

*National Action Plan to
Prevent Health Care-
Associated Infections: Road
Map to Elimination*

Phase Four: Coordination among Federal Partners
to Leverage HAI Prevention and Antibiotic
Stewardship

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FOREWORD

Prevention of health care-associated infections (HAIs) continues to be a public health priority of the U.S. Department of Health and Human Services (HHS). As health care quality activities progress, it is important to recognize the interconnected relationship between HAIs, antibiotic use, and antibiotic resistance. Prevention of HAIs leads to fewer illnesses requiring antibiotic treatment. Proper use of antibiotics slows the development and spread of antibiotic resistant organisms that can be difficult to treat. Focused HAI prevention activities and improved antibiotic use are synergistic and can amplify the impact of broader efforts to slow the development of antibiotic resistance. The federal government maintains two national action plans with goals related to HAI prevention: the *HHS Action Plan to Prevent Health Care-Associated Infections (HAI Action Plan)* (2009) and the *National Action Plan for Combating Antibiotic-Resistant Bacteria (CARB Action Plan)* (2015). While these plans cover many other distinct topics, both recognize the relationship between improved antibiotic use and the potential to prevent and reduce rates of infections that may occur during the course of health care delivery.

In recent years, federal agencies have worked to enhance collaboration by sharing and disseminating resources and lessons learned. In an era of evidence-based medicine coupled with limited resources, improved coordination can lead to better health care delivery and improved outcomes. To highlight this collaboration and coordination among federal agencies, the Federal Steering Committee for the Prevention of HAIs tasked the Office of Disease Prevention and Health Promotion (ODPHP) within the Office of the Assistant Secretary for Health (OASH) to develop a “Phase Four” of the *HAI Action Plan*. Phase Four is intended to demonstrate the complementary work of federal agencies on antibiotic stewardship efforts, describe the relationship between HAIs and antibiotic resistance, and to point the way for future health care quality improvement efforts.

INTRODUCTION

Multiple steps can be taken to reduce HAIs, such as infection control, hand hygiene, aseptic techniques, and proper use of antibiotics. Any use of an antibacterial drug creates selective pressure that can drive the development of resistance. Antibiotics are used for both HAI treatment and prevention, and effective prevention of HAIs helps reduce antibiotic use and slow the development of antibiotic resistance. Since the 1940s these drugs have greatly reduced illness and death, but widespread and indiscriminate use of antibiotics has accelerated the development of antibiotic-resistant organisms, in some cases rendering many drugs ineffective.¹

Antibiotic resistance is a growing, serious public health threat. Organisms can develop resistance when antibiotics are prescribed and administered appropriately, yet inappropriate antibiotic use is a preventable driver of resistance. Studies have demonstrated that treatment indication, choice of antibiotic, or duration of therapy can be incorrect in up to 30% of the instances in which antibiotics are prescribed,² and data suggest that prescribing practices for antibiotics vary widely across the U.S.³ Immunization against vaccine-preventable diseases can reduce antibiotic use and is a public health priority.

Judicious use of antibiotics is essential to slow the development of resistance, help prevent untreatable infections, and extend the useful lifetime of our most urgently needed antibiotics. Antibiotic stewardship is thought to be among the most effective approaches to improving antibiotic use. Antibiotic stewardship can optimize clinical outcomes, minimize unintended consequences, improve patient safety, and improve the cost effectiveness of antibiotic use through a multidisciplinary approach that reduces inappropriate antibiotic use. Antibiotic stewardship is important across the spectrum of health care.

Many health care settings have developed Antibiotic Stewardship Programs (ASPs) to provide guidance to clinicians to drive improvements in antibiotic use, regular updates on antibiotic prescribing patterns, antibiotic resistance patterns, and infectious disease management. ASPs have been shown to improve individual patient outcomes, reduce the overall burden of antibiotic resistance, and save health care dollars.⁴ If everyone — health care providers, health care administrators, policy makers, family members, caregivers, and patients — works together to improve antibiotic use, we can improve patient care, more effectively combat antibiotic resistance, and ultimately save lives.

Antibiotic resistant organisms are among the most serious consequences of excessive antibiotic use and constitute an important public health problem. Each year in the United States at least two million people become infected with bacteria that are resistant to antibiotics, and at least 23,000 people die as a direct

¹ Antibiotic/Antimicrobial Resistance. Centers for Disease Control and Prevention website <http://www.cdc.gov/drugresistance/index.html>. Updated August 18, 2017. Accessed October 30, 2017.

² Fleming-Dutra KE, Friedman CR, Hicks LA. Early azithromycin treatment to prevent severe lower respiratory tract illnesses in children. *JAMA*. 2016; 315(17):1864-73.

³ Hicks LA, Bartoces MG, Suda KJ, Hunkler RJ, Taylor TH Jr, Schrag SJ. US outpatient antibiotic prescribing variation according to geography, patient population, and provider specialty in 2011. *Clin Infect Dis*. 2015; 60(9):1308-16.

⁴ Doron S, Davidson LE. Antimicrobial stewardship. *Mayo Clin Proc*. 2011; 86(11): 1113-1123.

result of these infections.⁵ Over the past two decades, antibiotic resistance in hospitals and communities continues to rise at an alarming rate, despite widespread efforts to prevent or control it.⁵ At the same time, antibiotic drug development has slowed and the approval of new antibiotics is not keeping pace with the emergence of multi-drug-resistant organisms (MDROs). MDROs cause infections associated with prolonged and costlier treatments, longer hospital stays, and long-term negative health impacts for patients. It is estimated that the cost of antibiotic-resistant infections to U.S. hospitals is eight million excess hospital days and \$21 billion each year.⁵

In 2013, the Centers for Disease Control and Prevention (CDC) published a threat report outlining the top eighteen drug-resistant threats to the U.S.⁵ The threats listed in **Table A** are categorized based on level of concern (urgent, serious or concerning), with urgent and serious threats requiring surveillance and prevention efforts. Several organisms on the threat list have been mentioned in earlier Phases of the *HAI Action Plan*, such as *Clostridium difficile* infection (CDI), vancomycin-resistant *Enterococcus*, methicillin-resistant *Staphylococcus aureus* (MRSA), and vancomycin-resistant *Staphylococcus aureus*.

In 2009, HHS released the *HHS Action Plan to Prevent Health Care-Associated Infections* to address the increasing concerns around HAIs and the need for increased coordination and collaboration of activities within the Department. This *Action Plan* initially focused on six high-priority HAIs within acute care hospital settings: surgical site infections, central-line-associated bloodstream infections (CLABSIs), ventilator-associated pneumonia, catheter-associated urinary tract infection (CAUTI), CDI, and MRSA infection. In 2011, the *Action Plan* was expanded to include a Phase Two that focused on ambulatory surgical centers, end-stage renal disease (ESRD) facilities, and influenza vaccination of health care personnel. Soon after, Phase Three was released and included long-term care facilities (LTCFs) and updated the name of the Action Plan to the *National Action Plan to Prevent Health Care-Associated Infections: Road Map to Elimination (HAI Action Plan)*.

In 2015, the U.S. Government released the *CARB National Action Plan*, a five-year roadmap to guide the nation in reducing and preventing the spread of antibiotic resistance. The *CARB Action Plan* encompasses surveillance, research, innovation, education and outreach, and global coordination around both human and animal health, with a goal specifically focused on slowing the emergence of resistant bacteria and preventing the spread of resistant infections. Within this goal, the *CARB Action Plan* highlights the importance of judicious use of antibiotics in health care settings as essential to slowing the emergence of resistance and extending the useful lifetime of effective antibiotics. Many of the objectives and milestones within this goal focus on supporting implementation of ASPs in a variety of health care settings.

The first three Phases of the *HAI Action Plan* led to meaningfully enhanced coordination of federal efforts to address HAIs by establishing a structure to regularly share best practices, resources, and lessons learned among federal partners. Given the pressing public health threat of antibiotic resistance and the need to maximize efficiency of federal activities, the Federal Steering Committee for the Prevention of Health Care-Associated Infections (HAI FSC) recognized the opportunity to leverage this existing

⁵Centers for Disease Control and Prevention. Antibiotic resistance threats in the United States, 2013. Atlanta, GA: US Department of Health and Human Services, CDC; 2013. <https://www.cdc.gov/drugresistance/threat-report-2013/index.html>. Updated April 10, 2017. Accessed June 27, 2017.

committee and network of participants to work collaboratively with the Presidential Advisory Council on Combatting Antibiotic Resistance (PACCARB) to enhance the implementation of the CARB goal of slowing the emergence of resistant bacteria through antibiotic stewardship programs in health care settings.

Phase Four of the *HAI Action Plan* reviews current federal antibiotic stewardship efforts across various health care settings, highlighting the importance of antibiotic stewardship to prevent resistance in HAIs and the coordination between various health agencies (exampled in **Table B**). The “Next Steps” section of Phase Four describes efforts that will reinforce and complement the *CARB Action Plan* objectives for improvements in health care quality and slowing the emergence of resistance.

Phase Four also aligns and supports other larger federal efforts to prevent and address antibiotic resistance, including the PACCARB and implementation of Section 3041 of the 21st Century Cures Act. The PACCARB provides advice, information, and recommendations to the Secretary of HHS intended to support and elevate the implementation of the U.S. government activities related to combating antibiotic resistant bacteria. The Secretary transmits all written reports created by the PACCARB to the President. The PACCARB members include experts in human, biomedical, public health, and agricultural fields. Phase Four also supports efforts implemented in response to the 21st Century Cures Act, which was signed into law in December 2016. The Act requires HHS to encourage the health care facilities of the DoD, Department of Veterans Affairs (VA), and the Indian Health Service (IHS) to report on antimicrobial drug use, microbial resistance to antimicrobial drugs, and antimicrobial stewardship programs. The Act also requires HHS to annually publish information on antimicrobial resistance and antimicrobial stewardship; disseminate guidance and materials regarding antimicrobial stewardship; continue working with state and local public health departments on antimicrobial resistance programs; and collect, evaluate, and publish data from the antimicrobial stewardship activities of health care facilities.⁶

Finally, Phase Four presents actions that leverage the HAI FSC as a unique opportunity to enhance coordination of federal activities. Building on the work of the HAI FSC, Phase Four highlights the network within the committee and its effectiveness in leveraging existing relationships. Those relationships are well positioned to enhance federal coordination and activities related to the goals of the *CARB Action Plan*. Phase Four showcases the essential nature of coordination and collaboration among federal partners engaged in antibiotic stewardship and HAI prevention. This update to the *HAI Action Plan* reaffirms a federal commitment towards improving health care quality and protecting the health of all Americans.

⁶ 21st Century Cures Act, Pub. L. 114-255, 130 Stat.1033, Dec 13, 2016. <https://www.congress.gov/bill/114th-congress/house-bill/34/>. Accessed November 3, 2017.

ANTIBIOTIC STEWARDSHIP

SCOPE OF THE PROBLEM

Inappropriate antibiotic use has been identified as a problem in inpatient, outpatient, and long-term care settings. The following sections describe trends in antibiotic use in these settings.

HOSPITALS

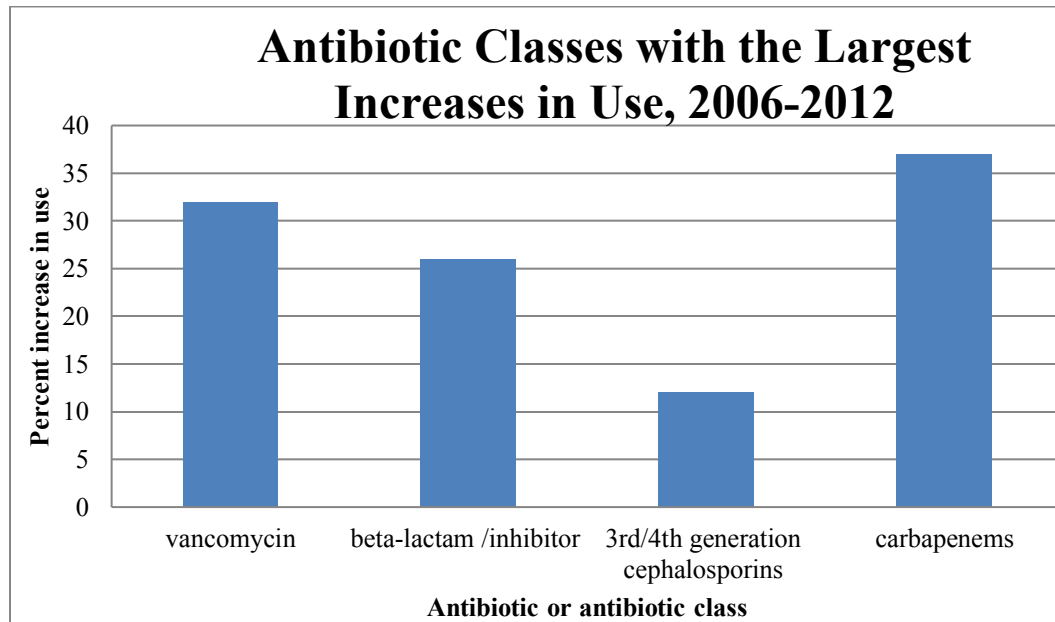
Antibiotics are used frequently in hospitals. In 2011, CDC's Emerging Infections Program found that 50% of patients receive an antibiotic for at least one day during an average hospital stay.⁷ In a 2016 study, CDC experts found that overall rates of antibiotic use in U.S. hospitals did not change from 2006-2012, with more than half of patients receiving at least one antibiotic during their hospital stay (**Figure 1**). However, there were significant changes across that time period in the types of antibiotics prescribed, with increasing use over time to the most powerful antibiotics. There was a 37% rise in the use of carbapenems, which are largely reserved for treatment of organisms that are resistant to most other antibiotics, and a 32% rise in the use of vancomycin, an antibiotic with efficacy against MRSA. Infections caused by carbapenem-resistant organisms can be especially difficult to treat, and even deadly. Data from CDC's National Healthcare Safety Network (NHSN) Antibiotic Use Option show that health care providers in some hospitals prescribe up to three times as many antibiotics as providers in similar areas of other hospitals. In fact, one-third of antibiotic prescriptions in hospitals involve potential prescribing errors such as giving an antibiotic without proper testing or evaluation, prescribing an antibiotic when it is not needed, or giving an antibiotic for too long.⁸

⁷ McAllister L, Neuhauser M, Beldavs ZG, Dumyati G, Duran J, Edwards J, Kainer MA, Lynfield R, Melchreit R, Nadle J, Ray SM, Thompson D, Wilson L, Fridkin S. Point prevalence survey of antimicrobial use in US acute care hospitals. Oral presentation at: IDWeek; October 2012; San Diego, CA.

<https://idsa.confex.com/idsa/2012/webprogram/Paper34846.html>. Accessed October 30, 2017.

⁸ Hecker MT, Aron DC, Patel NP, Lehmann MK, Donskey CJ. Unnecessary use of antimicrobials in hospitalized patients: current patterns of misuse with an emphasis on the anti-anaerobic spectrum of activity. *Arch Intern Med* 2003;163:972–8.

Figure 1: Antibiotic use in U.S. hospitals from 2006-2012



Research indicates there is a need for educational initiatives and larger dissemination of practice guidelines on antibiotic stewardship. A study found that while physicians at a teaching hospital were aware of the relationship between antibiotic use and resistance, they believed that overprescribing was more of a problem with others than themselves; however, the majority of physicians still wanted to learn more about antibiotics and feedback on their own use.⁹ A similar study found disparities in knowledge between specialties.¹⁰

A national survey of antibiotic use facilitated by CDC's Emerging Infections Program found that two out of three antibiotics in hospitals are given for three conditions: pneumonia, urinary tract infections, or skin infections. Improving prescribing practices for those three conditions could have a significant impact on improving appropriate antibiotic use. Likewise, studies have shown that there are many opportunities to improve the use of vancomycin and fluoroquinolones, two of the most commonly prescribed types of antibiotics used in hospitals. It is estimated that reducing use of these antibiotics by 30% would only contribute to a 5% reduction in overall antibiotic use, but would prevent 26% of CDI associated with inpatient antibiotic therapy. Reducing inpatient CDI by this magnitude could also have additional benefit

⁹ Abbo L, Sinkowitz-Cochran R, Smith L, Aria-Heredia E, Gomez-Marin O, Srinivasan A, Hooton TM. Faculty and resident physicians' attitudes, perceptions, and knowledge about antimicrobial use and resistance. *Infect Control Hosp Epidemiol.* 2011;32(7):714-8.

¹⁰ Srinivasan A, Song X, Sinkowitz-Cochran R, Cardo D, Rand C. A survey of knowledge, attitudes, and beliefs of house staff physicians from various specialties concerning antimicrobial use and resistance. *Arch Intern Med.* 2004;164(13):1451-6.

toward reducing transmission of *C. difficile* throughout the community.¹¹ The *CARB Action Plan* sets a goal that, by the year 2020, all hospitals will have antibiotic stewardship programs to help reduce inappropriate antibiotic prescriptions in hospitals by 20%. While some have considered this goal to be aspirational, efforts from the Federal sector within the VA nationwide healthcare system (Veterans Health Administration/VHA) have demonstrated sizeable system-wide reductions are achievable, with a coordinated program and effort starting with education and strong administrative support. After inception of a national antimicrobial stewardship initiative, VHA was able to achieve a 12% reduction in hospital antibiotic use nationwide.¹² An added benefit is that comprehensive efforts to improve antibiotic use have consistently demonstrated direct cost savings of up to hundreds of thousands of dollars per year for a single hospital.¹³

LONG-TERM CARE FACILITIES

Most long-term care facilities (LTCFs) in the United States are nursing homes (NHs) caring for older adults. In 2014, more than 15,600 NHs provided care for more than 1.4 million residents, of whom nearly 85% were 65 years of age or older.¹⁴ It has been estimated that nearly 6-11% of NH residents are taking systemic antibiotics at any given time, yet up to half of antibiotics are prescribed without an evidence-based indication.^{15, 16, 17, 18} Frequent or extended use of antibiotics is known to place residents at increased risk of developing an infection with an antibiotic-resistant organism or CDI, and residents of facilities with high antibiotic utilization are at increased risk of experiencing adverse antibiotic-associated

¹¹ Centers for Disease Control and Prevention. Vital signs: improving antibiotic use among hospitalized patients. *MMWR Morb Mortal Wkly Rep.* 2014; 63(09):194-200. <https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6309a4.htm> Updated March 7, 2014. Accessed October 30, 2017.

¹² Kelly AA, Jones MM, Echevarria KL, Kralovic SM, Samore MH, Goetz MB, Madaras-Kelly KJ, Simbarti LA, Morreale AP, Neuhauser MM, Roselle GA. A report of the efforts of the veterans health administration national antimicrobial stewardship initiative, *Infect Control Hosp Epidemiol.* 2017; 38(5):513-520.

¹³ Dellit TH, Owens RC, McGowan JE, Jr., Gerding DN, Weinstein RA, Burke JP, Huskins WC, Paterson DL, Fishman NO, Carpenter CF, Brennan PJ, Billeter M, Hooton TM, Infectious Diseases Society of America, Society for Healthcare Epidemiology of America. Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship. *Clin Infect Dis.* 2007; 44(2):159-177.

¹⁴ Centers for Medicare and Medicaid Services. *Nursing Home Data Compendium 2015 Edition.* 2015.

https://www.cms.gov/Medicare/Provider-Enrollment-and-Certification/CertificationandCompliance/Downloads/nursinghomedatacompendium_508-2015.pdf. Accessed October 30, 2017.

¹⁵ Pakyz AL, Dwyer LL. Prevalence of antimicrobial use among United States nursing home residents: results from a national survey. *Infect Control Hosp Epidemiol.* 2010; 31(6):661-662.

¹⁶ Daneman N, Gruneir A, Newman A, Fischer HD, Bronskill SE, Rochon PA, Anderson GM, Bell CM. Antibiotic use in long-term care facilities. *J Antimicrob Chemother.* 2011; 66(12):2856-2863.

¹⁷ Phillips CD, Adepoju O, Stone N, Moudouni DK, Nwaiwu O, Zhao H, Frentzel E, Mehr D, Garfinkel S. Asymptomatic bacteriuria, antibiotic use, and suspected urinary tract infections in four nursing homes. *BMC Geriatrics.* 2012; 12:73.

¹⁸ Peron EP, Hirsch AA, Jury LA, Jump RL, Donskey CJ. Another setting for stewardship: high rate of unnecessary antimicrobial use in a veterans affairs long-term care facility. *J Am Geriatr Soc.* 2013; 61(2):289-290.

outcomes, even if they do not directly receive antibiotic therapy.^{19, 20, 21, 22} These consequences create significant burden for patients, families, and the health care system; NH-onset *C. difficile* alone is associated with a 30-day mortality rate of 8-10% and annual costs of \$800 million.^{18, 23} Phase Three of the *HAI Action Plan* included CDI as a priority area and recommended the goal to pilot implementation of reporting to NHSN, evaluate variability in measures, and obtain consensus on measureable five-year goals.

OUTPATIENT SETTINGS

In 2015, approximately 269 million antibiotics were dispensed from outpatient pharmacies in the U.S. – enough to provide one antibiotic to five out of every six individuals –²⁴ over 60% of all human antibiotic prescribing.²⁵ An estimated 30% of all oral antibiotic prescriptions in outpatient settings are unnecessary, and the rate of inappropriate prescribing is even higher for acute respiratory conditions.^{24, 26} Even when antibiotics are needed, providers often prescribe drugs that may be less effective and carry more risk than drugs indicated in treatment guidelines.²⁴

Overall antibiotic prescribing decreased by 5% decrease from 2011 to 2014 in outpatient settings. Although antibiotic prescribing noticeably declined in children (ages 0-19) from 75 million prescriptions in 2011 to about 64 million prescriptions in 2014, antibiotic prescription rates for adults have remained

¹⁹ Drinka PJ, Crnich CJ, Nace DA. An antibiotic prescription induces resistance at the individual level more than the group level. *J Am Med Dir Assoc.* 2013; 14(9):707-708.

²⁰ Hunter JC, Mu Y, Dumyati GK, Farley MM, Winston LG, Johnston HL, Meek JI, Perlmutter R, Holzbauer SM, Beldavs ZG, Phipps EC, Dunn JR, Cohen JA, Avillan J, Stone ND, Gerding DN, McDonald LC, Lessa FC. Burden of nursing home-onset clostridium difficile infection in the United States: estimates of incidence and patient outcomes. *Open Forum Infect Dis.* 2016; 3(1):ofv196.

²¹ Zilberberg MD, Shorr AF, Wang L, Baser O, Yu H. Development and validation of a risk score for Clostridium difficile infection in Medicare beneficiaries: a population-based cohort study. *J Am Geriatr Soc.* 2016; 64(8):1690-1695.

²² Daneman N, Bronskill SE, Gruneir A, Newman AM, Fischer HD, Rochon PA, Anderson GM, Bell CM. Variability in antibiotic use across nursing homes and the risk of antibiotic-related adverse outcomes for individual residents. *JAMA Intern Med.* 2015; 175(8):1331-1339.

²³ Yu H, Baser O, Wang L. Burden of Clostridium difficile-associated disease among patients residing in nursing homes: a population-based cohort study. *BMC geriatrics.* 2016; 16(1):193.

²⁴ Centers for Disease Control and Prevention. Antibiotic use in the United States, 2017: progress and opportunities. Atlanta, GA: US Department of Health and Human Services, CDC; 2017. <https://www.cdc.gov/antibiotic-use/stewardship-report/pdf/stewardship-report.pdf>. Accessed October 30, 2017

²⁵ Suda KJ, Hicks LA, Roberts RM, Hunkler RJ, Danziger LH. A national evaluation of antibiotic expenditures by healthcare setting in the United States, 2009. *J Antimicrob Chemother.* 2013; 68(3):715-718.

²⁶ Fleming-Dutra KE, Hersh AL, Shapiro DJ, Bartoces M, Enns EA, File TM Jr, Finkelstein JA, Gerber JS, Hyun DY, Linder JA, Lynfield R, Margolis DJ, May LS, Merenstein D, Metlay JP, Newland JG, Piccirillo JF, Roberts RM, Sanchez GV, Suda KJ, Thomas A, Woo TM, Zetts RM, Hicks LA. Prevalence of inappropriate antibiotic prescriptions among US ambulatory care visits, 2010-2011. *Jama.* 2016; 315(17):1864-1873.

comparatively stable from about 192 million in 2011 to 198 million in 2014. Children under the age of two and adults age 65 years and older still receive the most antibiotic prescriptions overall.²⁷

Most of these unnecessary prescriptions are for respiratory conditions most commonly caused by viruses – such as the common cold, sore throats, and bronchitis – which do not respond to antibiotics. Even some bacterial infections do not need antibiotic therapy, such as many sinus and ear infections.²⁸

Some adverse events might be more common in dialysis settings, given altered pharmacokinetics and polypharmacy in patients requiring chronic hemodialysis.²⁹ Limited data have been collected on patient outcomes in ESRD facilities, but infection is recognized as the second leading cause of hospitalization and death in this patient population.^{30,31, 32} The United States Renal Data System reported that from 1993 to 2010, the number of hospitalizations due to infection rose by 45.8%; these infections are associated with up to 20% mortality, and mortality rates are substantially higher for infections from multi-drug resistant organisms.³³ Addressing antibiotic resistance in ESRD facilities is part of the larger effort to prevent HAIs in ESRD facilities, this is addressed in greater detail in Phase Two of the HAI Action Plan.

Urgent action is required to address this growing public health crisis. Improving the prescribing of antibiotics in all health care settings is one important part of a broader strategy to counter the increase in antibiotic resistance. Correct antibiotic treatment is critical to saving lives of all patients with certain infectious diseases, including HAIs.

ANTIBIOTICS AND HEALTH CARE-ASSOCIATED INFECTIONS

As mentioned in previous phases of the *HAI Action Plan*, HAIs are a serious health care quality issue. On any given day, about one in 31 patients has at least one health care-associated infection while

²⁷ Centers for Disease Control and Prevention. Antibiotic use in the United States, 2017: progress and opportunities. Atlanta, GA: US Department of Health and Human Services, CDC; 2017. <https://www.cdc.gov/antibiotic-use/stewardship-report/pdf/stewardship-report.pdf>. Accessed October 30, 2017.

²⁸ Fleming-Dutra KE, Hersh AL, Shapiro DJ, Bartoces M, Enns EA, File TM Jr, Finkelstein JA, Gerber JS, Hyun DY, Linder JA, Lynfield R, Margolis DJ, May LS, Merenstein D, Metlay JP, Newland JG, Piccirillo JF, Roberts RM, Sanchez GV, Suda KJ, Thomas A, Woo TM, Zetts RM, Hicks LA. Prevalence of inappropriate antibiotic prescriptions among US ambulatory care visits, 2010-2011. *Jama*. 2016; 315(17):1864-1873.

²⁹ D'Agata EM. Antimicrobial use and stewardship programs among dialysis centers. *Semin Dial*. 2013; 26(4): 457-64.

³⁰ United States Renal Data System. 2015 USRDS annual data report: epidemiology of kidney disease in the United States. National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases. Bethesda, MD, 2015. <https://www.usrds.org/2015/view/Default.aspx>. Accessed October 30, 2017.

³¹ Drekonja DM, Filice GA, Greer N, Olson A, MacDonald R, Rutks I, Wilt TJ. Antimicrobial stewardship in outpatient settings: a systematic review. *Infect Control Hosp Epidemiol*. 2015; 36(2): 142-52.

³² US Department of Health and Human Services. National action plan to prevent health care-associated infections: road map to elimination. Washington, DC: US Department of Health and Human Services; 2013. <https://health.gov/hcq/prevent-hai-action-plan.asp>. Updated October 30, 2017. Accessed October 30, 2017.

³³ US Renal Data System, USRDS 2010 Annual Data Report: Atlas of Chronic Kidney Disease and End-Stage Renal Disease in the United States, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD, 2010. <https://www.usrds.org/atlas10.aspx>. Accessed November 2, 2017.

hospitalized.³⁴ These infections can be caused by antibiotic-resistant bacteria, making them difficult to treat. One in seven catheter- and surgery-related HAIs in acute care hospitals, and one in four catheter- and surgery-related HAIs in long-term care acute care hospitals, are caused by any of six resistant bacteria (not including *C. difficile*).³⁵ Antibiotic-resistant HAIs can be reduced by preventing the spread of bacteria between patients, improving antibiotic use, and instituting infection control and HAI prevention measures. Conversely, preventing HAIs will contribute significantly to antibiotic stewardship by reducing episodes of illness requiring antibiotic therapy.

In developing antibiotic stewardship initiatives, health care systems can learn from infection prevention models. Both infection prevention and antibiotic stewardship have the same underlying goals: to achieve the best clinical outcomes for patients and minimize adverse events. Both efforts should be multidisciplinary and collaborative and contribute to a culture of safety. There is a clear need to enhance efforts between preventing HAIs, implementing antibiotic stewardship efforts, and treating infections.

STATE EFFORTS IN ANTIBIOTIC STEWARDSHIP

Two states have developed policies to improve antibiotic use in hospitals: California and Missouri. California was the first state to enact legislation to improve antibiotic use. Specifically, California Senate Bills 739 and 1311 require hospitals to develop a process for monitoring antibiotic use and implementing antibiotic stewardship. In addition to requiring all Missouri hospitals to create antibiotic stewardship programs, Missouri Senate Bill 579, passed in 2016, requires all non-psychiatric hospitals to begin reporting antibiotic use to CDC's National Healthcare Safety Network.

While California and Missouri are currently the only two states with legislation on antibiotic stewardship, state health departments track resistance and work with federal health agencies to address HAIs and antibiotic resistance. In July 2016, CDC awarded \$67 million to help health departments tackle antibiotic resistance and other patient safety threats, including HAIs. In more than 30 states and cities, CDC is aggressively expanding MDRO prevention and ASPs, including implementing proven strategies in health care facilities to prevent infections and transmission across health care settings. In March 2017, CDC hosted a meeting of health department grantees and key partners, including CMS, AHRQ, the Association of Public Health Laboratories, the Association for Professionals in Infection Control and Epidemiology, and the Society for Healthcare Epidemiology of America, to provide updated guidance on containing antibiotic resistant infections and improving antibiotic use. In 2017, CDC awarded nearly \$77 million to 50 states, Puerto Rico, and six major cities to detect, respond to, and contain antibiotic resistance, HAIs, and other patient safety threats.

³⁴ Magill SS, Wilson L, Thompson D, Ray SM, Nadle J, Lynfield R, Janelle SJ, Kainer MA, Greissman S, Dumyati G, Beldavs ZG, Edwards JR, Emerging Infections Program Hospital Survey Team. Reduction in the prevalence of healthcare-associated infections in US acute care hospitals, 2015 versus 2011. Oral presentation at: IDWeek; October 2017; San Diego, CA. <https://idsa.confex.com/idsa/2017/webprogram/Paper63280.html>. Accessed October 30, 2017.

³⁵Vital Signs: Making Health Care Safer. Centers for Disease Control and Prevention website. <https://www.cdc.gov/vitalsigns/protect-patients/index.html?permalink=http://www.cdc.gov/vitalsigns/protect-patients/index.html>. Updated March 3, 2016. Accessed October 30, 2017.

PROTOCOLS, GUIDELINES, AND PREVENTION ACTIVITIES

In 2015, following the release of the *CARB Action Plan*, the White House convened more than 150 stakeholders from government, the food industry, pharmaceutical and diagnostic industries, professional societies, and more, for a forum on antibiotic stewardship. Participating organizations from the public and private sector affirmed their commitments to improve antibiotic use and slow development of antibiotic resistance. The White House emphasized key areas of coordination between Agency for Healthcare Research and Quality (AHRQ), CDC, the Centers for Medicare and Medicaid Services (CMS), and the Food and Drug Administration (FDA), and the National Institutes of Health (NIH) that leverage each agency's resources and expertise to address this critical public health priority.^{36,37} Descriptions of these activities are included in the following sections of this document.

In recognition of the urgent need to improve antibiotic use in hospitals and the proven benefits of ASPs, CDC recommended in 2014 that all acute care hospitals implement such programs. CDC's *Core Elements of Hospital Antibiotic Stewardship Programs* provides a framework for establishing and improving antibiotic stewardship in hospitals (**Table C**). The *Core Elements* provide guidance that define the structural elements and key functions of ASPs. Since their adoption, the *Core Elements* have been used as the implementation strategy by large health systems and have become part of The Joint Commission's accreditation standards for antibiotic stewardship. The *Core Elements* were designed to be flexible enough to be adopted in hospitals of any size, and have since been adapted to LTCFs and outpatient settings.

The *CARB Action Plan* identifies implementation of antibiotic stewardship programs as a significant outcome. Specifically the goal is for every U.S. hospital to have a stewardship program incorporating all of the *Core Elements* by 2020. To reach that goal, CDC is currently working with diverse public health and health care partners (e.g., health systems, national and state hospital associations, professional organizations, academic investigators, private industry, patient and consumer organizations, state and local health departments, federal partners) to promote and facilitate implementation of the *Core Elements*.

From October 2015 to January 2017, the AHRQ, CDC, CMS, NIH, OASH, and the IHS participated in a Cross-Agency Priority Goal to expand ASPs in hospitals nationwide. The stated goal of this effort was to increase from 40% to 60% the number of U.S. hospitals with stewardship programs which are aligned with the CDC *Core Elements*. The Agency Priority Goal effort brought about closer coordination of the participating agencies' activities, and the percent of hospitals reporting stewardship programs rose to 64.1% in 2016.

³⁶ Brayton J. The White House Hosts a Forum on Combating Antibiotic Resistance. Obama White House Archives website. <https://obamawhitehouse.archives.gov/blog/2015/06/02/white-house-hosts-forum-combating-antibiotic-resistance>. Updated June 2, 2015. Accessed November 2, 2017.

³⁷ Burwell SM, Vilsack T. White House Forum on Antibiotic Stewardship Convenes Government and Private Sector Leaders Committed to Improving Antibiotic Prescribing. Obama White House Archives website <https://obamawhitehouse.archives.gov/blog/2015/06/03/white-house-forum-antibiotic-stewardship-convenes-government-and-private-sector-lead>. Updated June 3, 2015. Accessed November 2, 2017.

Acknowledging the difficulties of implementing ASPs in smaller hospitals or facilities with fewer resources, CDC worked with the Pew Charitable Trusts, the American Hospital Association, and the Federal Office of Rural Health Policy (FORHP) to develop practical guidance for implementing stewardship programs in small and critical access hospitals. CDC and partners met with hospital representatives to get their feedback and gain a more in-depth understanding of the challenges in these health care settings. The resulting guidance document, *Implementation of Antimicrobial Stewardship Core Elements at Small and Critical Access Hospitals*,³⁸ uses the CDC's *Core Elements of Hospital Antibiotic Stewardship Programs* as a framework for initiating and/or expanding antibiotic stewardship activities.

In 2016, CDC partnered with the National Quality Forum's National Quality Partnership, a not-for-profit, nonpartisan, membership-based organization that works to catalyze improvements in health care, to lead a team of experts, including AHRQ and CMS, in creating a practical guide to help hospitals implement CDC's *Core Elements*. The resulting document, *Antibiotic Stewardship in Acute Care: A Practical Playbook*, provides real-world strategies to help hospitals and health systems of all sizes implement and improve ASPs.³⁹

In 2015, CDC released *The Core Elements of Antibiotic Stewardship for Nursing Homes*, which adapts the original recommendations for hospitals into a format more appropriate for LTCFs.⁴⁰ Though the elements remain unchanged compared to the hospital version, *Core Elements of Antibiotic Stewardship for Nursing Homes* highlights differences in the approach to implementation and suggests strategies that may achieve success in NHs. For example, a NH-specific companion checklist was created to help facilities assess their progress and identify areas for improvement.

In 2016, CDC released *The Core Elements of Outpatient Antibiotic Stewardship*, which provides a framework for antibiotic stewardship for outpatient clinicians and facilities that routinely provide antibiotic treatment. The *Core Elements of Outpatient Antibiotic Stewardship* were adapted to the four elements that are most relevant in outpatient settings: Commitment, Action for Policy and Practice, Tracking and Reporting, and Education and Expertise.

CMS contracts with quality improvement organization experts nationwide to improve health care quality in various settings. In an effort to bring about improvements in patient safety in inpatient settings, CMS

³⁸ Centers for Disease Control and Prevention. Core elements of hospital antibiotic stewardship programs. Atlanta, GA: US Department of Health and Human Services, CDC; 2014. <https://www.cdc.gov/antibiotic-use/healthcare/implementation/core-elements-small-critical.html>. Updated October 26, 2017. Accessed November 2, 2017.

³⁹ National Quality Forum, National Quality Partners, Antibiotic Stewardship Action Team. National quality partners playbook: antibiotic stewardship in acute care. Washington, DC: National Quality Forum; 2016. http://www.qualityforum.org/Publications/2016/05/National_Quality_Partners_Playbook_Antibiotic_Stewardship_in_Acute_Care.aspx. Accessed November 3, 2017.

⁴⁰ Centers for Disease Control and Prevention. Core elements of antibiotic stewardship for nursing homes. Atlanta, GA: US Department of Health and Human Services, CDC; 2015. <https://www.cdc.gov/longtermcare/prevention/antibiotic-stewardship.html>. Updated February 28, 2017. Accessed May 19, 2017.

Hospital Improvement Innovation Network (HIIN) contractors continue to evaluate and support the capacity of large scale quality improvement efforts by focusing on 11 core areas, which include HAIs and antibiotic stewardship.⁴¹ As of May 1, 2017, HIINs recruited over 4,000 hospitals nationally to continue work toward achieving a 20% decrease in overall patient harm and a 12% reduction in 30-day hospital readmissions. This work includes direct assistance to monitor and reduce HAIs, including those associated with antibiotic misuse and/or overuse such as CDI. CMS HIINs are also recruiting hospitals to promote and/or implement antibiotic stewardship programs which conform to the CDC's *Core Elements*. Several of the HIINs and their participating hospitals (approximately 2,800) have also expanded the focus of their work to include efforts aimed at reducing the incidence of other multi-drug resistant organisms such as MRSA. CDC is also working closely with the HIINs by providing prevention tools and expertise to target HAIs and antibiotic-resistant infections in acute care and critical access hospitals.

Similarly, CMS and Quality Innovation Network-Quality Improvement Organization (QIN-QIO) partners launched the National Nursing Home Quality Care Collaborative in 2015 with the aims of instilling quality and performance improvement practices in NHs, eliminating health care-acquired conditions (HACs), and increasing NH resident satisfaction.⁴²

CMS' Quality Innovation Network National Coordinating Center developed six nursing home training sessions to enhance understanding of important concepts and practices that promote team communication, antibiotic stewardship, and *C. difficile* prevention. Nursing contact hours or a certificate of completion is available after completing each one of the six sessions between April 1, 2017 and September 30, 2019. Training sessions are publicly available on the QIO Program website.⁴³

QIN-QIO contractors are working to facilitate adoption of antibiotic stewardship programs in the outpatient setting as of October of 2016. QIN-QIOs completed recruitment of outpatient practices and facilities in July 2017 to help facilitate uptake of *CDC's Core Elements of Outpatient Antibiotic Stewardship (Table D)*, QIN-QIOs recruited over 7,600 outpatient facilities nationwide exceeding its total recruitment goal by 40%. The QIN-QIOs will also be working with outpatient facilities in this capacity through July 2019. QIN-QIOs are working with ESRD facilities on antibiotic stewardship in which they will implement CMS' four Quality Improvement (QI) activities that are very similar to the CDC's Core Elements of Outpatient Antibiotic Stewardship. At the conclusion of the project, QIN-QIOs will submit successes, lessons learned, and strategies which will be written as a best practices paper and shared for learning opportunities.

⁴¹ About the Partnership. Centers for Medicare and Medicaid Services website. <https://partnershipforpatients.cms.gov/about-the-partnership/what-is-the-partnership-about/lpwhat-the-partnership-is-about.html>. Accessed November 2, 2017.

⁴² QIO News: National Nursing Home Quality Care Collaborative Aims to Create Lasting Improvements. Centers for Medicare and Medicaid Services Quality Improvement Organization website. <http://qioprogram.org/qionews/articles/national-nursing-home-quality-care-collaborative-aims-create-lasting-improvements>. Accessed November 2, 2017.

⁴³ Quality Innovation Network National Coordinating Center. Nursing home training sessions introduction. Baltimore, MD: US Department of Health and Human Services, CMS; 2017. <http://qioprogram.org/nursing-home-training-sessions>. Updated November 2, 2017. Accessed November 2, 2017.

AHRQ's efforts in antibiotic stewardship encompass supporting research to develop improved methods for conducting antibiotic stewardship, providing practical guidance on stewardship, and promoting implementation of stewardship activities in a variety of health care settings. In September 2016, AHRQ launched the *AHRQ Safety Program for Improving Antibiotic Use*.^{44,45} This 5-year nationwide project is adapting AHRQ's highly successful Comprehensive Unit-based Safety Program (CUSP), which has been effective in preventing HAIs, to improve antibiotic use and promote antibiotic stewardship in multiple health care settings. The first phase of the project, which serves as a pilot phase, involves three integrated delivery systems that comprise hospital acute care, long-term care, and ambulatory care settings. In subsequent cohorts, the project will promote and support implementation of antibiotic stewardship in 250-500 acute care hospitals, 250-500 long-term care facilities, and 250-500 ambulatory care settings across the country. As part of the project, a toolkit will be produced to promote implementation of antibiotic stewardship in all of the settings and will be made publicly available at the end of the project. AHRQ project activities are being coordinated with federal partners. Project interventions are consistent with CDC's *Core Elements*, and CDC and CMS serve as ex-officio members of the project's Technical Expert Panel. Monthly calls are being held with CMS to coordinate centrally the activities of the project with those of the HIINs and QIN-QIOs and to open lines of communication for coordination at the regional and local level. Discussions are also ongoing for participation of DoD hospitals and ambulatory settings in the project.

AHRQ has developed implementation guidance for antibiotic stewardship in nursing homes. The *Nursing Home Antimicrobial Stewardship Guide* is based on the results of four previous AHRQ-funded research studies of antibiotic stewardship in this setting, and aligns with CDC's *Core Elements*.⁴⁶ The implementation guide has been field tested and is currently being widely disseminated. As part of the wide dissemination strategy, the *Guide* was presented in October, 2016, at IDWeek and in March, 2017, at the annual conference of AMDA—The Society for Post-Acute and Long-Term Care Medicine. The *Guide* provides four sets of toolkits to help nursing home staff address the following challenges: how to create an antibiotic stewardship program, how to determine whether to treat with antibiotics, how to choose the right antibiotic, and how to engage residents and families to improve antibiotic use. AHRQ has involved CDC and CMS staff in the development and dissemination of the *Guide*. CDC and CMS staff served as ex officio members of the Expert Panel that guided development of the *Guide*, and CDC and CMS staff have helped disseminate the *Guide* through participation in presentations to stakeholder and professional audiences.

⁴⁴ AHRQ Safety Program for Improving Antibiotic Use. Agency for Healthcare Research and Quality website. <https://www.ahrq.gov/professionals/quality-patient-safety/hais/tools/antibiotic-stewardship/index.html>. Updated September 2017. Accessed November 2, 2017.

⁴⁵ AHRQ Safety Program for Improving Antibiotic Use. Agency for Healthcare Research and Quality website. <https://safetyprogram4antibioticstewardship.org/public/Home>. Accessed November 2, 2017.

⁴⁶ Agency for Healthcare Research and Quality. Nursing Home Antimicrobial Stewardship Guide. Washington, DC: US Department of Health and Human Services, AHRQ; 2017 <https://www.ahrq.gov/nhguide/index.html>. Accessed November 2, 2017.

AHRQ released a *Toolkit to Reduce CAUTI and other HAIs in Long-Term Care Facilities* on March 14, 2017, which is available on the AHRQ website.⁴⁷ The toolkit is based on the experiences of more than 450 long-term care facilities across the country that participated in the *AHRQ Safety Program for Long-Term Care: HAIs/CAUTI*, a three year implementation project that reduced CAUTI rates by around 50%. Based on principles and methods from AHRQ's CUSP, the toolkit provides resources to enhance leadership and staff engagement, teamwork, and safety culture in order to promote consistent use of evidence-based practices to prevent infections. The toolkit contributes to antibiotic stewardship in two ways. First, every HAI prevented means a course of antibiotics avoided, thereby avoiding an exposure that promotes antibiotic resistance. Secondly, materials in the toolkit address appropriate use of urine cultures, including avoiding urine cultures for most asymptomatic patients, to help decrease inappropriate use of antibiotics for asymptomatic bacteriuria. CDC and CMS staff served as *ex officio* members of the Technical Expert Panel that guided the implementation of the *AHRQ Safety Program for Long-Term Care* and the development of the *Toolkit to Reduce CAUTI and other HAIs in Long-Term Care Facilities*, and CDC staff provided additional technical input. CMS and CDC staff are also involved in dissemination of the *Toolkit*.

The goal of antibiotic stewardship is to optimize the treatment of infections, which includes the rapid treatment of severe infections like sepsis. CDC launched the Sepsis Awareness Campaign that integrates stewardship with efforts to improve the timely and effective prevention and treatment of sepsis. The campaign emphasized that preventing infections and the spread of resistant organisms is an important part of preventing sepsis and also that antibiotic stewardship is an important part of making sure that patients with sepsis get prompt and effective antibiotic treatment. Additionally, there is a critical need to emphasize that the early recognition and treatment of sepsis is an important part of antibiotic stewardship. Finally, the campaign emphasizes the need to reassess sepsis therapy after 24-48 hours in order to optimize antibiotics-another core component of antibiotic stewardship. CDC will focus on new and existing educational efforts to ensure both that antibiotics are used properly and that patients who might have sepsis are recognized and started on the right antibiotic promptly.

Likewise, CDC continues to explore opportunities to integrate efforts to improve antibiotic use with efforts to prevent healthcare associated infections. For example, state health departments that are leading projects to reduce *C. difficile* are being asked to incorporate antibiotic stewardship as a key intervention.

In addition to gaps in provider knowledge, research shows patients are not very knowledgeable about antibiotics. A 2015 study of Massachusetts parents with Medicaid-insured children found that parents often thought green nasal discharge required antibiotics and they often requested unnecessary antibiotics.⁴⁸ The National Science Foundation's nationally representative Survey of Public Attitudes Toward and Understanding of Science and Technology had indicated that knowledge on antibiotics and

⁴⁷Toolkit to Reduce CAUTI and Other HAIs in Long-Term Care Facilities. Agency for Healthcare Research and Quality website. <https://www.ahrq.gov/professionals/quality-patient-safety/quality-resources/tools/cauti-ltc/index.html>. Updated May 2017. Accessed June 20, 2017.

⁴⁸ Vaz LE, Kleinman KP, Lakoma MD, Dutta-Linn MM, Nahill C, Hellinger J, Finkelstein JA. Prevalence of parental misconceptions about antibiotic use. *Pediatrics*. 2015; 136(2):221-231.

resistance has increased since 1990, but knowledge remains suboptimal.⁴⁹ Despite this, patients still influence the prescribing of antibiotics;⁵⁰ patients recognize antibiotic resistance as a public health concern but perceive low personal susceptibility. Yet the same study found that patients express high self-efficacy and a desire to be involved in their health care.⁵¹ This pattern of beliefs indicates the clear need to develop educational materials to better inform patients, and encourage shared decision making between patients and providers. The broadening of responsibility and accountability for patient safety, including the recognition of a role for patients and their families, has been one of the most positive developments in the patient safety movement. Patients want their symptoms to be quickly resolved, with clear explanations of providers' recommendations, and they may have misconceptions about when antibiotics work. There is evidence to indicate that patients are increasingly concerned about overuse and resistance. Over the past several years, federal health agencies have worked diligently to develop educational materials on antibiotic resistance for the public.

CDC's educational initiative is the *Get Smart: Know When Antibiotics Work*. CDC launched the National Campaign for Appropriate Antibiotic Use in the Community in 1995 and renamed it to *Get Smart: Know When Antibiotics Work* in 2003. The program has focused on improving prescribing for children and works closely with a variety of partners to reduce unnecessary antibiotic use in the community and various health care settings. The goal of the program is to increase awareness among health care providers and the general public. The program offers a variety of materials and resources such as posters, facts sheets, brochures, videos, and graphics. CDC also collaborates with health care provider and patient organizations at the local level to distribute tools and resources that complement their efforts. In November 2017, CDC will be rebranding the Get Smart program and launching a new educational effort to enhance healthcare provider and patient education on appropriate antibiotic use. The new educational effort, *Be Antibiotics Aware*, will expand the health care provider and patient target audiences.

Every year CDC recognizes *U.S. Antibiotic Awareness Week* (formerly *Get Smart About Antibiotics Week*) by working to increase awareness of antibiotic resistance and appropriate use in all health care settings.⁵² CDC also collaborates with international partners to raise awareness about appropriate antibiotic use during *US Antibiotic Awareness Week*. The week coincides with European Antibiotic Awareness Day, Australia's Antibiotic Awareness Week, Canada's Antibiotic Awareness Week, and the World Health Organization's (WHO's) World Antibiotic Awareness Week. The observance engages stakeholders, including professional societies, advocacy groups, for-profit companies, state and local health departments, the general public and the media, around antibiotic stewardship. In 2016, more than 65 partners participated and helped reach millions of people in the United States and abroad.

The nationally distributed VHA health care system operates over 130 hospitals and 133 long-term care

⁴⁹ National Science Board. Science and engineering indicators 2014. Arlington, VA: National Science Foundation, NCSES; 2014. <https://www-nsf.gov.ezproxyhhs.nihlibrary.nih.gov/statistics/seind14/>. Accessed November 2, 2017.

⁵⁰ Podolsky SH. The antibiotic era: reform, resistance, and the pursuit of a rational therapeutics. Baltimore, MD, USA: Johns Hopkins University Press, 2014.

⁵¹ Heid C, Knobloch MJ, Schulz LT, Safda N. Use of health belief model to study patient perceptions of antimicrobial stewardship in the acute care setting. *Infect Control Hosp Epidemiol*. 2016; 37(5):576-582.

⁵² US Antibiotic Awareness Week. Centers for Disease and Control website. <https://www.cdc.gov/antibiotic-use/week/index.html>. Updated October 4, 2017. Accessed November 2, 2017.

facilities (also known as Community Living Centers) making it one of the largest integrated health care systems in the U.S. As a founding member of the Federal Interagency Task Force on Antimicrobial Resistance (ITFAR), VA leadership acknowledged the threat posed by antimicrobial resistance as well as HAIs. Coordinated, nationwide efforts to reduce HAIs began in 2005 in VHA's intensive care units (ICUs) for CLABSIs and ventilator-associated pneumonias (VAPs), with these measures expanding to encompass all acute care units within a few years. Sizeable reductions have been achieved in ICU CLABSIs with a 76.6% reduction from 2006 to 2014 and in ICU VAPs with an 81.6% reduction during the same period. From 2011 to 2014, VA ICUs had a 41.1% reduction in CAUTIs, while in the non-ICU acute care setting and long-term care settings, CAUTIs were reduced 38.5% and 41%, respectively. Nationwide CLABSI rates fell 48.8% in non-ICU acute care settings from 2010 to 2014, while in long-term care they fell 22.2% from 2011 to 2014.^{53,54}

Concurrent to these HAI reduction initiatives, additional national programs aimed at MDROs and antimicrobial stewardship were also initiated within VHA, starting with the MRSA Prevention Initiative (which later expanded to become the MDRO Prevention Initiative) in 2007 and the Antimicrobial Stewardship Programs Initiative which began with coordinated national efforts in 2010. In the first eight years after implementation of these initiatives, VHA has seen sizeable reductions in MRSA HAIs with decreases of 87% in ICUs and 80% in non-ICU acute care and 49% reductions in long-term care.^{55,56} Reductions in CDI and Gram negative bacteremia have also been noted in association with these initiatives.^{57,58} The VA has acknowledged the interdependent nature of the HAIs and antibiotic resistance and began its antimicrobial stewardship initiative with a series of nationwide educational offerings in 2010 followed by establishing the infrastructure to support this maturing program, culminating in 2014 with VHA Directive 1031,⁵⁹ which requires VA hospitals to have active antimicrobial stewardship

⁵³ Render ML, Hasselbeck R, Freyberg RW, Hofer TP, Sales AE, Almenoff PL, VA ICU Clinical Advisory Group. Reduction of central line infections in Veterans Administration intensive care units: an observational cohort using a central infrastructure to support learning and improvement. *BMJ Qual Saf*, 2011; 20(8):725-32.

⁵⁴ Clifton M, Kralovic S, Simbartl LA, Hasselbeck R, Martin T, DeRoos KA, Roselle GA. National implementation of evidence-based bundles for prevention of device-associated infections in Veterans Health Administration (VHA) facilities. *Am J Infect Control*, 2015; 43(6):S59.

⁵⁵ Jain R, Kralovic SM, Evans ME, Ambrose M, Simbartl LA, Obrosky DS, Render ML, Freyberg RW, Jernigan JA, Muder RR, Miller LJ. Veterans Affairs initiative to prevent methicillin-resistant staphylococcus aureus infections. *N Engl J Med*. 2011; 364(14):19-30.

⁵⁶ Evans ME, Kralovic SM, Simbartl LA, Jain R, Roselle GA. Eight years of decreased methicillin-resistant staphylococcus aureus health care-associated infections associated with a Veterans Affairs prevention initiative. *Am J Infect Control*, 2017; 45(4): 13-6.

⁵⁷ Evans ME, Kralovic SM, Simbartl LA, Jain R, Roselle GA. Effect of a clostridium difficile infection prevention initiative in Veterans Affairs acute care facilities. *Infect Control and Hosp Epidemiol*. 2014; 37(6): 720-22.

⁵⁸ Goto M, O'Shea AMJ, Livorsi DJ, McDanel JS, Makoto MJ, Richardson KK, Beck BF, Alexander B, Evans ME, Roselle GA. The effect of a nationwide infection control program expansion on hospital-onset gram-negative rod bacteremia in 130 Veterans Health Administration medical centers: an interrupted time-series analysis. *Clin Infect Dis*, 2016; 63(5):642-650.

⁵⁹ Department of Veterans Affairs, Veterans Health Administration. Antimicrobial Stewardship Programs (ASP). *VHA Directive 1031*. January 22, 2014. https://www.va.gov/vhapublications/ViewPublication.asp?pub_ID=2964. Accessed November 3, 2017.

programs. Since inception of this initiative VHA hospital facilities realized a 12% reduction in antibiotic use.⁶⁰

Both patients and providers are integral to effective antibiotic stewardship efforts; all stakeholders need guidance and support to adhere to appropriate prescribing guidelines. A multi-pronged approach which includes practice guidelines, educational activities, and prevention activities will be necessary in the implementation of antibiotic stewardship initiatives.

⁶⁰ Kelly AA, Jones MM, Echevarria KL, Kralovic SM, Samore MH, Goetz MB, MAdaras-Kelly KJ, Simbartl LA, Morreale AP, Neuhauser MM, Roselle GA. A report of the efforts of the Veterans Health Administration national antimicrobial stewardship initiative. *Infect Control Hosp Epidemiol*, 2017; 38(5):513-520.

SURVEILLANCE

Surveillance activities are essential for improving prescribing practices, increasing transparency, and monitoring antibiotic use to track and better understand resistance. Surveillance activities include tracking the implementation of stewardship programs through process measures, tracking overall and appropriate antibiotic use, and tracking HAI rates through outcome measures.

Federal health agencies coordinate surveillance efforts to ensure robust and accurate data collection. One key tool federal agencies have to track antibiotic use in hospitals is CDC's NHSN. NHSN standardizes surveillance definitions to ensure consistent reporting of data across facilities. More than 22,000 facilities across the continuum of care now use NHSN to monitor several types of HAIs and it now includes a module on antibiotic use and resistance. Two-thirds of VHA's medical centers are now enrolled in the NHSN antibiotic use module. Over a quarter of DOD's military hospitals are also using NHSN to track antibiotic use and resistant pathogens within their healthcare facilities. CMS has been influential in increasing adoption of NHSN in hospitals and other health care settings.

The NHSN Antibiotic Use Option allows any of the over 6,000 hospitals that currently use NHSN to monitor antibiotic use. CDC is working with the two largest hospital systems in the country, the Hospital Corporation of America and Ascension Health, to enroll their member hospitals in the NHSN Antibiotic Use option.

The centerpiece of the Antibiotic Use Option is the Standardized Antimicrobial Administration Ratio (SAAR), a risk-adjusted benchmarking measure of antibiotic use that was endorsed by the National Quality Forum in 2016 as a metric for hospitals. The SAAR uses modeled data from all reporting hospitals to calculate the ratio of observed antibiotic use to predicted antibiotic use, and allows hospitals to compare their antibiotic use with similar facilities. While the SAAR cannot be used to measure the appropriateness of antibiotic use in a hospital, it can be used to direct hospital antibiotic stewardship programs to areas where antibiotic use deviates from what is expected.

CDC is working with a variety of experts to improve the usefulness of the SAAR for improving antibiotic use. CDC is partnering with organizations and hospitals reporting NHSN Antibiotic Use data submitting data to enhance risk adjustment, make data more actionable, and improve the use of data to guide stewardship interventions. CDC collaborated with The Pew Charitable Trusts and a number of experts to develop an assessment tool to help hospitals find opportunities to improve use in locations with high SAARs.⁶¹ Though the tool is designed to be used in conjunction with the SAAR, it could be used to look for improvement opportunities in any location where use is higher than expected. CDC has also funded a project with the Duke Antibiotic Stewardship Outreach Network that will increase understanding of how to most effectively use antibiotic use data and the SAAR to target and monitor stewardship practices.

⁶¹ Centers for Disease Control and Prevention, The PEW Charitable Trusts. Strategies to Assess Antibiotic Use to Drive Improvements in Hospitals. Atlanta, GA: US Department of Health and Human Services, CDC; 2014. <https://www.cdc.gov/getsmart/healthcare/pdfs/strategies-to-assess-antibiotic-use-in-hospitals-508.pdf>. Accessed November 2, 2017.

CDC has been assessing the implementation of the *Core Elements of Hospital Antibiotic Stewardship Programs* through the NHSN Annual Survey. In 2014, 41% of hospitals reported implementing all seven elements. By 2015, that had increased to 48%. National uptake improved in 2016, increasing 64.1% for all hospitals, however data indicates that there is more to do. There were important differences in implementation in 2016, with larger hospitals showing much more uptake: 81.5% of hospitals with over 200 beds reported all seven *Core Elements*, compared to 69% of hospitals with 51-200 beds and 46% of hospitals with 1-50 beds.⁶² In order to improve usage of antibiotic stewardship program, especially in smaller hospitals which face special challenges to implementation, CDC partnered with The Pew Charitable Trusts, the American Hospital Association and the FORHP to develop *Implementation of Antimicrobial Stewardship Core Elements at Small and Critical Access Hospitals*.

CDC is also supporting state efforts to improve antibiotic use by promoting use of NHSN for antibiotic use reporting and promote antibiotic stewardship programs in hospitals. For example, in 2016 the state of Missouri passed a law requiring all hospitals to have antibiotic stewardship programs and to make plans to report antibiotic use data to NHSN. CDC is assisting efforts in MO to ensure all hospitals are able to meet these requirements.

Collecting data from LTCFs has historically been a challenge, as many facilities have not had the resources necessary to report accurate and timely data, or available data have been collected using differing methodologies that limited the ability to compare data between facilities. In September 2012, CDC launched the LTCF component of the NHSN to standardize reporting across these facilities.⁶³ The LTCF component currently contains three modules: an HAI module for tracking catheter and non-catheter associated urinary tract infections, a laboratory-identified (LabID) event module for tracking MDROs and CDI, and a prevention process measures module for tracking staff adherence to proper hand hygiene and glove/gown procedures.⁶⁴ Phase Three of the *HAI Action Plan* proposed a goal of enrolling 5% of certified NHs in NHSN in the first five years of the program. CMS, through QIN-QIO program contractors, partnered with CDC to help reach, and ultimately surpass, this enrollment goal. By March 30, 2017, QIN-QIOs had enrolled 2,336 NHs to report CDI infection data to NHSN, which will allow CDC to calculate a national baseline for LTCF-onset CDI.⁶⁵

The newest version of CDC's Antibiotic Resistance Patient Safety Atlas contains data on antibiotic prescriptions dispensed in outpatient pharmacies per 1,000 people and information on the implementation

⁶² Centers for Disease Control and Prevention unpublished data.

⁶³ About NHSN. Centers for Disease Control and Prevention website. <https://www.cdc.gov/nhsn/about-nhsn/index.html>. Updated October 15, 2017. Accessed November 2, 2017.

⁶⁴ Antilla A. Tracking Infections in Long-term Care Facilities (LTCFs) Using NHSN, 2017. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwimltCGw6DXAhUD4mMKHbWjDUwQFggoMAA&url=https%3A%2F%2Fwww.cdc.gov%2Fnhsn%2Fpdfs%2Ftraining%2F2017%2FAntila_March20.pdf&usg=AOvVaw1ly7j4luBf8YDNCfUPb3uu. Accessed November 2, 2017.

⁶⁵ Office of Disease Prevention and Health Promotion, Watch our Webinar to Learn More about Preventing Health-Care Associated Infections. Office of Disease Prevention and Health Promotion Prevention Policy Matters Blog website. <https://health.gov/news/announcements/2017/06/watch-our-webinar-to-learn-more-about-preventing-health-care-associated-infections/>. Updated June 2017. Accessed November 2, 2017.

of hospital antibiotic stewardship programs.⁶⁶ This interactive database can be used to look at how antibiotic prescribing varies by state, age group, and over time from 2011-2014 and to look at national and state level data on the implementation of the CDC *Core Elements for Hospital Antibiotic Stewardship Programs* for 2014 and 2015.

Assessing appropriate antibiotic use is also a key aspect of surveillance. CDC has used data from a variety of surveillance systems to determine the frequency of inappropriate antibiotic use in outpatient practices. In collaboration with the Pew Charitable Trusts and a panel of experts, CDC estimated that 30% of outpatient antibiotic use was unnecessary and inappropriate use was especially common for patients with respiratory syndromes.⁶⁷ Additionally, even when antibiotics are indicated, providers were not prescribing the first-line antibiotic recommended in guidelines in roughly half of cases.⁶⁸ Both of these findings provide important data for action.

Assessing appropriate use in the hospital and nursing home settings has been more challenging. CDC is using the Emerging Infections Program's Healthcare-Associated Infections Community Interface to work with ten state health departments and many hundreds of healthcare facilities on national point prevalence surveys for both hospitals and nursing homes to address this gap. In addition to updated estimates of the national burden of HAIs, both the hospital survey (completed in 2017) and nursing home survey (launched in 2017) will have nationally representative assessments of appropriate antibiotic use. In the hospital setting, two antibiotic types, fluoroquinolones and vancomycin, and two infections, community acquired pneumonia and urinary tract infections, are the key targets for assessment. The nursing home survey will be the first national survey on HAIs and antibiotic use in this setting and will include information on the frequency, indications, and appropriateness of antibiotic use, with a specific focus on use for treatment of urinary tract infections, which are the most common infections being treated with antibiotics in these patients.

⁶⁶ CDC's Antibiotic Resistance Patient Safety Atlas. Centers for Disease Control and Prevention website. <https://www.cdc.gov/hai/surveillance/ar-patient-safety-atlas.html>. Updated March 3, 2016. Accessed November 2, 2017.

⁶⁷ Fleming-Dutra KE, Hersh AL, Shapiro DJ, Bartoces M, Enns EA, File TM Jr, Finkelstein JA, Gerber JS, Hyun DY, Linder JA, Lynfield R, Margolis DJ, May LS, Merenstein D, Metlay JP, Newland JG, Piccirillo JF, Roberts RM, Sanchez GV, Suda KJ, Thomas A, Woo TM, Zetts RM, Hicks LA. Prevalence of inappropriate antibiotic prescriptions among US ambulatory care visits, 2010-2011. *Jama*. 2016; 315(17):1864-1873.

⁶⁸ Hersh AL, Fleming-Dutra KE, Shapiro DJ, Hyun DY, Hicks LA, Outpatient Antibiotic Use Target-Setting Workgroup. Frequency of first-line antibiotic selection among US ambulatory care visits for otitis media, sinusitis, and pharyngitis. *JAMA*, 2016; 176(12):1870-1872.

INCENTIVES AND OVERSIGHT

CMS uses multiple drivers of change to influence practice and improve patient safety. This section discusses the various ways these tools and initiatives are being used to support the nation's efforts to expand antibiotic stewardship.

In 2016, CMS proposed that its Infection Control Conditions of Participation (CoPs) for hospitals and critical access hospitals be revised to include a requirement for antibiotic stewardship that aligns with CDC's *Core Elements of Hospital Antibiotic Stewardship Programs*.⁶⁹ These revisions would require Medicare and Medicaid participating hospitals, including Critical Access Hospitals, to develop and maintain a facility-wide ASP as an effective means to improve antibiotic prescribing practices and curb patient risk for possibly deadly CDI, as well as other future, and potentially life-threatening, antibiotic-resistant infections. The proposed CoPs would also require facilities to establish designated and qualified leaders in these facilities to guide and oversee this effort. New interpretive guidance would incorporate CDC's *Core Elements*.

In October 2016, CMS released new Requirements of Participation for LTCFs, which establish more robust infection prevention and control practices, including antibiotic stewardship, in a phased-in manner.⁷⁰ Starting in November 2016, LTCFs are required to have policies and procedures in place to identify, report, investigate, and control infections and communicable diseases among residents, staff, and visitors. By November 2017, facilities are required to have operational antibiotic stewardship programs that include antibiotic use protocols and systems to monitor antibiotic use. Finally, by November 2019, a health care professional with infection prevention and control training is required to be in charge of each facility's infection prevention and control program. CMS' QIN-QIO contractors are working with CMS Survey and Certification Group to provide technical assistance to LTCF to prepare them to meet these requirements where needed. The CMS Requirements of Participation for LTCFs reflect CDC's *Core Elements* as a model for best practices in LTCFs, and CMS and CDC have worked together to develop a pilot surveyor infection control and prevention worksheets used by the CMS Survey and Certification Group. CDC provided technical expertise that was used to develop antibiotic stewardship questions for use by both hospital and LTCF surveyors, and these worksheets are currently being tested by CDC and CMS as part of a pilot project in 40 pairs of hospitals and LTCFs.

On January 1, 2017, as required by the Medicare Access and CHIP Reauthorization Act of 2015, the Quality Payment Program began for physicians and other clinicians, implementing a new approach to Medicare payment that rewards the delivery of high-quality care. Eligible clinicians can choose to participate in this program in one of two tracks: the Merit-based Incentive Payment System (MIPS) or

⁶⁹ Medicare and Medicaid Programs; Hospital and Critical Access Hospital (CAH) Changes To Promote Innovation, Flexibility, and Improvement in Patient Care, 81 Fed. Reg. § 39447 (June 16, 2016). <https://www.federalregister.gov/documents/2016/06/16/2016-13925/medicare-and-medicaid-programs-hospital-and-critical-access-hospital-cah-changes-to-promote>. Accessed November 3, 2017.

⁷⁰ Medicare and Medicaid Programs; Reform of Requirements for Long-Term Care Facilities, 81 Fed. Reg. § 68688 (Oct. 10, 2016). <https://www.federalregister.gov/documents/2016/10/04/2016-23503/medicare-and-medicaid-programs-reform-of-requirements-for-long-term-care-facilities>. Accessed November 3, 2017.

Advanced Alternative Payment Models.⁷¹ Under MIPS, a clinician receives a performance score and a component of this score is affected by reporting of Clinical Practice Improvement Activities, which clinicians can choose from a list of more than 90 activities across nine categories. Highly-weighted quality measures that providers can choose to collect and report include “Avoidance of Antibiotic Treatment in Adults with Acute Bronchitis” and “Acute Otitis Externa: Systemic Antimicrobial Therapy – Avoidance of Inappropriate Use.”⁷² CDC is also working with CMS to develop additional training on antibiotic stewardship for MIPS participants.

The Medicare HAC Reduction Program provides an incentive for hospitals to reduce HACs.⁷³ Effective beginning Fiscal Year (FY) 2015 (discharges beginning on October 1, 2014), the HAC Reduction Program requires the Secretary of HHS to adjust Medicare payments to applicable hospitals that rank in the worst-performing quartile of all subsection (d) Medicare hospitals with respect to risk-adjusted HAC quality measures. These hospitals will have their payments reduced to 99% of what would otherwise have been paid for their Medicare discharges. In the FY 2017 HAC Reduction Program, hospitals with a total HAC score greater than 6.57 are subject to a payment reduction. MRSA and *C. difficile* infection, both of which can be caused by antibiotic misuse and/or overuse, are adopted measures in the FY2017 HAC Reduction and Hospital Value-based Purchasing programs.⁷³ Improving antibiotic use through stewardship is an important intervention that hospitals are implementing to meet HAC reduction goals.

While payment policy is unavailable as a driver of change from the FORHP, it utilizes the Medicare Rural Hospital Flexibility Grant Program (Flex Program) to offer grants to states and territories to help implement initiatives to influence practice and patient safety in Critical Access Hospitals (CAHs). FORHP created the Medicare Beneficiary Quality Improvement Project (MBQIP) as an activity within the Flex Program for CAHs to report on measures and implement quality improvement initiatives to improve their patient care and operations. Implementation of ASPs based on the guidance document: *Implementation of Antimicrobial Stewardship Core Elements at Small and Critical Access Hospitals* is now a core measure within MBQIP.

Improving antibiotic use in CAHs is imperative to improving patient outcomes, decreasing antibiotic resistance, and reducing HAIs. FORHP and CDC both understand the unique challenges that rural hospitals face when implementing several of the core elements of an antibiotic stewardship program and have collaborated to create an implementation guide that identifies common challenges and best practices for an antibiotic stewardship program in a CAH. This guide was presented at the 2017 Flex grantee meeting in July 2017. During this session, FORHP and CDC led a discussion on the types of technical assistance and resources state Flex programs and CAHs need to implement successful antibiotic

⁷¹ MACRA. Center for Medicare and Medicaid Services website. <https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/Value-Based-Programs/MACRA-MIPS-and-APMs/MACRA-MIPS-and-APMs.html>. Updated October 31, 2017. Accessed November 2, 2017.

⁷² MIPS: Quality Measures. Centers for Medicare and Medicaid Services website. <https://qpp.cms.gov/mips/quality-measures>. Accessed November 2, 2017.

⁷³ Hospital-Acquired Condition Reduction Program (HACRP). Centers for Medicare and Medicaid Services website. <https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/HAC-Reduction-Program.html>. Updated July 20, 2017. Accessed November 2, 2017.

stewardship programs. CDC and FOHRP continue to work together following the discussion to address challenges and barriers for CAHs.

RESEARCH

Research and evaluation of antibiotic stewardship programs and appropriate antibiotic use are needed on an ongoing basis in order to inform practice and policy. The federal health agencies are working to coordinate a research agenda to support the implementation of antibiotic stewardship efforts.

AHRQ has greatly increased its support for research to develop improved methods for combating antibiotic resistance and conducting antibiotic stewardship. Such research is critically important for strengthening the knowledge base to ensure the effectiveness of the interventions being used today and to develop more effective interventions for tomorrow. This comprehensive portfolio of research addresses all three of the domains of the national enterprise to overcome antibiotic resistance – promoting and conducting antibiotic stewardship, preventing transmission of resistant bacteria, and preventing HAIs in the first place. In late FY 2016 and early FY 2017, AHRQ published four Funding Opportunity Announcements (FOAs): two new FOAs for research on CARB, one for R01 applications and the other for R18 applications, and two reissued FOAs for research on HAI prevention, one for R01 applications and the other for R18 applications. In response to these FOAs, the volume of grant applications has increased. AHRQ’s areas of interest are reflected in these FOAs:

- CARB FOA, R01 <https://grants.nih.gov/grants/guide/pa-files/PA-16-423.html>
- CARB FOA, R18: <https://grants.nih.gov/grants/guide/pa-files/PA-16-422.html>
- HAI Prevention FOA, R01: <https://grants.nih.gov/grants/guide/pa-files/PA-17-008.html>
- HAI Prevention FOA, R18: <https://grants.nih.gov/grants/guide/pa-files/PA-17-007.html>

Examples of currently funded AHRQ studies that are addressing antibiotic stewardship are the following:

- Developing antibiotic stewardship approaches and recommendations that are personalized to the hospital patient
- Examining influences on physician and nurse decisions about antibiotics in nursing homes to distinguish decisions based on evidence from decisions based on other factors
- Examining non-visit-based antibiotic use in ambulatory care to improve safety and limit unnecessary use

As part of the focus on research, AHRQ and CDC jointly held a meeting of experts and stakeholders in June, 2016 to highlight existing knowledge gaps for effective prevention of antibiotic-resistant HAIs and identify potential interventions.

CDC is supporting a number of projects to explore optimized implementation of current approaches to antibiotic stewardship and to explore new ones. For example, CDC has provided funding to three different health systems to implement the stewardship core elements in each of the three different settings (hospital, outpatient and nursing homes) to help optimize implementation approaches. For the hospital effort, the effectiveness will be monitored through the NHSN antibiotic use option.

A funded project to assess the implementation of a provider led “antibiotic time out” was recently completed. CDC is also funding a project to explore the use of electronic health records to assess the appropriateness of antibiotic use, with a goal of establishing a less labor intensive way of collecting these data. Another project is exploring various ways of providing data on hospital antibiotic use to make it

most actionable to stewardship programs. Recognizing the key role antibiotic stewardship plays in preventing *C. difficile*, CDC is funding a project to perform a focused stewardship implementation in a group of hospitals to reduce the use of antibiotics that create the highest risks for *C. difficile* infection. This project is being done in collaboration with the Emerging Infections Program and will monitor the impact of the intervention on both in-hospital and post-discharge *C. difficile* infections.

Several antibiotic stewardship projects are underway in partnership with academic experts in CDC's Prevention Epicenters, including work focused on improving clinical decision support, identifying the impact of newly recommended sepsis care protocols on antibiotic use, and determining the effect of pre-surgical antibiotic therapy on subsequent surgical site infection risk. CDC is also working with the American Academy of Pediatrics and Anthem Healthcare on a project in the state of Virginia to explore ways to provide individual provider feedback to improve outpatient antibiotic use. New partnerships will also be critical to expanding stewardship efforts. In addition to exploring collaborations with payers, such as Anthem, CDC is working with the American Thoracic Society to explore ways to better engage the intensive care community and the American Nurses Association (ANA) on ways to better engage nurses. The CDC and ANA released a white paper in 2017 on the roles of nurses in hospital antibiotic stewardship that outlines several key next steps, which CDC is working with the nursing community to address.⁷⁴

CDC is also conducting applied research on the microbiome to identify effective public health approaches that protect people, their microbiomes, and the effectiveness of antibiotics. The human microbiome is the collective genome of microbial communities that live in and on us. These microbial communities are found on our skin, and in our mouths, respiratory tract, urinary tract, and gut. In collaboration with partners, CDC aims to determine how antibiotics disrupt a healthy microbiome, how a disrupted microbiome puts people at risk, and how improving antibiotic use can protect the microbiome. As part of this, CDC is working with FDA and other partners to develop Microbiome Indices that measure the health status of a person's microbiome. CDC believes Microbiome Indices will have a positive impact on patient care, antibiotic stewardship, infection control, and drug development. From a public health perspective, Microbiome Indices can serve as tools for infection prevention and control and antibiotic stewardship. By measuring patients' Microbiome Indices, CDC can identify subsets of the population at risk for infection or for transmitting pathogens, to determine how to best implement infection control measures.

The National Institute of Allergy and Infectious Diseases (NIAID) is supporting the development of diagnostics to facilitate antibiotic stewardship and inform clinical decision-making. For example, in June 2017, NIAID released RFA-AI-17-014, Partnerships for Development of Clinically Useful Diagnostics for Antimicrobial-Resistant Bacteria.⁷⁵ In September 2016, NIAID and the Biomedical Advanced

⁷⁴ Centers for Disease Control and Prevention, American Nurses Association. Redefining the Antibiotic Stewardship Team: Recommendations from the American Nurses Association/Centers for Disease Control and Prevention Workgroup on the Role of Registered Nurses in Hospital Antibiotic Stewardship Practices. Atlanta, GA: US Department of Health and Human Services, CDC; 2017. <http://www.nursingworld.org/ANA-CDC-AntibioticStewardship-WhitePaper>. Accessed November 2, 2017.

⁷⁵ Department of Health and Human Services. National Institutes of Health website. <https://grants.nih.gov/grants/guide/rfa-files/RFA-AI-17-014.html>. Accessed November 2, 2017.

Research and Development Authority (BARDA) announced the Antimicrobial Resistance Diagnostic Challenge, which seeks diagnostic tests that identify and characterize antibiotic-resistant bacteria or that distinguish between viral and bacterial infections to reduce unnecessary use of antibiotics.⁷⁶ In March 2017, ten semi-finalists for Step 1 of this competition were announced.^{77,78} NIAID also supports research grants and contracts to identify new treatment strategies to optimize and preserve the use of currently available antibiotic agents for healthcare-associated and drug-resistant pathogens.⁷⁹

The NIH Clinical Center and the National Human Genome Research Institute collaborate on research aimed at understanding and preventing HAI caused by multidrug-resistant bacteria and fungi. Using whole genome and whole plasmid sequencing and analysis, researchers investigate mechanisms of antimicrobial resistance and develop methods for prompt detection and recognition of common, emerging, and novel strains of resistant bacteria. The collaborative team is currently focusing research efforts on the role of the hospital environment as a potential source of HAI.

In addition, NIH researchers have collaborated with investigators at the CDC to sequence the emerging multidrug-resistant yeast *Candida auris* and to initiate basic science and clinical research studies of *C. auris*.

⁷⁶ News Release: Federal prize competition seeks innovative ideas to combat antimicrobial resistance. National Institutes of Health website. <https://www.nih.gov/news-events/news-releases/federal-prize-competition-seeks-innovative-ideas-combat-antimicrobial-resistance>. Updated September 2016. Accessed November 2017.

⁷⁷ Antimicrobial Resistance Diagnostic (AMR) Challenge Semifinalists. National Institutes of Health website. <https://dpcpsi.nih.gov/AMRChallengeSemifinalists>. Updated March 31, 2017. Accessed November 2, 2017.

⁷⁸ Antimicrobial Resistance Rapid, Point-of-Need Diagnostic Test Challenge. CCC Innovation Center website. <https://www.cccinnovationcenter.com/challenges/antimicrobial-resistance-diagnostic-challenge/>. Accessed November 2, 2017.

⁷⁹ Antibacterial Resistance Clinical Research Activities. National Institutes of Health website. <https://www.niaid.nih.gov/research/antibacterial-resistance-clinical-research-activities>. Updated June 16, 2017. Accessed November 2, 2017.

NEXT STEPS

The *CARB Action Plan* provides goals, objectives, and specific milestones for federal agencies aimed at improving prescribing practices across all health care settings, preventing the spread of antibiotic-resistant organisms in health care facilities and communities, and eliminating the use of medically important antibiotics for growth promotion in animals. Phase Four leverages opportunities to complement and reinforce the *CARB Action Plan*, and therefore, the goal listed below for this Phase are aligned with those in the *CARB Action Plan*.

The *HAI Action Plan* and this Phase Four focus on Goal One of the *CARB Action Plan*: to “slow the emergence of resistant bacteria and prevent the spread of resistant infections.” By aligning with this goal, the *HAI Action Plan* promotes continued coordination of antibiotic stewardship activities among federal agencies and thereby helps achieve the outcomes outlined in the *CARB Action Plan*. By pursuing the objectives and milestones within this goal, the following outcomes are expected by 2020:

- Establishment of antibiotic stewardship programs in all acute care hospitals and improved antibiotic stewardship across all health care settings
- Reduction of inappropriate antibiotic use by 50% in outpatient settings and by 20% in inpatient settings
- Establishment of State Antibiotic Resistance Prevention Programs in all 50 states to monitor regionally important resistant organisms and provide feedback and technical assistance to health care facilities

To achieve these outcomes, the *CARB Action Plan* identified broad objectives with specific milestones to be achieved within one, three, and five years. Objectives from the *CARB Action Plan* that relate to the implementation of Phase Four of the *HAI Action Plan* can be found in **Table E**. These objectives of the *CARB Action Plan* provide a basis for measuring the success of the coordination effort described in the Phase Four document.

To move forward the work outlined in Phase Four, and to remain accountable to its intent of this addition to the *HAI Action Plan*, actions will be undertaken to both bridge the work that has been underway within the *CARB Action Plan* and the *HAI Action Plan*, and create new paths to maximize the interagency efforts towards reduction of HAIs and increased uptake of evidence-based medicine, including implementation of ASPs. The goals of both the *CARB Action Plan* and Phase Four will be achieved through collaboration among federal partners. The HAI FSC is uniquely positioned, both historically and functionally, to leverage existing networks for such coordination. To that purpose, the HAI FSC will periodically assess federal efforts in antibiotic stewardship implementation and HAI prevention, and when appropriate, identify need for additional efforts. Slowing the rate of the emergence of resistant bacteria and prevention of the spread of resistant infections will continue to be a health care quality priority.

CONCLUSION

As can be seen, the *National Action Plan to Prevent of Health Care-Associated Infections: Road Map to Elimination* and the *National Action Plan for Combating Antibiotic Resistant Bacteria* work in complementary fashion to protect Americans. Major strides have been made in reducing HAIs and increasing the implementation of ASPs across the nation, but work still remains. In large part, those successes can be attributed to the collaboration and coordination among federal agencies, each bringing to the table their strengths to work for common purposes. The Federal Steering Committee for HAI prevention will work in a coordinated and collaborative manner to prevent health care-associated infections and improve antibiotic stewardship practices. Phase Four of the *HAI Action Plan* serves to bring together the various federal partners in one cohesive and unified effort towards improving antibiotic use.

As health care evolves, federal agencies will continue to play a key role to protect patients and make health care better. Policies and practices that are thoughtfully developed, up-to-date, and authentically embraced will go a long way in improving the health of all Americans.

TABLES

Table A. CDC’s Drug Resistant Threat List Identified in the 2013 Antibiotic Resistant Threat Report:

Urgent Threat Level Pathogens
• <i>Clostridium difficile</i>
• Carbapenem-Resistant Enterobacteriaceae (CRE)
• <i>Neisseria gonorrhoeae</i>
Serious Threat Level Pathogens
• Multidrug-Resistant <i>Acinetobacter</i>
• Drug-Resistant <i>Campylobacter</i>
• Fluconazole-Resistant <i>Candida</i>
• Extended Spectrum β -Lactamase (ESBL)-Producing <i>Enterobacteriaceae</i>
• Vancomycin-Resistant <i>Enterococcus</i> (VRE)
• Multidrug-Resistant <i>Pseudomonas aeruginosa</i>
• Drug-Resistant Non-Typhoidal <i>Salmonella</i>
• Drug-Resistant <i>Salmonella enterica</i> serovar <i>Typhi</i>
• Drug-Resistant <i>Shigella</i>
• Methicillin-Resistant <i>Staphylococcus aureus</i> (MRSA)
• Drug-Resistant <i>Streptococcus pneumoniae</i>
• Drug-Resistant <i>Tuberculosis</i>
Of Concern Threat Level Pathogens
• Vancomycin-Resistant <i>Staphylococcus aureus</i>
• Erythromycin-Resistant Group A <i>Streptococcus</i>
• Clindamycin-Resistant Group B <i>Streptococcus</i>

Table B. Federal Coordination

Project	Lead Agency	Supporting Agencies	Coordination
Protocols, Guidelines, & Prevention Activities			
<i>Core Elements of Hospital Antibiotic Stewardship Programs</i>	CDC	AHRQ, CDC, CMS, NIH, OASH, IHS, VA*	Supported the implementation of the previous Agency Priority Goal, to increase the number of hospitals using the <i>Core Elements</i>
<i>Implementation of Antibiotic Stewardship Core Elements at Small and Critical Access Hospitals</i>	CDC	FORHP	CDC worked with FORHP to develop the document, which uses <i>Core Elements</i> as a framework
<i>The Core Elements of Antibiotic Stewardship for Nursing Homes</i>	CDC	CMS AHRQ	CoP for LTCF align with the <i>Core Elements</i> AHRQ's <i>Nursing Home Guide</i> and <i>Safety Program</i> align with the <i>Core Elements</i>
<i>The Core Elements of Outpatient Antibiotic Stewardship</i>	CDC	CMS AHRQ	Outpatient facilities in QINs-QIOs have been recruited to implement the <i>Core Elements</i> AHRQ's <i>Safety Program</i> aligns with the <i>Core Elements</i>
<i>AHRQ Safety Program for Improving Antibiotic Use</i>	AHRQ	CDC, CMS	Aligns with CDC <i>Core Elements</i> , and CDC and CMS served as ex officio members on the project's Technical Expert Panel
<i>Nursing Home Antimicrobial Stewardship Guide</i>	AHRQ	CDC, CMS	CDC and CMS staff were involved in development and dissemination
<i>AHRQ Safety Program for Long-Term Care</i>	AHRQ	CDC, CMS	CDC and CMS staff were involved in development and dissemination
<i>Toolkit to Reduce CAUTI and other HAIs in Long-Term Care Facilities</i>	AHRQ	CDC, CMS	CDC and CMS staff were involved in development and dissemination
Surveillance			
<i>NHSN</i>	CDC	CMS, VA, DOD	CMS has been influential in the adoption of NHSN in hospitals and other health care settings. VA has committed to having all VHA medical centers report antibiotic use.

Project	Lead Agency	Supporting Agencies	Coordination
Incentives & Oversight			
<i>Infection Control Pilot</i>	CMS	CDC	CMS and CDC are working together on a three- year Infection Control pilot which involves using draft surveyor Infection Control Worksheets (ICWS) in both hospitals and nursing homes. Efforts are centered on Infection Control and Prevention, Transitions of Care and also Antibiotic Use.
<i>Hospital Associated Conditions Reduction Program, Hospital Value-based Purchasing</i>	CMS	CDC	IPPS Hospitals report multi-drug resistant organisms such as MRSA and those related to misuse or overuse of antibiotics such as C. diff as part of CMS' payment incentive programs using surveillance data from NHSN.
Research			
<i>Grant Applications</i>		AHRQ, NIH, CDC	AHRQ, NIH, and CDC coordinate the assignment of grant applications to the most appropriate agency. AHRQ and CDC jointly held a meeting of experts to identify knowledge gaps for prevention of resistant HAIs

* Note—VA had implemented its own antimicrobial stewardship initiative prior to development of CDCs Core Elements and their release; however, the Core Elements encompass the efforts which VA has already undertaken and are also supported by VA.

Table C. Core Elements from CDC’s *Core Elements of Hospital Antibiotic Stewardship Programs* and CDC’s *Core Elements of Antibiotic Stewardship for Nursing Homes*

<i>Core Element</i>	<i>Definition</i>
Leadership Commitment	Dedicating necessary human, financial, and information technology resources
Accountability	Appointing a single leader responsible for program outcomes
Drug Expertise	Appointing a single pharmacist leader responsible 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 of information on antibiotic use and resistance to doctors, nurses, and relevant staff
Education	Educating clinicians about resistance and optimal prescribing

Table D. Core Elements from CDC’s *Core Elements of Outpatient Antibiotic Stewardship*

<i>Core Element</i>	<i>Definition</i>
Commitment	Demonstrate dedication to and accountability for optimizing antibiotic prescribing and patient safety
Action for Policy and Practice	Implement at least one policy or practice to improve antibiotic prescribing, assess whether it is working, and modify as needed
Tracking and Reporting	Monitor antibiotic prescribing practices and offer regular feedback to clinicians, or have clinicians assess their own antibiotic prescribing practices themselves
Education and Expertise	Provide educational resources to clinicians and patients on antibiotic prescribing, and ensure access to needed expertise on optimizing antibiotic prescribing

Table E. CARB National Action Plan Goal 1 Select Objectives and Sub-Objectives

Goal: Slow the Emergence of Resistant Bacteria and Prevent the Spread of Resistant Infections	
Objective: Implement public health programs and reporting policies that advance antibiotic resistance prevention and foster antibiotic stewardship in health care settings and the community	
Sub-Objective 1.1.1A	Strengthen antibiotic stewardship in inpatient, outpatient, and long-term care settings by expanding existing programs, developing new ones, and monitoring progress and efficacy.
Sub-Objective 1.1.1B	Strengthen educational programs that inform physicians and the public about good antibiotic stewardship.
Sub-Objective 1.1.2	Expand collaborative efforts by groups of health care facilities that focus on preventing the spread of antibiotic resistant bacteria that pose a serious threat to public health.
Sub-Objective 1.1.3	Implement annual reporting of antibiotic use in inpatient and outpatient settings and identify variations at the geographic or provider/patient level to help guide interventions.
Sub-Objective 1.1.4	Develop and pilot new interventions to address drivers of the emergence and spread of antibiotic resistance
Sub-Objective 1.1.5	Streamline regulatory processes for updating antibiotic susceptibility testing devices (only year 5 milestones)

LIST OF ACRONYMS

AHRQ	Agency for Healthcare Research and Quality
APHL	Association of Public Health Laboratories
APIC	Association for Professionals in Infection Control and Epidemiology
ASP	Antibiotic stewardship program
<i>CARB Action Plan</i>	<i>National Action Plan for Combating Antibiotic-Resistant Bacteria</i>
CAUTI	Catheter-associated urinary tract infection
CDC	Centers for Disease Control and Prevention
CDI	<i>Clostridium difficile</i> infection
CMS	Centers for Medicare and Medicaid Services
CoPs	Conditions of participation
CUSP	Comprehensive Unit-based Safety Program
DOD	Department of Defense
ESRD	End-stage renal disease
FORHP	Federal Office of Rural Health Policy
FOA	Funding opportunity announcement
HACs	Health care-acquired condition
HAI	Health care-associated infection
<i>HAI Action Plan</i>	<i>National Action Plan to Prevent Health Care-Associated Infections: Road Map to Elimination</i>
HHS	U.S. Department of Health and Human Services
HIIN	Hospital Improvement Innovation Network
IHS	Indian Health Service
LTCF	Long-term care facility
ITFAR	Federal Interagency Task Force on Antimicrobial Resistance
MBQIP	Medicare Beneficiary Quality Improvement Project
MDRO	Multi-drug resistant organism
MIPS	Merit-based Incentive Payment System
MRSA	Methicillin-resistant <i>Staphylococcus aureus</i>
NH	Nursing home
NHSN	National Healthcare Safety Network
NIH	National Institutes for Health
OASH	Office of the Assistant Secretary for Health
PPS	Prospective Payment System
QIN-QIO	Quality Innovation Network-Quality Improvement Organization
QIP	Quality Incentive Program
QRP	Quality Reporting Program
SAAR	Standardized Antimicrobial Administration Ratio
SHEA	Society for Healthcare Epidemiology of America
SNF	Skilled nursing facility
VA	Department of Veterans Affairs
VHA	Veterans Health Administration
VBP	Value-Based Purchasing Program