	-7.7	-16.3
300 or more beds	(n=97)	-23.5	-28.4	-17.2	-34.4	-42.2 *
Compliance with 4 key components of ASPs						
Yes	(n=34)	-33.3	-30.4	-31.4	-32.0	-40.0
No	(n=274)	-31.6 ***	-13.3	-22.7	-26.0 *	-27.9 *
Unit type						
ICU	(n=105)	-52.0 ***	-47.4 *	-23.2	-46.2	-33.7
Med or surg or med/surg Floor	(n=194)	-20.5	1.2	-23.0	-15.5	-24.1

Note: 308 units from 259 hospitals contributed to this analysis. Linear mixed model was used to generate the estimate, with random hospital unit effect and repeated measurement over time. The entire cohort model includes bimonth variable as the independent variable; each stratified model includes bimonth variable, stratified variable, and their interaction terms as the independent variables. Findings were not presented for units from non-AMC teaching hospitals with less than 100 beds due to small subgroup sample size (n=5) and for units in other types due to heterogeneity within the subgroup and the small sample size (n=10). * denotes p-value<0.05; ** denotes p-value<0.01; *** denotes p-value<0.001.

APPENDIX EXHIBIT B-4.3: ESTIMATED DOT PER 1,000 PATIENT-DAYS, SAFETY PROGRAM ACUTE CARE COHORT AND WEIGHTED PREMIER SAMPLE



NOTE: The estimates were marginal means generated from DID model, including 352 units from the AHRQ Safety Program acute care cohort and 1,711 Premier hospital units. The Premier sample was weighted to be similar to the acute care cohort for hospital teaching status, urban/rural location, census division, unit type, and baseline patient-days. Linear mixed model was used to generate the estimate, with random hospital unit effect, repeated measurement over time. The model includes bimonth variable, group indicator, and their interaction terms as the independent variable. Please note that the estimated DOT per 1,000 patient-days for acute care cohort over time is slightly different from Exhibit 34 due to change in the parameter estimates for auto-correlation within units. The substantial difference in DOT per 1,000 patient-days (800–900 per 1,000 patient-days on average for the Safety Program acute care cohort vs 600–700 per 1,000 patient-days on average for the Premier sample) suggested systematic differences between the two samples in non-overserved dimensions.

APPENDIX EXHIBIT B-4.4: ESTIMATED CHANGES IN DOT PER 1,000 PATIENT-DAYS OVER TIME, OVERALL AND BY HOSPITAL TEACHING STATUS AND UNIT TYPE, SAFETY PROGRAM COHORT, AND THE DIFFERENCES

Sample AHRQ Safety Program acute care cohort (N=352 units)	Mar–Apr, Change From Baseline (Jan–Feb)	May–Jun, Change From Baseline (Jan–Feb)	July–Aug, Change From Baseline (Jan–Feb)	Sept–Oct, Change From Baseline (Jan–Feb)	Nov–Dec, Change From Baseline (Jan–Feb)
Entire cohort	-30.3***	-15.5	-28.3*	-30.4*	-29.6**
Teaching hospitals	-33.6**	-14.8	-10.1	-19.6	-18.2
Nonteaching hospitals	-27.9*	-15.8	-40.7**	-37.9*	-37.5*
Intensive care units (ICUs)	-47.0***	-53.0**	-34.2	-56.9**	-38.9
Non-ICUs	-21.3*	4.8	-25.0*	-16.1	-24.5

NOTE: The estimates were marginal means and contrasts from DID model, including 352 units from AHRQ Safety Program acute care cohort and 1,711 Premier hospital units, who were weighted to be comparable with the 352 acute care cohort units on hospital teaching status, urban/rural location, census division, unit type, and baseline patient-days. Please note that the estimates for acute care entire cohort, non-teaching hospitals, ICUs and non-ICUs were slightly different from those presented in Exhibit 37 due to change in the model parameters. Linear mixed model was used to generate the estimate, with random hospital unit effect and repeated measurement over time; bimonth variable, group indicator, subgroup variable and all-way interaction terms as the independent variables. * denotes p-value<0.05; ** denotes p-value<0.01; *** denotes p-value<0.001.

APPENDIX EXHIBIT B-4.5: ESTIMATED CHANGES IN DOT PER 1,000 PATIENT-DAYS OVER TIME, OVERALL AND BY HOSPITAL TEACHING STATUS AND UNIT TYPE, PREMIER SAMPLE, AND THE DIFFERENCES

Sample Weighted Premier sample (N=1,711 units)	Mar–Apr, Change From Baseline (Jan–Feb)	May–Jun, Change From Baseline (Jan–Feb)	July–Aug, Change From Baseline (Jan–Feb)	Sept–Oct, Change From Baseline (Jan–Feb)	Nov–Dec, Change From Baseline (Jan–Feb)
Entire sample	12.0	-28.4	-24.5	-21.6	-9.0
Teaching hospitals	9.4	-23.3	-13.4	-10.7	19.0
Nonteaching hospitals	13.9	-32.1	-31.9	-28.8	-28.1*
ICUs	-47.3***	-87.5***	-92.9***	-92.6***	-59.4***
Non-ICUs	44.3	3.6	13.6	18.9	18.2

NOTE: The estimates were marginal means and contrasts from DID model, including 352 units from AHRQ Safety Program acute care cohort and 1,711 Premier hospital units, who were weighted to be comparable with the 352 acute care cohort units on hospital teaching status, urban/rural location, census division, unit type, and baseline patient-days. Please note that the estimates for acute care entire cohort, non-teaching hospitals, ICUs and non-ICUs were slightly different from those presented in Exhibit 37 due to change in the model parameters. Linear mixed model was used to generate the estimate, with random hospital unit effect and repeated measurement over time; bimonth variable, group indicator, subgroup variable and all-way interaction terms as the independent variables. * denotes p-value<0.05; ** denotes p-value<0.01; *** denotes p-value<0.001.

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