The Core Elements of
Hospital Antibiotic Stewardship Programs

National Center for Emerging and Zoonotic Infectious Diseases
Division of Healthcare Quality Promotion

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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. The prompt initiation of antibiotics to treat infections has been proven to reduce morbidity and save lives, with a recent example being the rapid administration of antibiotics in the management of sepsis.[1] However, 20–50% of all antibiotics prescribed in U.S. acute care hospitals are either unnecessary or inappropriate.[2–7] Like all medications, antibiotics have serious side effects, including adverse drug reactions and *Clostridium difficile* infection (CDI).[8–11] Patients who are unnecessarily exposed to antibiotics are placed at risk for serious adverse events with no clinical benefit. The misuse of antibiotics has also contributed to the growing problem of antibiotic resistance, which has become one of the most serious and growing threats to public health.[12] Unlike other medications, the potential for spread of resistant organisms means that the misuse of antibiotics can adversely impact the health of patients who are not even exposed to them. The Centers for Disease Control and Prevention (CDC) estimates more than two million people are infected with antibiotic-resistant organisms, resulting in approximately 23,000 deaths annually.[13]

Improving the use of antibiotics is an important patient safety and public health issue as well as a national priority.[14] The 2006 CDC guideline "Management of Multi-Drug Resistant Organisms in Healthcare Settings" stated that control of multi-drug resistant organisms in healthcare "must include attention to judicious antimicrobial use."[15] In 2009, CDC launched the "Get Smart for Healthcare Campaign" to promote improved use of antibiotics in acute care hospitals and in 2013;[16] the CDC highlighted the need to improve antibiotic use as one of four key strategies required to address the problem of antibiotic resistance in the U.S.[13]

A growing body of evidence demonstrates that hospital based programs dedicated to improving antibiotic use, commonly referred to as "Antibiotic Stewardship Programs (ASPs)," can both optimize the treatment of infections and reduce adverse events associated with antibiotic use.[17, 18] These programs help clinicians improve the quality of patient care[19] and improve patient safety through increased infection cure rates, reduced treatment failures, and increased frequency of correct prescribing for therapy and prophylaxis.[20, 21] They also significantly reduce hospital rates of CDI[22–24] and antibiotic resistance.[25, 26] Moreover these programs often achieve these benefits while saving hospitals money.[17, 27–30] In recognition of the urgent need

to improve antibiotic use in hospitals and the benefits of antibiotic stewardship programs, in 2014 CDC recommended that all acute care hospitals implement Antibiotic Stewardship Programs.[7]

This document summarizes core elements of successful hospital Antibiotic Stewardship Programs. It complements existing guidelines on ASPs from organizations including the Infectious Diseases Society of America in conjunction with the Society for Healthcare Epidemiology of America, American Society of Health System Pharmacists, and The Joint Commission.[6, 31, 32] There is no single template for a program to optimize antibiotic prescribing in hospitals. The complexity of medical decision making surrounding antibiotic use and the variability in the size and types of care among U.S. hospitals require flexibility in implementation. However, experience demonstrates that antibiotic stewardship programs can be implemented effectively in a wide variety of hospitals and that success is dependent on defined leadership and a coordinated multidisciplinary approach.[33–36]

Summary of Core Elements of Hospital Antibiotic Stewardship Programs

- **Leadership Commitment:** Dedicating necessary human, financial and information technology resources.
- **Accountability:** Appointing a single leader responsible for program outcomes. Experience with successful programs show that a physician leader is effective.
- **Drug Expertise:** Appointing a single pharmacist leader responsible for working to improve antibiotic use.
- **Action:** Implementing at least one recommended action, such as systemic evaluation of ongoing treatment need after a set period of initial treatment (i.e. “antibiotic time out” after 48 hours).
- **Tracking:** Monitoring antibiotic prescribing and resistance patterns.
- **Reporting:** Regular reporting information on antibiotic use and resistance to doctors, nurses and relevant staff.
- **Education:** Educating clinicians about resistance and optimal prescribing.

Leadership Commitment

Leadership support is critical to the success of antibiotic stewardship programs and can take a number of forms, including:

- Formal statements that the facility supports efforts to improve and monitor antibiotic use.
- Including stewardship-related duties in job descriptions and annual performance reviews.
- Ensuring staff from relevant departments are given sufficient time to contribute to stewardship activities.
- Supporting training and education.
- Ensuring participation from the many groups that can support stewardship activities.

Financial support greatly augments the capacity and impact of a stewardship program and stewardship programs will often pay for themselves, both through savings in both antibiotic expenditures and indirect costs.[17, 27–30]

Accountability and Drug Expertise

- **Stewardship program leader:** Identify a single leader who will be responsible for program outcomes. Physicians have been highly effective in this role.[6]
- **Pharmacy leader:** Identify a single pharmacy leader who will co-lead the program.

Formal training in infectious diseases and/or antibiotic stewardship benefits stewardship program leaders.[6, 37, 38] 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, off-site expertise and hospitalists.[33] Hospitalists can be ideal physician leaders for efforts to improve antibiotic use given their increasing presence in inpatient care, the frequency with which they use antibiotics and their commitment to quality improvement.[37, 38] The Pharmacy and Therapeutics committee should not be considered the stewardship team within a hospital if only performing its traditional duties of managing the formulary and monitoring drug-related patient safety, though in some smaller facilities the pharmacy and therapeutics committee has expanded its role to assess and improve antibiotic use.[33–36]

Key Support

The work of stewardship program leaders is greatly enhanced by the support of other key groups in hospitals where they are available.

- **Clinicians and department heads**. As the prescribers of antibiotics, it is vital that clinicians are fully engaged in and supportive of efforts to improve antibiotic use in hospitals.
- **Infection preventionists and hospital epidemiologists** coordinate facility-wide monitoring and prevention of healthcare-associated infections and can readily bring their skills to auditing, analyzing and reporting data. They can also assist with monitoring and reporting of resistance and CDI trends, educating staff on the importance of appropriate antibiotic use, and implementing strategies to optimize the use of antibiotics.[39]
- **Quality improvement staff** can also be key partners given that optimizing antibiotic use is a medical quality and patient safety issue.
- **Laboratory staff** can guide the proper use of tests and the flow of results. They can also guide empiric therapy by creating and interpreting a facility cumulative antibiotic resistance report, known as an antibiogram. Lab and stewardship staff can work collaboratively to ensure that lab reports present data in a way that supports optimal antibiotic use. For facilities that have laboratory services performed offsite, information provided should be useful to stewardship efforts and contracts should be written to ensure this is the case.
- **Information technology staff** are critical to integrating stewardship protocols into existing workflow. Examples include embedding relevant information and protocols at the point of care (e.g., immediate access to facility-specific guidelines at point of prescribing); implementing clinical decision support for antibiotic use; creating prompts for action to review antibiotics in key situations and facilitating the collection and reporting of antibiotic use data.[40–45]
- **Nurses** can assure that cultures are performed before starting antibiotics. In addition, nurses review medications as part of their routine duties and can prompt discussions of antibiotic treatment, indication, and duration.[46, 47]

Implement Policies and Interventions to Improve Antibiotic Use

Key points

- Implement policies that support optimal antibiotic use.
- Utilize specific interventions that can be divided into three categories: broad, pharmacy driven and infection and syndrome specific.
- Avoid implementing too many policies and interventions simultaneously; always prioritize interventions based on the needs of the hospital as defined by measures of overall use and other tracking and reporting metrics.

Policies that support optimal antibiotic use

Implement policies that apply in all situations to support optimal antibiotic prescribing, for example:

- **Document dose, duration, and indication.** Specify the dose, duration and indication for all courses of antibiotics so they are readily identifiable. Making this information accessible helps ensure that antibiotics are modified as needed and/or discontinued in a timely manner.[4, 48, 49]
- **Develop and implement facility specific treatment recommendations.** Facility-specific treatment recommendations, based on national guidelines and local susceptibilities and formulary options can optimize antibiotic selection and duration, particularly for common indications for antibiotic use like community-acquired pneumonia, urinary tract infection, intra-abdominal infections, skin and soft tissue infections and surgical prophylaxis.

Interventions to improve antibiotic use

Choose interventions based on the needs of the facility as well as the availability of resources and content expertise; stewardship programs should be careful not to implement too many interventions at once.[50] Many potential interventions are highlighted in the CDC/Institute for Healthcare Improvement "Antibiotic Stewardship Driver Diagram and Change Package."[51] Assessments of the use of antibiotics as mentioned in the "Process Measures" section of this document can be a starting point for selecting specific interventions.[52]

Stewardship interventions are listed in three categories below: broad, pharmacy-driven; and infection and syndrome specific.

Broad interventions

- **Antibiotic "Time outs."** Antibiotics are often started empirically in hospitalized patients while diagnostic information is being obtained. However, providers often do not revisit the selection of the antibiotic after more clinical and laboratory data (including culture results) become available.[53–56] An antibiotic "time out" prompts a reassessment of the continuing need and choice of antibiotics when the clinical picture is clearer and more diagnostic information is available. All clinicians should perform a review of antibiotics 48 hours after antibiotics are initiated to answer these key questions:
    - Does this patient have an infection that will respond to antibiotics?
    - If so, is the patient on the right antibiotic(s), dose, and route of administration?
    - Can a more targeted antibiotic be used to treat the infection (de-escalate)?
    - How long should the patient receive the antibiotic(s)?
- **Prior authorization.** Some facilities restrict the use of certain antibiotics based on the spectrum of activity, cost, or associated toxicities[57] to ensure that use is reviewed with an antibiotic expert before therapy is initiated. This intervention requires the availability of expertise in antibiotic use and infectious diseases and authorization needs to be completed in a timely manner.
- **Prospective audit and feedback.** External reviews of antibiotic therapy by an expert in antibiotic use have been highly effective in optimizing antibiotics in critically ill patients and in cases where broad spectrum or multiple antibiotics are being used.[25, 58, 59] Prospective audit and feedback is different from an antibiotic "time out" because the audits are conducted by staff other than the treating team. Audit and feedback requires the availability of expertise and some smaller facilities have shown success by engaging external experts to advise on case reviews.[33]

Pharmacy-driven Interventions

- **Automatic changes from intravenous to oral antibiotic therapy** in appropriate situations and for antibiotics with good absorption (e.g., fluoroquinolones, trimethoprim-sulfamethoxazole, linezolid, etc.),[60, 61] which improves patient safety by reducing the need for intravenous access.

- **Dose adjustments** in cases of organ dysfunction (e.g. renal adjustment).
- **Dose optimization** including dose adjustments based on therapeutic drug monitoring, optimizing therapy for highly drug-resistant bacteria, achieving central nervous system penetration, extended-infusion administration of beta-lactams, etc.[62, 63]
- **Automatic alerts in situations where therapy might be unnecessarily duplicative** including simultaneous use of multiple agents with overlapping spectra e.g. anaerobic activity, atypical activity, Gram-negative activity and resistant Gram-positive activity.[64]
- **Time-sensitive automatic stop orders** for specified antibiotic prescriptions, especially antibiotics administered for surgical prophylaxis.[65]
- **Detection and prevention of antibiotic-related drug-drug interactions** e.g. interactions between some orally administered fluoroquinolones and certain vitamins.

Infection and syndrome specific interventions

The interventions below are intended to improve prescribing for specific syndromes; however, these should not interfere with prompt and effective treatment for severe infection or sepsis.

- **Community-acquired pneumonia.** Interventions for community-acquired pneumonia have focused on correcting recognized problems in therapy, including: improving diagnostic accuracy, tailoring of therapy to culture results and optimizing the duration of treatment to ensure compliance with guidelines.[66–70]
- **Urinary tract infections (UTIs).** Many patients who get antibiotics for UTIs actually have asymptomatic bacteriuria and not infections.[71, 72] Interventions for UTIs focus on avoiding unnecessary urine cultures and treatment of patients who are asymptomatic and ensuring that patients receive appropriate therapy based on local susceptibilities and for the recommended duration.[73–77]
- **Skin and soft tissue infections.** Interventions for skin and soft tissue infections have focused on ensuring patients do not get antibiotics with overly broad spectra and ensuring the correct duration of treatment.[60, 78, 79]

- **Empiric coverage of methicillin-resistant *Staphylococcus aureus* (MRSA) infections.** 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 methicillin-sensitive *Staphylococcus aureus*.[58, 80]

- ***Clostridium difficile* infections.** Treatment guidelines for CDI urge providers to stop unnecessary antibiotics in all patients diagnosed with CDI, but this often does not occur.[81–84] Reviewing antibiotics in patients with new diagnoses of CDI can identify opportunities to stop unnecessary antibiotics which improve the clinical response of CDI to treatment and reduces the risk of recurrence.[82, 85]

- **Treatment of culture proven invasive infections.** Invasive infections (e.g. blood stream infections) present good opportunities for interventions to improve antibiotic use because they are easily identified from microbiology results. The culture and susceptibility testing often provides information needed to tailor antibiotics or discontinue them due to growth of contaminants.[86]

Tracking and Reporting Antibiotic Use and Outcomes

Monitoring antibiotic prescribing

Measurement is critical to identify opportunities for improvement and assess the impact of improvement efforts.[87] For antibiotic stewardship, measurement may involve evaluation of both process (Are policies and guidelines being followed as expected?) and outcome (Have interventions improved antibiotic use and patient outcomes?).

Antibiotic use process measures

Perform periodic assessments of the use of antibiotics or the treatment of infections to determine the quality of antibiotic use. Examples include determining if prescribers have: accurately applied diagnostic criteria for infections; prescribed recommended agents for a particular indication; documented the indication and planned duration of antibiotic therapy; obtained cultures and relevant tests prior to treatment; and modified antibiotic choices appropriately to microbiological findings. Standardized tools such as those for drug use evaluations or antibiotic audit forms like those developed by CDC can assist in these reviews.[88] Likewise, assess if antibiotics are

being given in a timely manner and assess compliance with hospital antibiotic use policies such as the documentation of dose, duration and indication or the performance of reassessments of therapy (antibiotic time outs). These reviews can be done retrospectively on charts which could be identified based on pharmacy records or discharge diagnoses. If conducted over time, process reviews assess the impact of efforts to improve use. For interventions that provide feedback to clinicians, it is also important to document interventions and track responses to feedback (e.g., acceptance).

Antibiotic use measures

Measure antibiotic use as either days of therapy (DOT) or defined daily dose (DDD). DOT is an aggregate sum of days for which any amount of a specific antimicrobial agent is administered or dispensed to a particular patient (numerator) divided by a standardized denominator (e.g., patient days, days present, or admissions).[44, 89] If a patient is receiving two antibiotics for 10 days, the DOT numerator would be 20. An alternative measure of antibiotic use is defined daily dose (DDD). This metric estimates antibiotic use in hospitals by aggregating the total number of grams of each antibiotic purchased, dispensed, or administered during a period of interest divided by the World Health Organization-assigned DDD.[90] DDDs are often available in facilities with pharmacy systems that cannot calculate DOTs. Compared to DOT, DDD estimates are not appropriate for children, are problematic for patients with reduced drug excretion such as renal impairment, and are less accurate for between-facility benchmarking.[91] However, DDDs can be a useful measure of progress when tracked using a consistent methodology over time.[92–95] In addition to measuring overall hospital antibiotic use, antibiotic stewardship programs should also focus analyses on specific antibiotic(s) and hospital locations where stewardship actions are implemented. For example, the assessment of an intervention to improve the treatment of community-acquired pneumonia (CAP) would be expected to impact the use of antibiotics most commonly used to treat CAP on medical wards, rather than surgical wards.

As part of the National Healthcare Safety Network (NHSN), CDC has developed an Antibiotic Use (AU) Option that automatically collects and reports monthly DOT data, which can be analyzed in aggregate and by specific agents and patient care locations. The AU module is available to facilities that have information system capability to submit electronic medication administration records (eMAR) and/or bar coding medication records (BCMA) using an HL7 standardized clinical document architecture. To participate in the AU option, facility personnel can work with their information technology staff and potentially with their pharmacy information software providers to

configure their system to enable the generation of standard formatted file(s) to be imported into NHSN.[44, 89] As more facilities enroll in the AU option, CDC will begin to establish risk adjusted facility benchmarks for antibiotic use. This type of benchmarking has been helpful in improving outcomes in hospital infection control and has been identified by stewardship experts as a high priority for the U.S.[96]

Outcome measures

Track clinical outcomes that measure the impact of interventions to improve antibiotic use. Improving antibiotic use has a significant impact on rates of hospital onset CDI and the current challenge of CDI in hospitals makes this an important target for stewardship programs.[10, 18, 24, 57] An advantage of this measure is that most acute care hospitals are already monitoring and reporting information on CDI into NHSN as part of the Centers for Medicare and Medicaid Services Hospital Inpatient Quality Reporting Program.

Reducing antibiotic resistance is another important goal of efforts to improve antibiotic use and 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.[97–99] The impact of stewardship interventions on resistance is best assessed when measurement is focused on pathogens that are recovered from patients after admission (when patients are under the influence of the stewardship interventions). Monitoring resistance at the patient level (i.e. what percent of patients develop resistant super-infections) has also been shown to be useful.[99]

Stewardship programs can result in significant annual drug cost savings and even larger savings when other costs are included.[18, 20, 21, 100] These savings have been helpful in garnering support for antibiotic stewardship programs. If hospitals monitor antibiotic costs, consideration should be given to assessing the pace at which antibiotic costs were rising before the start of the stewardship program.[101] After an initial period of marked costs savings, antibiotic use patterns and savings often stabilize, so continuous decreases in antibiotic use and cost should not be expected; however, it is important to continue support for stewardship to maintain gains as costs can increase if programs are terminated.[30]

Education

Antibiotic stewardship programs should provide regular updates on antibiotic prescribing, antibiotic resistance, and infectious disease management that address both national and local issues.[2] 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.[102] 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 and flyers and newsletters or electronic communication to staff groups. Reviewing de-identified cases with providers where changes in antibiotic therapy could have been made is another useful approach. A variety of web-based educational resources are available that can help facilities develop education content.[103, 104] Education has been found to be most effective when paired with corresponding interventions and measurement of outcomes.[6]

Emerging Developments in Antibiotic Stewardship

Strategies for improving antibiotic use and evidence for best practices in antibiotic stewardship are evolving. The integration of IT into the clinical data presentation and decision-making for antibiotic use will expand with increased uptake and capabilities of electronic health records. The role of diagnostic laboratory testing is another area of evolution. Rapid diagnostic tests such as procalcitonin, fluorescence in situ hybridization using peptide nucleic acid probes (PNA FISH), and matrix-assisted laser desorption/ionization time of flight (MALDI-TOF) mass spectrometric analysis have been successfully incorporated by some stewardship programs and may become important additions to stewardship efforts.[105–108] The use of these diagnostic tools on patient care is an area of great interest, and further research is needed to determine how they can best be applied to stewardship efforts. Another area of on-going work is better characterization of the impact of antibiotic stewardship interventions on resistance. As more facilities engage in efforts to optimize antibiotic use, future work is needed to evaluate which interventions or antibiotic targets yield the greatest benefit in combating antibiotic resistance. In order to support this work, CDC's NHSN will launch the Antimicrobial Resistance (AR) Option in the summer of 2014 to facilitate evaluation of antimicrobial resistance data using a standardized approach.[89]

Checklist for Core Elements of Hospital Antibiotic Stewardship Programs

The following checklist is a companion to *Core Elements of Hospital Antibiotic Stewardship Programs.* This checklist should be used to systematically assess key elements and actions to ensure optimal antibiotic prescribing and limit overuse and misuse of antibiotics in hospitals. CDC recommends that all hospitals implement an Antibiotic Stewardship Program.

Facilities using this checklist should involve one or more knowledgeable staff to determine if the following principles and actions to improve antibiotic use are in place. The elements in this checklist have been shown in previous studies to be helpful in improving antibiotic use though not all of the elements might be feasible in all hospitals.

LEADERSHIP SUPPORT	**ESTABLISHED AT FACILITY**
A. Does your facility have a formal, written statement of support from leadership that supports efforts to improve antibiotic use (antibiotic stewardship)?	❑ Yes ❑ No
B. Does your facility receive any budgeted financial support for antibiotic stewardship activities (e.g., support for salary, training, or IT support)?	❑ Yes ❑ No
ACCOUNTABILITY	
A. Is there a physician leader responsible for program outcomes of stewardship activities at your facility?	❑ Yes ❑ No
DRUG EXPERTISE	
A. Is there a pharmacist leader responsible for working to improve antibiotic use at your facility?	❑ Yes ❑ No
KEY SUPPORT FOR THE ANTIBIOTIC STEWARDSHIP PROGRAM ***Does any of the staff below work with the stewardship leaders to improve antibiotic use?***	
B. Clinicians	❑ Yes ❑ No
C. Infection Prevention and Healthcare Epidemiology	❑ Yes ❑ No
D. Quality Improvement	❑ Yes ❑ No
E. Microbiology (Laboratory)	❑ Yes ❑ No
F. Information Technology (IT)	❑ Yes ❑ No
G. Nursing	❑ Yes ❑ No

ACTIONS TO SUPPORT OPTIMAL ANTIBIOTIC USE

POLICIES	POLICY ESTABLISHED
A. 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
B. Does your facility have facility-specific treatment recommendations, based on national guidelines and local susceptibility, to assist with antibiotic selection for common clinical conditions?	❑ Yes ❑ No

SPECIFIC INTERVENTIONS TO IMPROVE ANTIBIOTIC USE

Are the following actions to improve antibiotic prescribing conducted in your facility?

BROAD INTERVENTIONS	ACTION PERFORMED
C. Is there a formal procedure for all clinicians to review the appropriateness of all antibiotics 48 hours after the initial orders (e.g. antibiotic time out)?	❑ Yes ❑ No
D. Do specified antibiotic agents need to be approved by a physician or pharmacist prior to dispensing (i.e., pre-authorization) at your facility?	❑ Yes ❑ No
E. Does a physician or pharmacist review courses of therapy for specified antibiotic agents (i.e., prospective audit with feedback) at your facility?	❑ Yes ❑ No

PHARMACY-DRIVEN INTERVENTIONS ***Are the following actions implemented in your facility?***	ACTION PERFORMED
F. Automatic changes from intravenous to oral antibiotic therapy in appropriate situations?	❑ Yes ❑ No
G. Dose adjustments in cases of organ dysfunction?	❑ Yes ❑ No
H. Dose optimization (pharmacokinetics/pharmacodynamics) to optimize the treatment of organisms with reduced susceptibility?	❑ Yes ❑ No
I. Automatic alerts in situations where therapy might be unnecessarily duplicative?	❑ Yes ❑ No
J. Time-sensitive automatic stop orders for specified antibiotic prescriptions?	❑ Yes ❑ No

DIAGNOSIS AND INFECTIONS SPECIFIC INTERVENTIONS ***Does your facility have specific interventions in place to ensure optimal use of antibiotics to treat the following common infections?***	ACTION PERFORMED
K. Community-acquired pneumonia	❑ Yes ❑ No
L. Urinary tract infection	❑ Yes ❑ No
M. Skin and soft tissue infections	❑ Yes ❑ No
N. Surgical prophylaxis	❑ Yes ❑ No
O. Empiric treatment of Methicillin-resistant Staphylococcus aureus (MRSA)	❑ Yes ❑ No
P. Non-C. Difficile infection (CDI) antibiotics in new cases of CDI	❑ Yes ❑ No
Q. Culture-proven invasive (e.g., blood stream) infections	❑ Yes ❑ No

TRACKING: MONITORING ANTIBIOTIC PRESCRIBING, USE, AND RESISTANCE

PROCESS MEASURES	MEASURE PERFORMED	
A. Does your stewardship program monitor adherence to a documentation policy (dose, duration, and indication)?	❑ Yes	❑ No
B. Does your stewardship program monitor adherence to facility-specific treatment recommendations?	❑ Yes	❑ No
C. Does your stewardship program monitor compliance with one of more of the specific interventions in place?	❑ Yes	❑ No

ANTIBIOTIC USE AND OUTCOME MEASURES	MEASURE PERFORMED	
D. Does your facility track rates of C. difficile infection?	❑ Yes	❑ No
E. Does your facility produce an antibiogram (cumulative antibiotic susceptibility report?	❑ Yes	❑ No

Does your facility monitor antibiotic use (consumption) at the unit and/or facility wide level by one of the following metrics:	MEASURE PERFORMED	
F. By counts of antibiotic(s) administered to patients per day (Days of Therapy; DOT)?	❑ Yes	❑ No
G. By number of grams of antibiotics used (Defined Daily Dose, DDD)?	❑ Yes	❑ No
H. By direct expenditure for antibiotics (purchasing costs)?	❑ Yes	❑ No

REPORTING INFORMATION TO STAFF ON IMPROVING ANTIBIOTIC USE AND RESISTANCE

A. Does you stewardship program share facility-specific reports on antibiotic use with prescribers?	❑ Yes	❑ No
B. Has a current antibiogram been distributed to prescribers at your facility?	❑ Yes	❑ No
C. Do prescribers ever receive direct, personalized communication about how they can improve their antibiotic prescribing?	❑ Yes	❑ No

EDUCATION

A. Does your stewardship program provide education to clinicians and other relevant staff on improving antibiotic prescribing?	❑ Yes	❑ No

References

2. Dellinger RP, Levy MM, Rhodes A, et al. Surviving Sepsis Campaign: international guidelines for management of severe sepsis and septic shock, 2012. *Intensive care medicine.* Feb 2013;39(2):165–228.
3. Camins BC, King MD, Wells JB, et al. Impact of an antimicrobial utilization program on antimicrobial use at a large teaching hospital: a randomized controlled trial. *Infection control and hospital epidemiology : the official journal of the Society of Hospital Epidemiologists of America.* Oct 2009;30(10): 931–938.
4. Ingram PR, Seet JM, Budgeon CA, Murray R. Point-prevalence study of inappropriate antibiotic use at a tertiary Australian hospital. *Internal medicine journal.* Jun 2012;42(6):719–721.
5. Levin PD, Idrees S, Sprung CL, et al. Antimicrobial use in the ICU: indications and accuracy—an observational trial. *Journal of hospital medicine : an official publication of the Society of Hospital Medicine.* Nov–Dec 2012;7(9):672–678.
6. Patel SJ, Oshodi A, Prasad P, et al. Antibiotic use in neonatal intensive care units and adherence with Centers for Disease Control and Prevention 12 Step Campaign to Prevent Antimicrobial Resistance. *The Pediatric infectious disease journal.* Dec 2009;28(12):1047–1051.
7. Dellit TH, Owens RC, McGowan JE, Jr., et al. Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Jan 15 2007;44(2):159–177.
8. Fridkin SK, Baggs J, Fagan R, et al. Vital Signs: Improving Antibiotic Use Among Hospitalized Patients. *MMWR. Morbidity and mortality weekly report.* 2014;63.
9. Alshammari TM, Larrat EP, Morrill HJ, Caffrey AR, Quilliam BJ, Laplante KL. Risk of hepatotoxicity associated with fluoroquinolones: A national case-control safety study. *American journal of health-system pharmacy : AJHP : official journal of the American Society of Health-System Pharmacists.* Jan 1 2014;71(1):37–43.
10. Boggs SR, Cunnion KM, Raafat RH. Ceftriaxone-induced hemolysis in a child with Lyme arthritis: a case for antimicrobial stewardship. *Pediatrics.* Nov 2011;128(5):e1289–1292.
11. Hensgens MP, Goorhuis A, Dekkers OM, Kuijper EJ. Time interval of increased risk for *Clostridium difficile* infection after exposure to antibiotics. *The Journal of antimicrobial chemotherapy.* Mar 2012;67(3):742–748.
12. Lapi F, Wilchesky M, Kezouh A, Benisty JI, Ernst P, Suissa S. Fluoroquinolones and the risk of serious arrhythmia: a population-based study. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Dec 2012;55(11):1457–1465.
13. Huttner A, Harbarth S, Carlet J, et al. Antimicrobial resistance: a global view from the 2013 World Healthcare-Associated Infections Forum. *Antimicrobial resistance and infection control.* Nov 18 2013;2(1):31.
14. Centers for Disease Control and Prevention. *Antibiotic resistance threats in the United States, 2013.* Atlanta, GA: CDC;2013.
15. Centers for Disease Control and Prevention. CDC's Top Ten: 5 Health Achievements in 2013 and 5 Health Threats in 2014. 2013; http://blogs.cdc.gov/cdcworksforyou24-7/2013/12/cdc%e2%80%99s-top-ten-5-health-achievements-in-2013-and-5-health-threats-in-2014/ Accessed 2/24/2014.
16. Siegel JD; Rhinehart E; Jackson M; Chiarello L; Healthcare Infection Control Practices Advisory Committee. Management of Multidrug-Resistant Organisms In Healthcare Settings, 2006. 2006; http://www.cdc.gov/hicpac/pdf/MDRO/MDROGuideline2006.pdf Accessed 2/24/2014.

17. Centers for Disease Control and Prevention. Get Smart: Know When Antibiotics Work. http://www.cdc.gov/getsmart/healthcare/ Accessed 2/24/2014.
18. Davey P, Brown E, Charani E, et al. Interventions to improve antibiotic prescribing practices for hospital inpatients. *The Cochrane database of systematic reviews.* 2013;4:CD003543.
19. Malani AN, Richards PG, Kapila S, Otto MH, Czerwinski J, Singal B. Clinical and economic outcomes from a community hospital's antimicrobial stewardship program. *American journal of infection control.* Feb 2013; 41(2):145–148.
20. Stach LM, Hedican EB, Herigon JC, Jackson MA, Newland JG. Clinicians' Attitudes Towards an Antimicrobial Stewardship Program at a Children's Hospital. *Journal of the Pediatric Infectious Diseases Society.* September 1, 2012 2012;1(3):190–197.
21. Kaki R, Elligsen M, Walker S, Simor A, Palmay L, Daneman N. Impact of antimicrobial stewardship in critical care: a systematic review. *The Journal of antimicrobial chemotherapy.* Jun 2011;66(6):1223–1230.
22. Nowak MA, Nelson RE, Breidenbach JL, Thompson PA, Carson PJ. Clinical and economic outcomes of a prospective antimicrobial stewardship program. *American journal of health-system pharmacy : AJHP : official journal of the American Society of Health-System Pharmacists.* Sep 1 2012;69(17): 1500–1508.
23. Bishop J, Parry MF, Hall T. Decreasing *Clostridium difficile* infections in surgery: impact of a practice bundle incorporating a resident rounding protocol. *Connecticut medicine.* Feb 2013;77(2):69–75.
24. Leung V, Gill S, Sauve J, Walker K, Stumpo C, Powis J. Growing a "positive culture" of antimicrobial stewardship in a community hospital. *The Canadian journal of hospital pharmacy.* Sep 2011;64(5):314–320.
25. Valiquette L, Cossette B, Garant MP, Diab H, Pepin J. Impact of a reduction in the use of high-risk antibiotics on the course of an epidemic of *Clostridium difficile*-associated disease caused by the hypervirulent NAP1/027 strain. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Sep 1 2007;45 Suppl 2:S112–121.
26. DiazGranados CA. Prospective audit for antimicrobial stewardship in intensive care: impact on resistance and clinical outcomes. *American journal of infection control.* Aug 2012;40(6):526–529.
27. Elligsen M, Walker SA, Pinto R, et al. Audit and feedback to reduce broad-spectrum antibiotic use among intensive care unit patients: a controlled interrupted time series analysis. *Infection control and hospital epidemiology : the official journal of the Society of Hospital Epidemiologists of America.* Apr 2012;33(4):354–361.
28. Griffith M, Postelnick M, Scheetz M. Antimicrobial stewardship programs: methods of operation and suggested outcomes. *Expert review of anti-infective therapy.* Jan 2012;10(1):63–73.
29. Roberts RR, Hota B, Ahmad I, et al. Hospital and societal costs of antimicrobial-resistant infections in a Chicago teaching hospital: implications for antibiotic stewardship. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Oct 15 2009;49(8):1175–1184.
30. Sick AC, Lehmann CU, Tamma PD, Lee CK, Agwu AL. Sustained savings from a longitudinal cost analysis of an internet-based preapproval antimicrobial stewardship program. *Infection control and hospital epidemiology : the official journal of the Society of Hospital Epidemiologists of America.* Jun 2013;34(6):573–580.
31. Standiford HC, Chan S, Tripoli M, Weekes E, Forrest GN. Antimicrobial stewardship at a large tertiary care academic medical center: cost analysis before, during, and after a 7-year program. *Infection control and hospital epidemiology : the official journal of the Society of Hospital Epidemiologists of America.* Apr 2012;33(4):338–345.

32. The Joint Commission. Antimicrobial Stewardship Toolkit. 2013; http://store.jcrinc.com/antimicrobial-stewardship-toolkit/. Accessed 2/24/2014.

33. American Society of Health-System Pharmacists. Implementing Antimicrobial Stewardship Programs in Health Systems: An Interprofessional Team Approach. 2013; www.leadstewardship.org. Accessed 2/24/2014.

34. Yam P, Fales D, Jemison J, Gillum M, Bernstein M. Implementation of an antimicrobial stewardship program in a rural hospital. *American journal of health-system pharmacy : AJHP : official journal of the American Society of Health-System Pharmacists.* Jul 1 2012;69(13):1142–1148.

35. Goff DA, Bauer KA, Reed EE, Stevenson KB, Taylor JJ, West JE. Is the "Low-Hanging Fruit" Worth Picking for Antimicrobial Stewardship Programs? *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Jun 7 2012.

36. Ohl CA, Dodds Ashley ES. Antimicrobial stewardship programs in community hospitals: the evidence base and case studies. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Aug 2011;53 Suppl 1:S23–28; quiz S29–30.

37. Laible BR, Nazir J, Assimacopoulos AP, Schut J. Implementation of a pharmacist-led antimicrobial management team in a community teaching hospital: use of pharmacy residents and pharmacy students in a prospective audit and feedback approach. *Journal of pharmacy practice.* Dec 2010; 23(6):531–535.

38. Rohde JM, Jacobsen D, Rosenberg DJ. Role of the Hospitalist in Antimicrobial Stewardship: A Review of Work Completed and Description of a Multisite Collaborative. *Clinical therapeutics.* Jun 5 2013.

39. Srinivasan A. Engaging hospitalists in antimicrobial stewardship: the CDC perspective. *Journal of hospital medicine : an official publication of the Society of Hospital Medicine.* Jan 2011;6 Suppl 1:S31–33.

40. Moody J, Cosgrove SE, Olmsted R, et al. Antimicrobial stewardship: a collaborative partnership between infection preventionists and health care epidemiologists. *American journal of infection control.* Mar 2012;40(2):94–95.

41. Agwu AL, Lee CK, Jain SK, et al. A World Wide Web-based antimicrobial stewardship program improves efficiency, communication, and user satisfaction and reduces cost in a tertiary care pediatric medical center. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Sep 15 2008;47(6):747–753.

42. Amadeo B, Dumartin C, Parneix P, Fourrier-Reglat A, Rogues AM. Relationship between antibiotic consumption and antibiotic policy: an adjusted analysis in the French healthcare system. *The Journal of antimicrobial chemotherapy.* Feb 2011;66(2):434–442.

43. Pestotnik SL. Expert clinical decision support systems to enhance antimicrobial stewardship programs: insights from the society of infectious diseases pharmacists. *Pharmacotherapy.* Aug 2005;25(8):1116–1125.

44. Kullar R, Goff DA, Schulz LT, Fox BC, Rose WE. The EPIC Challenge of Optimizing Antimicrobial Stewardship: the Role of Electronic Medical Records and Technology. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* May 15 2013.

45. Fridkin SK, Srinivasan A. Implementing a strategy for monitoring inpatient antimicrobial use among hospitals in the United States. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Feb 2014;58(3):401–406.

46. Evans RS, Pestotnik SL, Classen DC, et al. A computer-assisted management program for antibiotics and other antiinfective agents. *The New England journal of medicine.* Jan 22 1998;338(4):232–238.

47. Edwards R, Drumright L, Kiernan M, Holmes A. Covering more Territory to Fight Resistance: Considering Nurses' Role in Antimicrobial Stewardship. *Journal of infection prevention.* Jan 2011;12(1):6–10.

48. Cheng VC, To KK, Li IW, et al. Antimicrobial stewardship program directed at broad-spectrum intravenous antibiotics prescription in a tertiary hospital. *European journal of clinical microbiology & infectious diseases : official publication of the European Society of Clinical Microbiology.* Dec 2009;28(12):1447–1456.

49. Braxton CC, Gerstenberger PA, Cox GG. Improving antibiotic stewardship: order set implementation to improve prophylactic antimicrobial prescribing in the outpatient surgical setting. *The Journal of ambulatory care management.* Apr–Jun 2010;33(2):131–140.

50. Malcolm W, Nathwani D, Davey P, et al. From intermittent antibiotic point prevalence surveys to quality improvement: experience in Scottish hospitals. *Antimicrobial resistance and infection control.* 2013;2(1):3.

51. Morris AM, Stewart TE, Shandling M, McIntaggart S, Liles WC. Establishing an antimicrobial stewardship program. *Healthcare quarterly.* 2010;13(2):64–70.

52. CDC, Institute for Healthcare Improvement. Antibiotic Stewardship Drivers and Change Package. 2013; http://www.cdc.gov/getsmart/healthcare/improve-efforts/driver-diagram/. Accessed 2/24/2014.

53. Gerber JS, Kronman MP, Ross RK, et al. Identifying Targets for Antimicrobial Stewardship in Children's Hospitals. *Infection control and hospital epidemiology : the official journal of the Society of Hospital Epidemiologists of America.* Dec 2013;34(12):1252–1258.

54. Bornard L, Dellamonica J, Hyvernat H, et al. Impact of an assisted reassessment of antibiotic therapies on the quality of prescriptions in an intensive care unit. *Medecine et maladies infectieuses.* Sep 2011;41(9): 480–485.

55. Kaye KS. Antimicrobial de-escalation strategies in hospitalized patients with pneumonia, intra-abdominal infections, and bacteremia. *Journal of hospital medicine : an official publication of the Society of Hospital Medicine.* Jan 2012;7 Suppl 1:S13–21.

56. Pardo J, Klinker KP, Borgert SJ, Trikha G, Rand KH, Ramphal R. Time to Positivity of Blood Cultures Supports Antibiotic De-escalation at 48 Hours. *The Annals of pharmacotherapy.* Nov 18 2013.

57. Stocker M, Ferrao E, Banya W, Cheong J, Macrae D, Furck A. Antibiotic surveillance on a paediatric intensive care unit: easy attainable strategy at low costs and resources. *BMC pediatrics.* 2012;12:196.

58. Dancer SJ, Kirkpatrick P, Corcoran DS, Christison F, Farmer D, Robertson C. Approaching zero: temporal effects of a restrictive antibiotic policy on hospital-acquired *Clostridium difficile,* extended-spectrum beta-lactamase-producing coliforms and meticillin-resistant *Staphylococcus aureus. International journal of antimicrobial agents.* Feb 2013;41(2):137–142.

59. Di Pentima MC, Chan S. Impact of antimicrobial stewardship program on vancomycin use in a pediatric teaching hospital. *The Pediatric infectious disease journal.* Aug 2010;29(8):707–711.

60. Toth NR, Chambers RM, Davis SL. Implementation of a care bundle for antimicrobial stewardship. *American journal of health-system pharmacy : AJHP : official journal of the American Society of Health-System Pharmacists.* May 1 2010;67(9):746–749.

61. Jenkins TC, Sabel AL, Sarcone EE, Price CS, Mehler PS, Burman WJ. Skin and soft-tissue infections requiring hospitalization at an academic medical center: opportunities for antimicrobial stewardship. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Oct 15 2010;51(8):895–903.

62. McCallum AD, Sutherland RK, Mackintosh CL. Improving antimicrobial prescribing: implementation of an antimicrobial IV-to-oral switch policy. *The journal of the Royal College of Physicians of Edinburgh.* Dec 2013;43(4): 294–300.

63. Canton R, Bryan J. Global antimicrobial resistance: from surveillance to stewardship. Part 2: stewardship initiatives. *Expert review of anti-infective therapy.* Dec 2012;10(12):1375–1377.

64. Avdic E, Cushinotto LA, Hughes AH, et al. Impact of an antimicrobial stewardship intervention on shortening the duration of therapy for community-acquired pneumonia. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Jun 2012;54(11):1581–1587.

65. Rattanaumpawan P, Morales KH, Binkley S, et al. Impact of antimicrobial stewardship programme changes on unnecessary double anaerobic coverage therapy. *The Journal of antimicrobial chemotherapy.* Nov 2011;66(11): 2655–2658.

66. Gomez MI, Acosta-Gnass SI, Mosqueda-Barboza L, Basualdo JA. Reduction in surgical antibiotic prophylaxis expenditure and the rate of surgical site infection by means of a protocol that controls the use of prophylaxis. *Infection control and hospital epidemiology : the official journal of the Society of Hospital Epidemiologists of America.* Dec 2006;27(12):1358–1365.

67. Ostrowsky B, Sharma S, Defino M, et al. Antimicrobial stewardship and automated pharmacy technology improve antibiotic appropriateness for community-acquired pneumonia. *Infection control and hospital epidemiology : the official journal of the Society of Hospital Epidemiologists of America.* Jun 2013;34(6):566–572.

68. Caterino JM, Stevenson KB. Disagreement between emergency physician and inpatient physician diagnosis of infection in older adults admitted from the emergency department. *Academic emergency medicine : official journal of the Society for Academic Emergency Medicine.* Aug 2012;19(8):908–915.

69. Bosso JA, Drew RH. Application of antimicrobial stewardship to optimise management of community acquired pneumonia. *International journal of clinical practice.* Jul 2011;65(7):775–783.

70. Mandell LA, Wunderink RG, Anzueto A, et al. Infectious Diseases Society of America/American Thoracic Society consensus guidelines on the management of community-acquired pneumonia in adults. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Mar 1 2007;44 Suppl 2:S27–72.

71. Bradley JS, Byington CL, Shah SS, et al. Executive summary: the management of community-acquired pneumonia in infants and children older than 3 months of age: clinical practice guidelines by the Pediatric Infectious Diseases Society and the Infectious Diseases Society of America. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Oct 2011;53(7):617–630.

72. Nicolle LE. Asymptomatic bacteriuria. *Current opinion in infectious diseases.* Feb 2014;27(1):90–96.

73. Gandhi T, Flanders SA, Markovitz E, Saint S, Kaul DR. Importance of urinary tract infection to antibiotic use among hospitalized patients. *Infection control and hospital epidemiology : the official journal of the Society of Hospital Epidemiologists of America.* Feb 2009;30(2):193–195.

74. Drekonja DM, Abbo LM, Kuskowski MA, Gnadt C, Shukla B, Johnson JR. A survey of resident physicians' knowledge regarding urine testing and subsequent antimicrobial treatment. *American journal of infection control.* Oct 2013;41(10):892–896.

75. Hermanides HS, Hulscher ME, Schouten JA, Prins JM, Geerlings SE. Development of quality indicators for the antibiotic treatment of complicated urinary tract infections: a first step to measure and improve care. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Mar 1 2008;46(5):703–711.

76. Slekovec C, Leroy J, Vernaz-Hegi N, et al. Impact of a region wide antimicrobial stewardship guideline on urinary tract infection prescription patterns. *International journal of clinical pharmacy.* Apr 2012;34(2):325–329.

77. Hooton TM, Bradley SF, Cardenas DD, et al. Diagnosis, prevention, and treatment of catheter-associated urinary tract infection in adults: 2009 International Clinical Practice Guidelines from the Infectious Diseases Society of America. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Mar 1 2010;50(5):625–663.

78. Gupta K, Hooton TM, Naber KG, et al. International clinical practice guidelines for the treatment of acute uncomplicated cystitis and pyelonephritis in women: A 2010 update by the Infectious Diseases Society of America and the European Society for Microbiology and Infectious Diseases. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Mar 1 2011;52(5):e103–120.

79. Stevens DL, Bisno AL, Chambers HF, et al. Practice guidelines for the diagnosis and management of skin and soft-tissue infections. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Nov 15 2005;41(10):1373–1406.

80. Lipsky BA, Berendt AR, Cornia PB, et al. 2012 Infectious Diseases Society of America clinical practice guideline for the diagnosis and treatment of diabetic foot infections. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Jun 2012;54(12):e132–173.

81. Johannsson B, Johnson SJ, Ernst EJ, et al. Antimicrobial Therapy for Bloodstream Infection Due to Methicillin-Susceptible *Staphylococcus aureus* in an Era of Increasing Methicillin Resistance: Opportunities for Antimicrobial Stewardship. *The Annals of pharmacotherapy.* Jun 2012;46(6):904–905.

82. Cohen Stuart HMD, Gerding Dale NMD, Stuart Johnson MD, et al. Clinical Practice Guidelines for *Clostridium difficile* Infection in Adults: 2010 Update by the Society for Healthcare Epidemiology of America (SHEA) and the Infectious Diseases Society of America (IDSA). *Infection Control and Hospital Epidemiology.* 2010;31(5):431–455.

83. Drekonja DM, Amundson WH, Decarolis DD, Kuskowski MA, Lederle FA, Johnson JR. Antimicrobial use and risk for recurrent *Clostridium difficile* infection. *The American journal of medicine.* Nov 2011;124(11):1081 e1081–1087.

84. Harpe SE, Inocencio TJ, Pakyz AL, Oinonen MJ, Polk RE. Characterization of continued antibacterial therapy after diagnosis of hospital-onset *Clostridium difficile* infection: implications for antimicrobial stewardship. *Pharmacotherapy.* Aug 2012;32(8):744–754.

85. Shaughnessy MK, Amundson WH, Kuskowski MA, DeCarolis DD, Johnson JR, Drekonja DM. Unnecessary antimicrobial use in patients with current or recent *Clostridium difficile* infection. *Infection control and hospital epidemiology : the official journal of the Society of Hospital Epidemiologists of America.* Feb 2013;34(2):109–116.

86. Mullane KM, Miller MA, Weiss K, et al. Efficacy of fidaxomicin versus vancomycin as therapy for *Clostridium difficile* infection in individuals taking concomitant antibiotics for other concurrent infections. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Sep 2011;53(5):440–447.

87. Garnacho-Montero J, Gutierrez-Pizarraya A, Escoresca-Ortega A, et al. De-escalation of empirical therapy is associated with lower mortality in patients with severe sepsis and septic shock. *Intensive care medicine.* Jan 2014;40(1):32–40.

88. Institute for Healthcare Improvement. Science of Improvement: Establishing Measures. 2011; http://www.ihi.org/knowledge/Pages/HowtoImprove/ScienceofImprovementEstablishingMeasures.aspx. Accessed 1/14/14.

89. Centers for Disease Control and Prevention. Antibiotic audit forms. 2013; http://www.cdc.gov/getsmart/healthcare/implementation.html. Accessed 3/3/2014.

90. Centers for Disease Control and Prevention. Antimicrobial Use and Resistance (AUR) Module. http://www.cdc.gov/nhsn/PDFs/pscManual/11pscAURcurrent.pdf. Accessed 2/24/14.

91. World Health Organization Collaborating Centre for Drug Statistics Methodology. ATC Index with DDDs. 2014; http://www.whocc.no/atc_ddd_index/. Accessed 1/14/2014.

92. Polk RE, Fox C, Mahoney A, Letcavage J, MacDougall C. Measurement of adult antibacterial drug use in 130 US hospitals: comparison of defined daily dose and days of therapy. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Mar 1 2007;44(5):664–670.

93. Ibrahim OM, Polk RE. Benchmarking antimicrobial drug use in hospitals. *Expert review of anti-infective therapy.* Apr 2012;10(4):445–457.

94. Polk RE, Hohmann SF, Medvedev S, Ibrahim O. Benchmarking risk-adjusted adult antibacterial drug use in 70 US academic medical center hospitals. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Dec 2011;53(11):1100–1110.

95. Pakyz AL, MacDougall C, Oinonen M, Polk RE. Trends in antibacterial use in US academic health centers: 2002 to 2006. *Archives of internal medicine.* Nov 10 2008;168(20):2254–2260.

96. Fridkin SK, Steward CD, Edwards JR, et al. Surveillance of antimicrobial use and antimicrobial resistance in United States hospitals: project ICARE phase 2. Project Intensive Care Antimicrobial Resistance Epidemiology (ICARE) hospitals. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Aug 1999;29(2):245–252.

97. Government Accounting Office. Antibiotic resistance: data gaps will remain despite HHS taking steps to improve monitoring. GAO-11-406. 2011; http://www.gao.gov/assets/320/319110.pdf. Accessed 2/24/2014.

98. McGowan JE. Antimicrobial stewardship—the state of the art in 2011: focus on outcome and methods. *Infection control and hospital epidemiology : the official journal of the Society of Hospital Epidemiologists of America.* Apr 2012;33(4):331–337.

99. Schulz LT, Fox BC, Polk RE. Can the antibiogram be used to assess microbiologic outcomes after antimicrobial stewardship interventions? A critical review of the literature. *Pharmacotherapy.* Aug 2012;32(8):668–676.

100. Schechner V, Temkin E, Harbarth S, Carmeli Y, Schwaber MJ. Epidemiological interpretation of studies examining the effect of antibiotic usage on resistance. *Clinical microbiology reviews.* Apr 2013;26(2):289–307.

101. Fishman N. Antimicrobial stewardship. *American journal of infection control.* Jun 2006;34(5 Suppl 1):S55–63; discussion S64–73.

102. Beardsley JR, Williamson JC, Johnson JW, Luther VP, Wrenn RH, Ohl CC. Show me the money: long-term financial impact of an antimicrobial stewardship program. *Infection control and hospital epidemiology : the official journal of the Society of Hospital Epidemiologists of America.* Apr 2012;33(4):398–400.

103. Patel SJ, Saiman L, Duchon JM, Evans D, Ferng YH, Larson E. Development of an antimicrobial stewardship intervention using a model of actionable feedback. *Interdisciplinary perspectives on infectious diseases.* 2012;2012:150367.

104. Gauthier TP, Lantz E, Heyliger A, Francis SM, Smith L. Internet-Based Institutional Antimicrobial Stewardship Program Resources in Leading US Academic Medical Centers. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Feb 2014;58(3):445–446.

105. Society of Infectious Diseases Pharmacists. Antimicrobial Stewardship: A Certificate Program for Pharmacists. 2012; http://www.sidp.org/Default.aspx?pageId=1442823. Accessed 2/24/1014.

106. Vlek AL, Bonten MJ, Boel CH. Direct matrix-assisted laser desorption ionization time-of-flight mass spectrometry improves appropriateness of antibiotic treatment of bacteremia. *PloS one.* 2012;7(3):e32589.

107. Huang AM, Newton D, Kunapuli A, et al. Impact of rapid organism identification via matrix-assisted laser desorption/ionization time-of-flight combined with antimicrobial stewardship team intervention in adult patients with bacteremia and candidemia. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America.* Nov 2013;57(9):1237–1245.

108. Holtzman C, Whitney D, Barlam T, Miller NS. Assessment of impact of peptide nucleic acid fluorescence in situ hybridization for rapid identification of coagulase-negative staphylococci in the absence of antimicrobial stewardship intervention. *Journal of clinical microbiology.* Apr 2011;49(4):1581–1582.

109. Forrest GN, Roghmann MC, Toombs LS, et al. Peptide nucleic acid fluorescent in situ hybridization for hospital-acquired enterococcal bacteremia: delivering earlier effective antimicrobial therapy. *Antimicrobial agents and chemotherapy.* Oct 2008;52(10):3558–3563.