The Core Elements of Hospital Antibiotic Stewardship Programs: 2019

Centers for Disease Control and Prevention
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Contents

Introduction

Antibiotics have transformed the practice of medicine, making once lethal infections readily treatable and making other medical advances, like cancer chemotherapy and organ transplants, possible. Prompt initiation of antibiotics to treat infections reduces morbidity and save lives, for example, in cases of sepsis [1]. However, about 30% of all antibiotics prescribed in U.S. acute care hospitals are either unnecessary or suboptimal [2, 3].

CDC estimates that more than 2.8 million antibiotic-resistant infections occur in the United States each year, and more than 35,000 people die as a result.

Like all medications, antibiotics have serious adverse effects, which occur in roughly 20% of hospitalized patients who receive them [4]. Patients who are unnecessarily exposed to antibiotics are placed at risk for these adverse events with no benefit. The misuse of antibiotics has also contributed to antibiotic resistance, a serious threat to public health [5]. The misuse of antibiotics can adversely impact the health of patients who are not even exposed to them through the spread of resistant organisms and *Clostridioides difficile (C. difficile)* [6].

Optimizing the use of antibiotics is critical to effectively treat infections, protect patients from harms caused by unnecessary antibiotic use, and combat antibiotic resistance. Antibiotic Stewardship Programs (ASPs) can help clinicians improve clinical outcomes and minimize harms by improving antibiotic prescribing [2, 7]. Hospital antibiotic stewardship programs can increase infection cure rates while reducing [7-9]:

- Treatment failures
- *C. difficile* infections
- Adverse effects
- Antibiotic resistance
- Hospital costs and lengths of stay

Antibiotic Stewardship and Sepsis

There have been some misperceptions that antibiotic stewardship may hinder efforts to improve the management of sepsis. However, rather than hindering effective patient care, antibiotic stewardship programs can play an important role in optimizing the use of antibiotics, leading to better patient outcomes.

In 2014, CDC called on all hospitals in the United States to implement antibiotic stewardship programs and released the *Core Elements of Hospital Antibiotic Stewardship Programs* (Core Elements) to help hospitals achieve this goal. The Core Elements outlines structural and procedural components that are associated with successful stewardship programs. In 2015, The United States National Action Plan for Combating Antibiotic Resistant Bacteria set a goal for implementation of the Core Elements in all hospitals that receive federal funding [10].

Core Elements Implementation

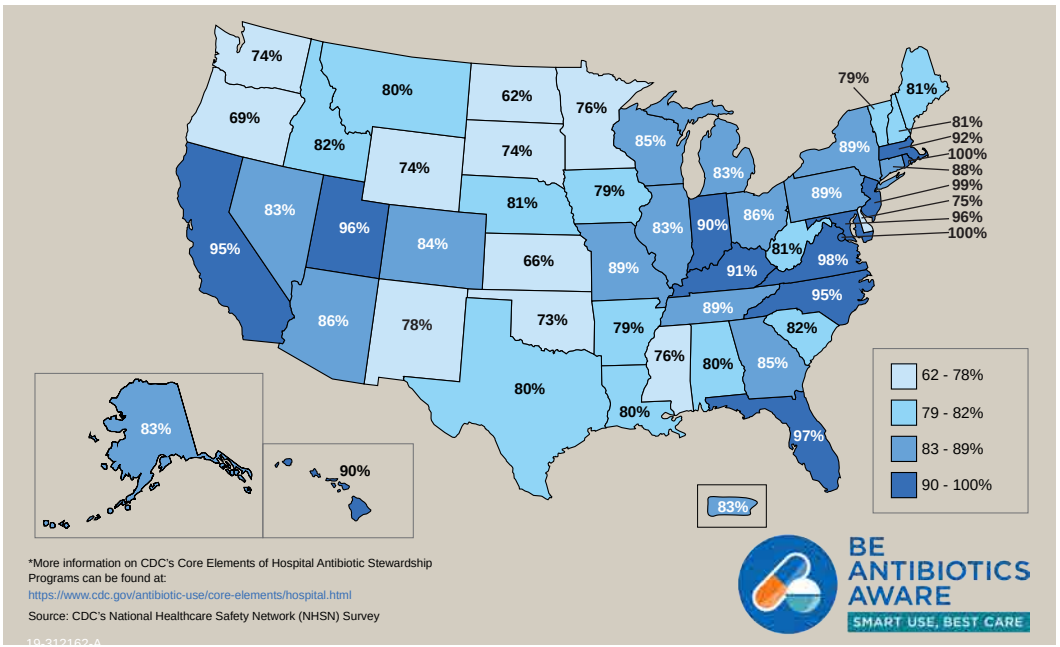
To further support the implementation of the Core Elements, CDC has:

- Partnered with the National Quality Forum to develop the National Quality Partners Playbook: Antibiotic Stewardship in Acute Care in 2016 [11].
- Worked with the Pew Charitable Trusts, the American Hospital Association and the Federal Office of Rural Health Policy to develop an implementation guide for the Core Elements in small and critical access hospitals in 2017 [12].

Partners across the country are using the Core Elements to guide antibiotic stewardship efforts in hospital settings. The Core Elements form the foundation for antibiotic stewardship accreditation standards from the Joint Commission and DNV-GL [13]. The 2019 hospital Conditions of Participation from the Centers for Medicare and Medicaid Services (CMS) created a federal regulation for hospital antibiotic stewardship programs and also reference the Core Elements [14]. United States hospitals have made considerable progress implementing the Core Elements. In 2018, 85% of acute care hospitals reported having all seven of the Core Elements in place, compared to only 41% in 2014 [15].

The field of antibiotic stewardship has advanced dramatically since 2014, with much more published evidence and the release of an implementation guideline from the Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America [16].

Percentage of Hospitals Meeting All 7 Core Elements by State, 2018



In 2018, 85% of acute care hospitals reported having all seven of the Core Elements in place, compared to only 41% in 2014 [15].

Core Elements for Hospital Antibiotic Stewardship Programs - 2019

This document updates the 2014 *Core Elements for Hospital Antibiotic Stewardship Programs* and incorporates new evidence and lessons learned from experience with the Core Elements. The Core Elements are applicable in all hospitals, regardless of size. There are suggestions specific to small and critical access hospitals in *Implementation of Antibiotic Stewardship Core Elements at Small and Critical Access Hospitals* [12].

There is no single template for a program to optimize antibiotic prescribing in hospitals. Implementation of antibiotic stewardship programs requires flexibility due to the complexity of medical decision-making surrounding antibiotic use and the variability in the size and types of care among U.S. hospitals. In some sections, CDC has identified priorities for implementation, based on the experiences of successful stewardship programs and published data. The Core Elements are intended to be an adaptable framework that hospitals can use to guide efforts to improve antibiotic prescribing. The assessment tool that accompanies this document can help hospitals identify gaps to address.

Summary of Updates to the *Core Elements of Hospital Antibiotic Stewardship Programs*

Optimizing the use of antibiotics is critical to effectively treat infections, protect patients from harms caused byunnecessary antibiotic use, and combat antibiotic resistance. Antibiotic stewardship programs can help clinicians improve clinical outcomes and minimize harms by improving antibiotic prescribing.

In 2019, CDC updated the hospital Core Elements to reflect both lessons learned from five years of experience as well as new evidence from the field of antibiotic stewardship. Major updates to the hospital Core Elements include:

Hospital Leadership Commitment: Dedicate necessary human, financial and information technology resources.

- The 2019 update has additional examples of hospital leadership, and the examples are stratified by “priority” and “other”.
- Priority examples of hospital leadership commitment emphasize the necessity of antibiotic stewardship programs leadership having dedicated time and resources to operate the program effectively, along with ensuring that program leadership has regularly scheduled opportunities to report stewardship activities, resources and outcomes to senior executives and hospital board.

Accountability: Appoint a leader or co-leaders, such as a physician and pharmacist, responsible for program management and outcomes.

- The 2019 update highlights the effectiveness of the physician and pharmacy co-leadership, which was reported by 59% of the hospitals responding to the 2019 NHSN Annual Hospital Survey.

Pharmacy Expertise (previously "Drug Expertise"): Appoint a pharmacist, ideally as the co-leader of the stewardship program, to lead implementation efforts to improve antibiotic use.

- This Core Element was renamed "Pharmacy Expertise" to reflect the importance of pharmacy engagement for leading implementation efforts to improve antibiotic use.

Action: Implement interventions, such as prospective audit and feedback or preauthorization, to improve antibiotic use.

- The 2019 update has additional examples of interventions which are stratified to "priority" and "other". The "other" interventions are categorized as infection-based, provider-based, pharmacy-based, microbiology-based, and nursing-based interventions.
- Priority interventions include prospective audit and feedback, preauthorization, and facility-specific treatment recommendations. Evidence demonstrates that prospective audit and feedback and preauthorization improve antibiotic use and are recommended in guidelines as "core components of any stewardship program". Facility-specific treatment guidelines can be important in enhancing the effectiveness of prospective audit and feedback and preauthorization.
- The 2019 update emphasizes the importance of actions focused on the most common indications for hospital antibiotic use: lower respiratory tract infection (e.g., community-acquired pneumonia), urinary tract infection, and skin and soft tissue infection.
- The antibiotic timeout has been reframed as a useful supplemental intervention, but it should not be a substitute for prospective audit and feedback.
- A new category of nursing-based actions was added to reflect the important role that nurses can play in hospital antibiotic stewardship efforts.

Tracking: Monitor antibiotic prescribing, impact of interventions, and other important outcomes like C. difficile infection and resistance patterns.

- It is important for hospitals to electronically submit antibiotic use data to the National Healthcare Safety Network (NHSN) Antimicrobial Use (AU) Option for monitoring and benchmarking inpatient antibiotic use.
- Antibiotic stewardship process measures were expanded and stratified into "priority" and "other".
- Priority process measures emphasize assessing the impact of the key interventions, including prospective audit and feedback, preauthorization, and facility-specific treatment recommendations.

Reporting: Regularly report information on antibiotic use and resistance to prescribers, pharmacists, nurses, and hospital leadership.

- The 2019 update points out the effectiveness of provider level data reporting, while acknowledging that this has not been well studied for hospital antibiotic use.

Education: Educate prescribers, pharmacists, and nurses about adverse reactions from antibiotics, antibiotic resistance and optimal prescribing.

- The 2019 update highlights that case-based education through prospective audit and feedback and preauthorization are effective methods to provide education on antibiotic use. This can be especially powerful when the case-based education is provided in person (e.g., handshake stewardship).
- The 2019 update also suggests engaging nurses in patient education efforts.

Core Elements of Hospital Antibiotic Stewardship Programs

Hospital Leadership Commitment
Dedicate necessary human, financial, and information technology resources.

Accountability
Appoint a leader or co-leaders, such as a physician and pharmacist, responsible for program management and outcomes.

Pharmacy Expertise (previously "Drug Expertise"):
Appoint a pharmacist, ideally as the co-leader of the stewardship program, to help lead implementation efforts to improve antibiotic use.

Action
Implement interventions, such as prospective audit and feedback or preauthorization, to improve antibiotic use.

Tracking
Monitor antibiotic prescribing, impact of interventions, and other important outcomes, like *C. difficile* infections and resistance patterns.

Reporting
Regularly report information on antibiotic use and resistance to prescribers, pharmacists, nurses, and hospital leadership.

Education
Educate prescribers, pharmacists, nurses, and patients about adverse reactions from antibiotics, antibiotic resistance, and optimal prescribing.

Hospital Leadership Commitment

Support from the senior leadership of the hospital, especially the chief medical officer, chief nursing officer, and director of pharmacy, is critical to the success of antibiotic stewardship programs. A lack of necessary resources is commonly cited as the top barrier to success by stewardship programs. Hospital leadership can play a critical role in helping the stewardship program get the resources needed to accomplish its goals.

Priority examples of leadership commitment include:

- Giving stewardship program leader(s) time to manage the program and conduct daily stewardship interventions.
- Providing resources, including staffing, to operate the program effectively. Staffing suggestions for hospital antibiotic stewardship programs are available from the Veteran's Administration [18] and a survey published in 2018 [19].

Though the primary goal of stewardship programs is to improve patient care, many studies have shown that they will pay for themselves, through savings in both antibiotic expenditures and indirect costs [7, 17].

- Having regular meetings with leaders of the stewardship program to assess the resources needed to accomplish the hospital's goals for improving antibiotic use.
- Appointing a senior executive leader to serve as a point of contact or "champion" for the stewardship program to help ensure that the program has resources and support to accomplish its mission.
- Reporting stewardship activities and outcomes (including key success stories) to senior leadership and the hospital board on a regular basis (e.g. including stewardship measures in hospital quality dashboard reports).

Other examples of leadership commitment include:

- Integrating antibiotic stewardship activities into other quality improvement and patient safety efforts, such as sepsis management and diagnostic stewardship.
- Having clear expectations for the leaders of the program on responsibilities and outcomes.
- Making formal statements of support for efforts to improve and monitor antibiotic use.
- Outlining stewardship-related duties in job descriptions and annual performance reviews for program leads and key support staff.
- Supporting training and education for program leaders (e.g. attendance of stewardship training courses and meetings) and hospital staff.
- Supporting enrollment in and reporting to the National Healthcare Safety Network (NHSN) Antimicrobial Use and Resistance (AUR) Module[20], including information technology support.

- Supporting participation in local, state, and national antibiotic stewardship quality improvement collaboratives.
- Ensuring that staff from key support departments (outlined below) have sufficient time to contribute to stewardship activities.

Key Support

Hospital leadership can help ensure that other groups and departments in the hospital are aware of stewardship efforts and collaborate with the stewardship program. Stewardship programs are greatly enhanced by strong support from the following groups:

Clinicians: It is vital that all clinicians are fully engaged in and supportive of efforts to improve antibiotic use. Hospitalists are especially important to engage because they are one of the largest prescribers of antibiotics in hospitals. They also often have experience with quality improvement work [21, 22].

Department or program heads: Support from clinical department heads, as well as the director of pharmacy, is especially important in embedding stewardship activities in daily workflow.

Pharmacy and therapeutics committee can play a key role in helping to develop and implement policies that will improve antibiotic use (e.g. incorporating stewardship into order sets and clinical pathways). Some hospitals have created a multidisciplinary stewardship subcommittee of the Pharmacy and Therapeutics Committee.

Infection preventionists and hospital epidemiologists can assist with educating staff and with analyzing and reporting data on antibiotic resistance and *C. difficile* infection trends [23, 24]. They can also support reporting to the NHSN AUR Module by updating monthly reporting plans, adding AUR users, and assisting with data upload.

Quality improvement, patient safety and regulatory staff can help advocate for adequate resources and integrate stewardship interventions into other quality improvement efforts, especially sepsis management. They might also be able to support implementation and outcome assessments.

Microbiology laboratory staff can:

- Guide the proper use of tests and the flow of results as part of "diagnostic stewardship" [25].
- Help optimize empiric antibiotic prescribing by creating and interpreting a facility cumulative antibiotic resistance report or antibiogram. Laboratory and stewardship personnel can work collaboratively to present data from lab reports in a way that supports optimal antibiotic use and is consistent with hospital guidelines.
- Guide discussions on the potential implementation of rapid diagnostic tests and new antibacterial susceptibility test interpretive criteria (e.g., antibiotic breakpoints) that might impact antibiotic use. Microbiology labs and stewardship programs can work together to optimize the use of such tests and the communication of results.

- Collaborate with stewardship program personnel to develop guidance for clinicians when changes in laboratory testing practices might impact clinical decision making [26].
- Hospitals where microbiology services are contracted to an external organization should ensure that information is available to inform stewardship efforts.

Information technology staff are critical to integrating stewardship protocols into existing workflow. Some examples include:

- Embedding relevant information and protocols at the point of care (e.g., order sets, access to facility-specific guidelines).
- Implementing clinical decision support for antibiotic use and creating prompts for action to review antibiotics in key situations.
- Facilitating and maintaining NHSN AUR reporting.

Nurses: There is growing recognition of the importance of engaging nurses in hospital stewardship efforts [27-29]. Nurses can play an especially important role in:

- Optimizing testing, or diagnostic stewardship. For example, nurses can inform decisions about whether or not a patient has symptoms that might justify a urine culture.
- Assuring that cultures are performed correctly before starting antibiotics.
- Prompting discussions of antibiotic treatment, indication, and duration.
- Improving the evaluation of penicillin allergies.

Accountability

The antibiotic stewardship program must have a designated leader or co-leaders who are accountable for program management and outcomes. Most hospitals have found a co-leadership model to be effective, according to the 2019 NHSN hospital survey, 59% of hospitals in the United States have stewardship programs that are co-led by a physician and pharmacist. Effective leadership, management and communication skills are essential for the leaders of a hospital antibiotic stewardship program [30].

Programs with co-leaders should have a clear delineation of responsibilities and expectations. This can be especially important for physician leaders who do not work full time at the hospital. Antibiotic prescribing is ultimately under the direction of the medical staff. If a non-physician is the leader of the program, it is important that the hospital designate a physician who can serve as a point of contact and support for the non-physician program leader. Regular “stewardship rounds” for the co-leaders, or the non-physician lead and the supporting physician can strengthen program leadership. Expanding these rounds to include discussions with prescribers (also called “handshake stewardship”) has been shown to improve antibiotic use and is an effective way to enhance the visibility and support of the stewardship program [31, 32].

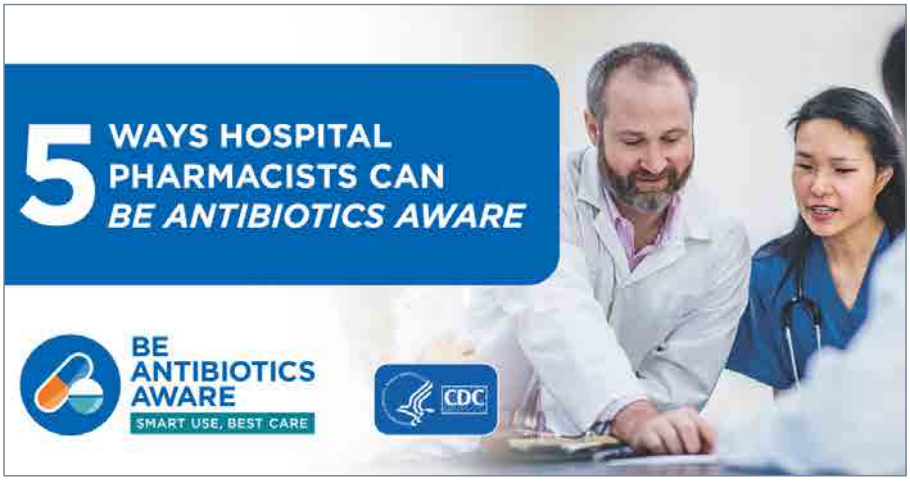
Training in infectious diseases and/or antibiotic stewardship benefits stewardship program leaders [2, 33]. Larger facilities have achieved success by hiring full-time staff to develop and manage stewardship programs while smaller facilities report other arrangements, including use of part-time or even off-site expertise, sometimes referred to as tele-stewardship [34, 35]. Hospitalists have also proven to be effective physician leaders or supporters for efforts to improve antibiotic use, especially in smaller hospitals, given their increasing presence in inpatient care, the frequency with which they use antibiotics and their experience with leading hospital quality improvement projects [21, 22].

Pharmacy Expertise (previously "Drug Expertise")

Highly effective hospital antibiotic stewardship programs have strong engagement of pharmacists, either as a leader or co-leader of the program [36, 37]. It is important to identify a pharmacist who is empowered to lead implementation efforts to improve antibiotic use. Infectious diseases trained pharmacists are highly effective in improving antibiotic use and often help lead programs in larger hospitals and healthcare systems [38, 39].

In hospitals without infectious disease trained pharmacists, general clinical pharmacists are often co-leaders or pharmacy leaders. General clinical pharmacists are more effective when they have specific training and/or experience in antibiotic stewardship.

There are a variety of resources to support the antibiotic stewardship efforts of clinical pharmacists, ranging from posters highlighting key stewardship interventions for pharmacists [40] to formal training and certificate programs in stewardship for pharmacists.



CDC has a number of posters for hospital pharmacists highlighting key stewardship interventions for pharmacists

Action

Antibiotic stewardship interventions improve patient outcomes [7, 9]. An initial assessment of antibiotic prescribing can help identify potential targets for interventions.

Priority Interventions to Improve Antibiotic Use

Stewardship programs should choose interventions that will best address gaps in antibiotic prescribing and consider prioritizing prospective audit and feedback, preauthorization and facility-specific treatment guidelines.

Published evidence demonstrates that **prospective audit and feedback** (sometimes called post-prescription review) and **preauthorization** are the two most effective antibiotic stewardship interventions in hospitals [16]. They are both strongly recommended in evidenced-based guidelines and can be considered "foundational" interventions for hospital stewardship programs.

Prospective audit and feedback is an external review of antibiotic therapy by an expert in antibiotic use, accompanied by suggestions to optimize use, at some point after the agent has been prescribed [16]. Prospective audit and feedback is different from an antibiotic "timeout" because the stewardship program rather than the treating team conducts the audits.

Audit and feedback can be implemented in a variety of ways, depending on the level of expertise available. Stewardship programs with limited infectious diseases expertise might choose to focus reviews on comparing prescribed treatment courses to recommendations in hospital specific treatment guidelines and focus on common conditions, such as community-acquired pneumonia, urinary tract infection, or skin and soft tissue infection. Programs with more advanced infectious diseases expertise might elect to review more complex antibiotic treatment courses.

The effectiveness of prospective audit and feedback can be enhanced by providing feedback in face-to-face meetings with providers, referred to as "handshake stewardship" [32] [41].

Preauthorization requires prescribers to gain approval prior to the use of certain antibiotics. This can help optimize initial empiric therapy because it allows for expert input on antibiotic selection and dosing, which can be lifesaving in serious infections, like sepsis. It can also prevent unnecessary initiation of antibiotics [42].

Decisions on which antibiotics to place under preauthorization should be made in consultation with providers to focus on opportunities to improve empiric use, rather than on drug costs [43]. This intervention requires the availability of expertise and staff who can complete authorizations in a timely manner [44]. Hospitals can tailor the agents, situations, and mechanisms (e.g. preauthorization through an electronic order entry system) to implement preauthorization based on program goals, available expertise, and resources in a way that does not delay therapy for serious infections. Stewardship programs should monitor potential unintended consequences of preauthorization, especially treatment delays.

Two studies have compared these two interventions directly and found prospective audit and feedback to be more effective than preauthorization [42, 44]. However, many experts suggest that these interventions should both be priorities for implementation since preauthorization can help optimize *initiation* of antibiotics and prospective audit and feedback can help optimize *continued therapy*. Hospitals can use local data and knowledge of practices to determine which antibiotics should be subject to prospective audit and feedback and/or preauthorization.

Facility-specific treatment guidelines are also considered a priority because they can greatly enhance the effectiveness of both prospective audit and feedback and preauthorization by establishing clear recommendations for optimal antibiotic use at the hospital. These guidelines can optimize antibiotic selection and duration, particularly for common indications for antibiotic use like community-acquired pneumonia, urinary tract infection, intra-abdominal infection, skin and soft tissue infection and surgical prophylaxis. Recommendations may be based on national guidelines but should reflect hospital treatment preferences based on local susceptibilities, formulary options, and patient mix.

Ideally, the recommendations should also address diagnostic approaches, such as when to send diagnostic samples and what tests to perform, including indications for rapid diagnostics and non-microbiologic tests (e.g. imaging, procalcitonin). The development of treatment guidelines is a good way for the stewardship program to engage prescriber stakeholders to develop consensus on antibiotic use.

Hospital guidelines can also facilitate prospective audit with feedback and preauthorization as prescriptions and/or requests for antibiotics can be compared to hospital recommendations. Stewardship programs can prioritize the development of guidelines based on the infections most commonly encountered. Adherence to hospital guidelines can be enhanced by embedding treatment recommendations in order sets and clinical pathways.

Common Infection-based Interventions

More than half of all antibiotics given to treat active infections in hospitals are prescribed for three infections where there are important opportunities to improve use: lower respiratory tract infection (e.g. community acquired pneumonia), urinary tract infection and skin and soft tissue infection [45]. Optimizing the duration of therapy can be especially important because many studies show infections are often treated for longer than guidelines recommend and data demonstrate that each additional day of antibiotics increases the risk of patient harm [4, 46]. Examples of interventions are below and summarized in Table 1.

Community-acquired pneumonia:
Interventions have focused on:

- Improving diagnostic accuracy
- Tailoring of therapy to culture results
- Optimizing the duration of treatment to ensure compliance with guidelines

The use of viral diagnostics and/or procalcitonin might help identify patients in whom antibiotics can be stopped because bacterial pneumonia is unlikely [47]. Optimizing the duration of therapy at hospital discharge is especially important as most excess antibiotic use in the treatment of community-acquired pneumonia occurs after discharge [48, 49].

Urinary tract infection (UTI): Many patients who are prescribed antibiotics for UTIs have asymptomatic bacteriuria that generally does not need to be treated. Successful stewardship interventions focus on avoiding obtaining unnecessary urine cultures and avoiding treatment of patients who are asymptomatic, unless there are specific reasons to treat [50]. For patients who need treatment, interventions can focus on ensuring patients receive appropriate therapy based on local susceptibilities for the recommended duration [51].

Skin and soft tissue infection: Interventions have focused on ensuring patients with uncomplicated infections do not receive antibiotics with overly broad spectra (e.g. unnecessary coverage for methicillin-resistant Staphylococcus aureus (MRSA) and gram-negative pathogens) and prescribing the correct route, dosage and duration of treatment [52, 53].

Table 1. Key opportunities to improve antibiotic use

INFECTIONS	DIAGNOSTIC CONSIDERATIONS	EMPIRIC THERAPY	DEFINITIVE THERAPY Tailor to culture results and define duration, including discharge prescription.
Community-acquired pneumonia[54]	Review cases after initiation of therapy to confirm pneumonia diagnosis versus non-infectious etiology.	Avoid empiric use of antipseudomonal beta-lactams and/or MRSA agents unless clinically indicated.	Guidelines suggest that in adults, most cases of uncomplicated pneumonia can be treated for 5 days when a patient has a timely clinical response [55, 56]. Data also suggest that negative results of MRSA nasal colonization testing can help guide decisions to discontinue empiric therapy for MRSA pneumonia [57]
Urinary tract infection (UTI)	Implement criteria for ordering urine cultures to ensure that positive cultures are more likely to represent infection than bladder colonization [58]. **Examples include:** • Order a urine culture only if the patient has signs and symptoms consistent with UTI such as urgency, frequency, dysuria, suprapubic pain, flank pain, pelvic discomfort or acute hematuria. • For patients with urinary catheters, avoid obtaining urine cultures based solely on cloudy appearance or foul smell in the absence of signs and symptoms of UTI. Nonspecific signs and symptoms such as delirium, nausea and vomiting should be interpreted with caution as, by themselves, they have a low specificity for UTI.	Establish criteria to distinguish between asymptomatic and symptomatic bacteriuria. Avoid antibiotic therapy for asymptomatic bacteriuria except in certain clinical situations where treatment is indicated, such as for pregnant women and those undergoing an invasive genitourinary procedure.	Use the shortest duration of antibiotic therapy that is clinically appropriate.
Skin and soft tissue infection	Develop diagnostic criteria to distinguish purulent and non-purulent infections and severity of illness (i.e., mild, moderate and severe) so that skin and soft tissue infections can be managed appropriately according to guidelines.	Avoid empiric use of antipseudomonal beta-lactams and/or anti-anaerobic agents unless clinically indicated. Use of therapy specific for MRSA may not be necessary in uncomplicated non-purulent cellulitis [53].	Guidelines suggest that most cases of uncomplicated bacterial cellulitis can be treated for 5 days if the patient has a timely clinical response [53].

Other Infection-based Interventions

Sepsis: Early administration of effective antibiotics is lifesaving in sepsis. Antibiotic stewardship programs should work with sepsis experts in the hospital, along with the pharmacy and microbiology lab, to optimize the treatment of sepsis. Important issues to address are:

- Developing antibiotic recommendations for sepsis that are based on local microbiology data.
- Ensuring protocols are in place to administer antibiotics quickly in cases of suspected sepsis.
- Ensuring there are mechanisms in place to review antibiotics started for suspected sepsis so that therapy can be tailored or stopped if deemed unnecessary.

***Staphylococcus aureus* infection:** In many cases, therapy for MRSA can be stopped if the patient does not have an MRSA infection or changed to a beta-lactam if the cause is not MRSA. Studies have also shown that treatment protocols and, where available, infectious diseases consultation, can improve outcomes in patients with *Staphylococcus aureus* bloodstream infections [59, 60].

***C. difficile* infection:** Treatment guidelines recommend providers stop unnecessary antibiotics in all patients diagnosed with *C. difficile* infection. Reviewing antibiotics in patients with new diagnoses of *C. difficile* infection can identify opportunities to stop unnecessary antibiotics, which improves the clinical response of these infections to treatment and reduces the risk of recurrence [61-63]. Stewardship programs can also make sure that patients are receiving guideline recommended therapy for their *C. difficile* infection [64].

Culture proven invasive infection: Invasive infections (e.g. blood stream infections) present opportunities for interventions to improve antibiotic use because they are easily identified from microbiology results and sub-optimal therapy often leads to worse outcomes. Prospective audit and feedback of new culture or rapid diagnostic results may be particularly beneficial to reduce the time needed to discontinue, narrow, or broaden antibiotic therapy as appropriate.

Review of planned outpatient parenteral antibiotic therapy (OPAT): In some cases, OPAT can be optimized or even avoided altogether following a review by the antibiotic stewardship program [65].

Provider-based Interventions

Antibiotic "timeouts": Antibiotics are commonly started empirically in hospitalized patients. However, providers often do not revisit the selection of the antibiotic after more data (including culture results) become available. An antibiotic timeout is a provider-led reassessment of the continuing need and choice of antibiotics when the clinical picture is clearer and more diagnostic information, especially results of cultures and rapid diagnostics, is available.

Antibiotic timeouts are different from prospective audit and feedback because the providers, not the stewardship team, are doing the reviews. A trial demonstrated that antibiotic timeouts at 48-72 hours of therapy improved the appropriateness of antibiotic selection, but did not reduce overall antibiotic use [66]. Antibiotic timeouts are a useful supplemental intervention but should not be considered a substitute for prospective audit and feedback by the stewardship program.

The optimal timing of antibiotic timeouts has not been established. Experts suggest that daily reviews of antibiotic selection, until a definitive diagnosis and treatment duration are established, can optimize treatment. Provider-led reviews of antibiotics can focus on four key questions [67]:

- Does this patient have an infection that will respond to antibiotics?
- Have proper cultures and diagnostic tests been performed?
- Can antibiotics be stopped or improved by narrowing the spectrum (also referred to as "de-escalation") or changing from intravenous to oral?
- How long should the patient receive the antibiotic(s), considering both the hospital stay and any post-discharge therapy?

Assessing penicillin allergy: About 15% of hospitalized patients report an allergy to penicillin [68]. However, less than 1% of the US population has a serious penicillin allergy that would preclude treatment with a beta-lactam antibiotic [69]. There are several effective approaches to properly assess penicillin allergies, including history and physical examination, challenge doses, and skin testing [69, 71]. Nurses may be able to play an important role in improving penicillin allergy assessments [27].

Pharmacy-based Interventions

The following interventions are often initiated by pharmacists and/or embedded into pharmacy sections of electronic health records:

- **Documentation of indications for antibiotics:** Requiring an indication for antibiotic prescriptions can facilitate other interventions, like prospective audit and feedback and optimizing post-discharge durations of therapy, and, in and of itself, can improve antibiotic use [72].
- **Automatic changes from intravenous to oral antibiotic therapy:** This change can improve patient safety by reducing the need for intravenous access in appropriate situations and for antibiotics with good absorption.
- **Dose adjustments:** when needed, such as in cases of organ dysfunction, especially renal, or based on therapeutic drug monitoring.
- **Dose optimization:** for example, extended-infusion administration of beta-lactams, particularly for patients who are critically-ill and patients infected with drug-resistant pathogens.
- **Duplicative therapy alerts:** Alerts in situations where therapy might be unnecessarily duplicative including simultaneous use of multiple agents with overlapping spectra (e.g. anaerobic activity and resistant Gram-positive activity) [73, 74].

- **Time-sensitive automatic stop orders:** for specified antibiotic prescriptions, especially antibiotics administered for surgical prophylaxis.
- **Detection and prevention of antibiotic-related drug-drug interactions:** for example, interactions between some orally administered fluoroquinolones and certain vitamins.

Microbiology-based Interventions

The microbiology lab in consultation with the stewardship program often implement the following interventions:

- **Selective reporting of antimicrobial susceptibility testing results:** tailoring hospital susceptibility reports to show antibiotics that are consistent with hospital treatment guidelines or recommended by the stewardship program [75] [76].
- **Comments in microbiology reports:** for example, to help providers know which pathogens might represent colonization or contamination [77].

Nursing-based interventions

Bedside nurses often initiate the following interventions:

- **Optimizing microbiology cultures:** Knowing proper techniques to reduce contamination and indications for when to obtain cultures, especially urine cultures [27].
- **Intravenous to oral transitions:** Nurses are most aware of when patients are able to tolerate oral medications and can initiate discussions on switching to oral antibiotics.
- **Prompting antibiotic reviews ("timeouts"):** Nurses often know how long a patient has been receiving an antibiotic and when laboratory results become available. They can play a key role in prompting reevaluations of therapy at specified times, such as after 2 days of treatment and/or when culture results are available [29].

Tracking

Measurement is critical to identify opportunities for improvement and to assess the impact of interventions. Measurement of antibiotic stewardship interventions may involve evaluation of both processes and outcomes. For example, a program will need to evaluate if policies and guidelines are being followed as expected (processes) and if interventions have improved patient outcomes and antibiotic use (outcomes).

Antibiotic Use Measures

It is important for hospitals to monitor and benchmark antibiotic use by electronically reporting to the National Healthcare Safety Network (NHSN) Antimicrobial Use (AU) Option The NHSN AU Option is available to hospitals that have information system capability to submit electronic medication administration records (eMAR) and/or bar-coding medication administration records (BCMA) using an HL7 standardized clinical document architecture [20].

There are a variety of health information technology companies that can facilitate the reporting of antibiotic use data to the AU Option [78]. Stewardship programs can work with their informatics technology staff to explore options for reporting data to the AU Option. Enrolling hospitals in the NHSN AU Option was a priority goal set forth in the National Strategy for Combating Antibiotic-Resistant Bacteria and by the President's Advisory Committee on Combating Antibiotic Resistant Bacteria [79].

The NHSN AU Option provides rates of antibiotic use expressed as days of therapy (DOTs) per days present for nearly all antibiotics for individual inpatient care locations, select outpatient care locations (e.g. emergency department and observation units), and for the entire hospital. Days of therapy are the sum of days for which any amount of a specific antibiotic agent is administered to a patient.

The AU Option also provides a risk-adjusted benchmark of antibiotic use referred to as the Standardized Antimicrobial Administration Ratio or "SAAR". Benchmarking has proven to be a powerful tool in hospital quality improvement and was a top priority for stewardship experts who advised CDC on the development of the NHSN AU Option. The SAAR compares observed antibiotic use to predicted use, where use is predicted based on risk adjusted models of data submitted to the NHSN AU Option [80]. SAARs were developed for a variety of groups of antibiotics for both adult, pediatric and neonatal care locations in response to suggestions from stewardship experts on the types of data that would be most actionable [20]. Stewardship programs are using the NHSN AU Option to both inform and assess interventions [81-83].

Hospitals that are not yet reporting to the NHSN AU Option can often get antibiotic use data from their pharmacy record systems, usually either as days of therapy or as defined daily doses (DDDs). The DDD estimates antibiotic use in hospitals by aggregating the total number of grams of each antibiotic purchased, ordered, dispensed, or administered during a period of interest divided by the World Health Organization-assigned DDD [84]. United States guidelines recommend the use of days of therapy rather than DDDs as the preferred numerator metric for hospital antibiotic use [16].

Outcome measures

***C. difficile* infection**s are an important target for stewardship programs, given the evidence that improved antibiotic use can prevent these infections [85, 86]. Most acute care hospitals are already monitoring and reporting information on *C. difficile* infection to NHSN as part of payment programs for CMS and/or for state requirements. *C. difficile* infection prevention is multifaceted and creates an opportunity for stewardship programs to collaborate with other groups, such as the laboratory and infection prevention.

Antibiotic Resistance. Improving antibiotic use is important to reduce antibiotic resistance, which presents another option for measurement. The development and spread of antibiotic resistance is multi-factorial and studies assessing the impact of improved antibiotic use on resistance rates have shown mixed results [7, 87, 88]. The impact of stewardship interventions on resistance is best assessed when measurement is focused on pathogens that are recovered from patients after admission when they are under the influence of hospital stewardship interventions [16]. Monitoring resistance at the patient level (i.e. what percent of patients develop resistant super-infections) has also been shown to be useful. Hospitals can also track antibiotic resistance though the NHSN Antimicrobial Resistance (AR) Option [20].

Financial Impact. Stewardship programs can achieve significant cost savings, particularly drug cost savings.[89, 90]. Costs should not be the primary outcome measure of a program's success; but demonstrating savings can be helpful in obtaining resources for antibiotic stewardship programs. If hospitals monitor antibiotic costs, they should assess the pace at which antibiotic costs were rising before the start of the stewardship program [91]. After an initial period of marked savings, costs often stabilize. However, it is important to continue support for stewardship programs since costs can increase if programs are terminated [17].

Process Measures for Quality Improvement

Process measures can focus on the specific interventions being implemented at the hospital. Priority process measures include:

- Tracking the types and acceptance of recommendations from prospective audit and feedback interventions, which can identify areas where more education or additional focused interventions might be useful.
- Monitoring of preauthorization interventions by tracking agents that are being requested for certain conditions and ensuring that preauthorization is not creating delays in therapy.
- Monitoring adherence to facility-specific treatment guidelines. If feasible, consider tracking adherence by each prescriber.

Additional process measures for quality improvement include:

- Monitoring the performance of antibiotic timeouts to assess how often they are preformed and if opportunities to improve use are being identified and acted on.
- Performing a medication use evaluation to assess courses of therapy for select antibiotics or infections to identify opportunities to improve use. Standardized tools or antibiotic audit forms can assist in these reviews [92] [76].
- Monitoring how often patients are converted from intravenous to oral therapy to identify missed opportunities to convert.
- Assessing how often patients are prescribed unnecessary duplicate therapy, for example if a patient is prescribed two antibiotics to treat anaerobes.
- Assessing how often patients are discharged on the correct antibiotics for the recommended duration.

Reporting

Antibiotic stewardship programs should provide regular updates to prescribers, pharmacists, nurses, and leadership on process and outcome measures that address both national and local issues, including antibiotic resistance. Antibiotic resistance information should be prepared in collaboration with the hospital's microbiology lab and infection control and healthcare epidemiology department. The local or state health department's healthcare infection control and antibiotic resistance program is also an important resource for local information on antibiotic resistant threats [93]. Summary information on antibiotic use and resistance along with antibiotic stewardship program work should be shared regularly with hospital leadership and the hospital board.

Findings from medication use evaluations along with summaries of key issues that arise during prospective audit and feedback reviews and preauthorization requests can be especially useful to share with prescribers. Sharing facility-specific information on antibiotic use is a tool to motivate improved prescribing, particularly if wide variations in the patterns of use exist among similar patient care locations [94]. Provider specific reports with peer comparisons have been effective in improving antibiotic use in outpatient settings [95], but there is limited experience with these reports for hospital-based providers.

Education

Education is a key component of comprehensive efforts to improve hospital antibiotic use; however, education alone is not an effective stewardship intervention [16]. There are many options for providing education on antibiotic use such as didactic presentations, which can be done in formal and informal settings, messaging through posters, flyers and newsletters, or electronic communication to staff groups.

Education is most effective when paired with interventions and measurement of outcomes. Case-based education can be especially powerful, so prospective audit with feedback and preauthorization are both good methods to provide education on antibiotic use. This can be especially effective when the feedback is provided in person, for example through handshake stewardship. Some hospitals review de-identified cases with providers to help identify changes in antibiotic therapy that could have been made. Education is most effective when tailored to the action(s) most relevant to the provider group, such as education on community acquired pneumonia guidelines for hospitalists or education on culture techniques for nurses. There are also a variety of educational materials on hospital antibiotic use and stewardship available from the Agency for Healthcare Research and Quality's Safety Program for Improving Antibiotic Use [97].

CDC has a variety of educational resources, including an online course on antibiotic stewardship that includes a module focused on improving antibiotic use in hospitals [96].

Patient education is also an important focus for antibiotic stewardship programs. It is important for patients to know what antibiotics they are receiving and for what reason(s). They should also be educated about adverse effects and signs and symptoms that they should share with providers. Patients should be alerted to side effects that may occur after they have been discharged and even after they have stopped taking antibiotics. Engaging patients in the development and review of educational materials can make these items more effective. Nurses are an especially important partner for patient education efforts. They should be engaged in developing educational materials and educating patients about appropriate antibiotic use.

BE ANTIBIOTICS AWARE
SMART USE, BEST CARE

CDC's national campaign, *Be Antibiotics Aware*, has resources to help healthcare providers educate their patients about appropriate antibiotic use, including a patient education handout specifically for antibiotic use in the hospital setting.

CDC Efforts to Support Antibiotic Stewardship

The *Core Elements of Hospital Antibiotic Stewardship Programs* is one of a suite of documents intended to help improve the use of antibiotics across the spectrum of health care. Building upon the hospital Core Elements framework, CDC also developed guides for other healthcare settings:

- *Core Elements of Antibiotic Stewardship for Nursing Homes* [98]
- *Core Elements of Outpatient Antibiotic Stewardship* [99]
- *Core Elements of Human Antibiotic Stewardship Programs in Resource Limited Settings* [100].

CDC has also published an implementation guide for the Core Elements in small and critical access hospitals, *Implementation of Antibiotic Stewardship Core Elements in Small and Critical Access Hospitals* [12].

CDC will continue to use a variety of data sources, including the NHSN annual survey of hospital stewardship practices and AU Option, to find ways to optimize hospital antibiotic stewardship programs and practices. CDC will also continue to collaborate with an array of partners who share a common goal of improving antibiotic use.

With stewardship programs now in place in most US hospitals, the focus is on optimizing these programs. CDC recognizes that research is essential to discover both more effective ways to implement proven stewardship practices as well as new approaches. CDC will continue to support research efforts aimed at finding innovative solutions to stewardship challenges.

Antibiotic Stewardship Program Assessment Tool

The antibiotic stewardship program assessment tool is a companion to the *Core Elements of Hospital Antibiotic Stewardship Programs*. This tool provides examples of ways to implement the Core Elements. The Core Elements are intended to be an adaptable framework that hospitals can use to guide efforts to optimize antibiotic prescribing. Thus, not all of the examples listed in the Core Elements (and below) may be necessary and/or feasible in all hospitals.

The assessment tool can be used on a periodic basis (e.g., annually) to document current program infrastructure and activities and to help identify items that could improve the effectiveness of the stewardship program. Consider listing specific details such as point of contacts, facility-specific guidelines with date in the "comments" column as reference for the antibiotic stewardship team.

CORE ELEMENTS OF HOSPITAL ANTIBIOTIC STEWARDSHIP PROGRAMS: ASSESSMENT TOOL		ESTABLISHED AT FACILITY	COMMENTS
Hospital Leadership Commitment	1. **[Priority Example]** Does facility leadership provide stewardship program leader(s) dedicated time to manage the program and conduct daily stewardship interventions?	❑ Yes ❑ No	
	2. **[Priority Example]** Does facility leadership provide stewardship program leader(s) with resources (e.g, IT support, training) to effectively operate the program?	❑ Yes ❑ No	
	3. **[Priority Example]** Does your antibiotic stewardship program have a senior executive that serves as a point of contact or "champion" to help ensure the program has resources and support to accomplish its mission?	❑ Yes ❑ No	
	4. **[Priority Example]** Do stewardship program leader(s) have regularly scheduled meetings with facility leadership and/or the hospital board to report and discuss stewardship activities, resources and outcomes?	❑ Yes ❑ No	
	5. Does your facility leadership ensure that staff from key support departments and groups have sufficient time to contribute to stewardship activities? (refer to Core Elements for key support staff)	❑ Yes ❑ No	
	6. Does facility leadership ensure that antibiotic stewardship activities are integrated into other quality improvement and patient safety efforts, such as sepsis management and diagnostic stewardship?	❑ Yes ❑ No	

CORE ELEMENTS OF HOSPITAL ANTIBIOTIC STEWARDSHIP PROGRAMS: ASSESSMENT TOOL		ESTABLISHED AT FACILITY	COMMENTS
Hospital Leadership Commitment	7. Does facility leadership support enrollment and reporting into the National Healthcare Safety Network (NHSN) Antimicrobial Use and Resistance (AUR) Module, including any necessary IT support?	❑ Yes ❑ No	
	8. Other example(s):	❑ Yes ❑ No	
Accountability	1. Does your facility have a leader or co-leaders responsible for program management and outcomes of stewardship activities?	❑ Yes ❑ No	
	a. If a non-physician is the leader of the program, does the facility have a designated physician who can serve as a point of contact and support for the non-physician leader?	❑ Yes ❑ No ❑ NA	
	2. Other example(s):	❑ Yes ❑ No	
Pharmacy Expertise	1. Does your facility have a pharmacist(s) responsible for leading implementation efforts to improve antibiotic use?	❑ Yes ❑ No	
	2. Does your pharmacist(s) leading implementation efforts have specific training and/or experience in antibiotic stewardship?	❑ Yes ❑ No	
	3. Other example(s):	❑ Yes ❑ No	
Action: Implement Interventions to Improve Antibiotic Use	1. **[Priority Example]** Does your facility perform prospective audit and feedback for specific antibiotic agents?	❑ Yes ❑ No	
	2. **[Priority Example]** Does your facility perform preauthorization for specific antibiotic agents?	❑ Yes ❑ No	
	3. **[Priority Example]** Does your facility have facility-specific treatment recommendations, based on national guidelines and local pathogen susceptibilities, to assist with antibiotic selection for common clinical conditions?	❑ Yes ❑ No	

CORE ELEMENTS OF HOSPITAL ANTIBIOTIC STEWARDSHIP PROGRAMS: ASSESSMENT TOOL		ESTABLISHED AT FACILITY	COMMENTS
Action: Implement Interventions to Improve Antibiotic Use	4. Does your facility have specific interventions (e.g., ensuring correct discharge duration of therapy) to ensure optimal use of antibiotics for treating the **most common infections** in most hospitals?		
	a. Community-acquired pneumonia	❑ Yes ❑ No	
	b. Urinary tract infections	❑ Yes ❑ No	
	c. Skin and soft tissue infections	❑ Yes ❑ No	
	5. Does your facility have specific interventions in place to ensure optimal use of antibiotics in the following situations?		
	a. Sepsis	❑ Yes ❑ No	
	b. *Staphylococcus aureus* infection	❑ Yes ❑ No	
	c. Stopping unnecessary antibiotic(s) in new cases of *Clostridioides difficile* infection (CDI)	❑ Yes ❑ No	
	d. Culture-proven invasive (e.g., blood stream) infections	❑ Yes ❑ No	
	e. Review of planned outpatient parenteral antibiotic therapy (OPAT)	❑ Yes ❑ No	
	6. Does your facility have a policy that requires prescribers to document in the medical record or during order entry a dose, duration and indication for all antibiotic prescriptions?	❑ Yes ❑ No	
	7. Does your facility have a formal procedure for all prescribers to conduct daily reviews of antibiotic selection until a definitive diagnosis and treatment duration are established (i.e. time out)?	❑ Yes ❑ No	

CORE ELEMENTS OF HOSPITAL ANTIBIOTIC STEWARDSHIP PROGRAMS: ASSESSMENT TOOL		ESTABLISHED AT FACILITY	COMMENTS
Action: Implement Interventions to Improve Antibiotic Use	8. Other example(s):	❑ Yes ❑ No	
	9. Other example(s):	❑ Yes ❑ No	
	10. Other example(s):	❑ Yes ❑ No	
	11. Other example(s):	❑ Yes ❑ No	
Tracking Antibiotic Use and Outcomes	1. **[Priority Example]** Does your antibiotic stewardship program track antibiotic use by submitting to the National Healthcare Safety Network (NHSN) Antimicrobial Use (AU) Option?	❑ Yes ❑ No	
	2. **[Priority Example]** Does your antibiotic stewardship program monitor prospective audit and feedback interventions by tracking the types of interventions and acceptance of recommendations?	❑ Yes ❑ No	
	3. **[Priority Example]** Does your antibiotic stewardship program monitor preauthorization interventions by tracking which agents are being requested for which conditions?	❑ Yes ❑ No	
	4. **[Priority Example]** Does your stewardship program monitor adherence to facility-specific treatment recommendations?	❑ Yes ❑ No	
	5. Does your stewardship program monitor adherence to a documentation policy (dose, duration and indication)?	❑ Yes ❑ No	
	6. Does your antibiotic stewardship program monitor the performance of antibiotic timeouts to see how often these are being done and if opportunities to improve use are being acted on during timeouts?	❑ Yes ❑ No	
	7. Does your antibiotic stewardship program routinely perform medication use evaluations to assess courses of therapy for select antibiotics and/or infections to identify opportunities to improve use?	❑ Yes ❑ No	

CORE ELEMENTS OF HOSPITAL ANTIBIOTIC STEWARDSHIP PROGRAMS: ASSESSMENT TOOL		ESTABLISHED AT FACILITY	COMMENTS
Tracking Antibiotic Use and Outcomes	8. Does your antibiotic stewardship program assess how often patients are discharged on the correct antibiotics for the recommended duration?	❑ Yes ❑ No	
	9. Does your antibiotic stewardship program track antibiotic resistance by submitting to the NHSN Antimicrobial Resistance (AR) Option?	❑ Yes ❑ No	
	10. Does your antibiotic stewardship program track CDI in context of antibiotic use?	❑ Yes ❑ No	
	11. Does your facility produce an antibiogram (cumulative antibiotic susceptibility report)?	❑ Yes ❑ No	
	12. Other example(s):	❑ Yes ❑ No	
Reporting Antibiotic Use and Outcomes	1. Does your antibiotic stewardship program share facility and/or individual prescriber-specific reports on antibiotic use with prescribers?	❑ Yes ❑ No	
	2. Does your antibiotic stewardship program report adherence to treatment recommendations to prescribers (e.g., results from medication use evaluations, etc)?	❑ Yes ❑ No	
	3. Has your facility distributed a current antibiogram to prescribers?	❑ Yes ❑ No	
	4. Other example(s):	❑ Yes ❑ No	

CORE ELEMENTS OF HOSPITAL ANTIBIOTIC STEWARDSHIP PROGRAMS: ASSESSMENT TOOL		ESTABLISHED AT FACILITY	COMMENTS
Education	1. Does your stewardship program provide education to prescribers and other relevant staff on optimal prescribing, adverse reactions from antibiotics, and antibiotic resistance?	❑ Yes ❑ No	
	2. Does your stewardship program provide education to prescribers as part of the prospective audit and feedback process (sometimes called "handshake stewardship")?	❑ Yes ❑ No	
	3. Other example(s):	❑ Yes ❑ No	

Notes

Notes

References

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