



APIC/SHEA/SIDP Antimicrobial Stewardship Position Paper

## Antimicrobial stewardship and infection prevention—leveraging the synergy: A position paper update



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During 2012, the Association for Professionals in Infection Control and Epidemiology (APIC) and the Society for Healthcare Epidemiology of America (SHEA) published a position paper highlighting the critical importance of infection preventionists (IPs) and health care epidemiologists (HEs) in effective antimicrobial stewardship (AS) programs.<sup>1</sup> AS refers to collaborative, coordinated programs and interventions designed to improve antimicrobial prescribing (ie, right drug, dose, duration, and route of administration when antibiotics are needed) to optimize clinical outcomes while minimizing unintended consequences of antimicrobial agent use such as toxicity, selection of pathogenic organisms, and emergence of resistance.<sup>2,3</sup>

In the intervening 5 years, much has happened to garner national and regulatory attention to the growing problem of antimicrobial resistance (AMR) and the importance of AS and the concomitant stewardship of diagnostic testing as strategies to slow the emergence of resistant organisms while limiting unintended consequences such as selecting for resistant pathogens and the development of *Clostridium difficile* infection (CDI). This paper updates and reaffirms the critical role of IPs and HEs in the prevention and control of health care-associated infections (HAIs), particularly those caused by multidrug-resistant organisms (MDROs). The key supporting role of infection prevention and control (IPC) programs in advancing the synergistic strategy of AS alongside physician and pharmacist AS leaders is also highlighted.

Three watershed events occurred in recent years to increase AMR and AS awareness among health care providers, policy makers, and the public. First, the human and economic cost of AMR in the United States was revealed in the Centers for Disease Control and Prevention (CDC) report, *Antibiotic Resistance Threats in the United States, 2013*.<sup>4</sup> Using conservative estimates, the CDC determined that antibiotic-resistant organisms are responsible for more than 2 million infections and 23,000 deaths per year in the United States, at a direct cost of \$20 billion.<sup>4</sup> This report provided the first comprehensive snapshot of dangers posed by antibiotic-resistant organisms in the United States, categorizing these hazards as urgent, serious, or concerning. A subsequent, and perhaps more sobering 2014 report commissioned by the UK Prime Minister and the Wellcome Trust suggested that without global action, 10 million deaths from AMR infections will occur worldwide by 2050.<sup>5</sup> Second, in response to this escalating problem, in 2014 President Obama implemented the National Strategy on Combating Antibiotic Resistant Bacteria through Executive Order 13676, followed in March 2015 by release of the *National Action Plan for Combating Antibiotic-Resistant Bacteria*,<sup>6</sup> which outlines specific actions to be taken to implement the strategy. The action plan provides a 5-year roadmap outlining critical actions by key federal departments and agencies, as well as goals, milestones, and metrics for measuring progress. Of specific interest to IPs and HEs are actions for major reductions in the incidence of urgent and serious threats, including carbapenem-resistant Enterobacteriaceae, methicillin-resistant *Staphylococcus aureus*, and CDI; improved AS across all health care settings; and enhanced capacity to prevent the spread of resistant infections.<sup>6</sup> Third, following release of the action plan, the White House convened the first-ever Forum on Antibiotic Stewardship and established the Presidential Advisory Council on Combating Antibiotic Resistant Bacteria. The Forum brought together 150 key human and animal health

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constituencies involved in AS, providing participants the opportunity to exchange ideas on ways public and private sectors can work together to improve responsible use of antibiotics, as well as commit to action.<sup>7</sup> The Advisory Council provides advice, information, and recommendations to the Secretary of Health and Human Services regarding programs and policies intended to support and evaluate the implementation of federal activities related to combating antibiotic-resistant bacteria.<sup>8</sup> Of note, the 2015 APIC, SHEA, and Society of Infectious Diseases Pharmacists (SIDP) presidents participated in the Forum on Antibiotic Stewardship and the 2017 APIC and SHEA presidents gave presentations during the Advisory Council meeting for nonfederal stakeholders during January 2017.

These 3 events directly influenced the development of subsequent reports and recent regulatory mandates that highlight the key supporting role of IPC programs in advancing successful AS interventions across the entire continuum of patient care, including:

- CDC Core Elements of Hospital Antibiotic Stewardship Programs,<sup>9</sup> CDC Core Elements of Antibiotic Stewardship for Nursing Homes,<sup>10</sup> CDC Core Elements of Outpatient Antibiotic Stewardship,<sup>11</sup> and Implementation of Antibiotic Stewardship Core Elements at Small and Critical Access Hospitals.<sup>12</sup> Each document identifies key structural and functional aspects of effective programs, and indicates that the work of physician and pharmacist AS program leaders is greatly enhanced by the support of other key groups, including IPC programs.
- National Quality Partners Playbook: Antibiotic Stewardship in Acute Care.<sup>13</sup> This comprehensive tool uses the CDC core elements as a framework and provides concrete strategies and practical suggestions to guide hospitals in strengthening existing AS initiatives or creating successful AS programs from the ground up.
- The Centers for Medicare and Medicaid Services new requirements for participation rule, effective in 2016, requires long-term care (LTC) facilities to update their IPC program, including requiring an IPC officer in 2019, and an AS program that includes antibiotic use protocols and a system to monitor antibiotic use to be implemented in 2017.<sup>14</sup> The Centers for Medicare and Medicaid Services proposed infection control conditions-of-participation rule that requires AS programs in all acute care and critical access hospitals is among the pending regulations awaiting approval.
- The Joint Commission Antimicrobial Stewardship Standard MM.09.01.01, effective January 1, 2017, requires hospitals, critical access hospitals, and nursing care centers have AS programs based on current scientific publications, and to have an AS multidisciplinary team that includes IPs.<sup>15</sup> The original standard contained 8 elements of performance (EPs)<sup>15</sup>; however, effective October 1, EP 3 (The [critical access] hospital educates patients, and their families as needed regarding the appropriate use of antimicrobial medications, including antibiotics) was deleted. This decision was based on feedback to The Joint Commission that education for patients regarding specific antimicrobial therapy they are receiving is already required under other medication management standards and that the value of general education on AS principles was unlikely to be retained by hospitalized patients and families and would be more appropriately delivered in outpatient settings.<sup>16</sup>

## THE SYNERGY OF IPC AND AS PROGRAMS

IPC and AS are bound by a strong *esprit de corps* and shared common goal—to keep patients safe and to improve patient outcomes, regardless of where care is delivered. The increasing incidence of MDRO infections has become a safety concern for patients across

the continuum of patient care. MRDO infections are more difficult to treat, incur greater treatment costs, and have greater morbidity and mortality than infections caused by organisms susceptible to antibiotics. Antibiotic misuse and overuse facilitates the development of MDROs, as well as CDI infections – an antibiotic-associated adverse drug event – making AS an important synergistic HAI prevention and control strategy.<sup>17</sup> In fact, a recent meta-analysis showed AS programs reduced the incidence of infections and colonization with multidrug-resistant gram-negative bacteria, extended-spectrum  $\beta$ -lactamase-producing gram-negative bacteria, and methicillin-resistant *S aureus*, as well as the incidence of CDI infections.<sup>18</sup> Furthermore, AS programs, when implemented alongside IPC measures, especially hand-hygiene interventions, were more effective than implementation of AS alone—verifying that a well-functioning IPC program is fundamental to a successful organizational AS strategy.<sup>18</sup> Similar data have also shown that the addition of AS interventions can enhance results of robust IPC measures, particularly when addressing an outbreak.<sup>19</sup>

AS programs have been shown to improve patient outcomes, reduce antimicrobial agent-related adverse events, and decrease AMR.<sup>18–21</sup> To date, primary strategies include prescriber preauthorization and prospective audit and feedback, with supplemental strategies such as guidelines and clinical pathway development, intravenous-to-oral conversion protocols, limiting inappropriate culturing, and provider education.<sup>29–12</sup> Changing practices and prescribing patterns and learned behaviors of physicians, nurses, pharmacists, and other health care providers will take time and investment, but is critical to affecting a long-term solution to the rise of AMR and CDI infections. It is equally important that all clinicians depend on evidence-based IPC interventions to reduce demand for antimicrobial agents by preventing infections from occurring in the first place, and making every effort to prevent transmission when they do. IP and HE leaders are credible IPC subject-matter experts with additional social and behavioral skills to effectively engage the different professional disciplines to promote, implement, support, sustain, and evaluate IPC strategies across practice settings—many of the same skills needed by those leading AS programs. IPC and AS programs are intrinsically linked, making effective collaboration essential to ensure patient safety.

The CDC identifies core elements associated with successful AS programs—7 elements for hospitals and LTC facilities<sup>9,10,12</sup> and 4 elements for outpatient facilities<sup>11</sup>—and provides a framework for implementation. Tables 1 and 2 provide a description of each element. APIC, SHEA, and SIDP support the CDC core elements as an AS framework and believe the following related to the synergy of IPC and AS:

1. Leadership commitment. Health care system leaders must prioritize IPC and AS as part of wider patient safety strategies, creating an infrastructure to promote, sustain, and disseminate best practices across the continuum of patient care. IPC and AS program leaders must work together to align their programs, promoting communication and collaboration, and reducing the likelihood of redundant initiatives. Given the synergy between the programs, they should seize every opportunity to benefit from each other's expertise and organizational influence and partner when making the case for program support and necessary resource allocation to clinical and administrative leadership.
2. Accountability. AS programs are best led by infectious disease (ID) physicians with clinical pharmacists with additional stewardship training.<sup>2,3,9</sup> Although this is the preferred approach, assuming this additional responsibility may exceed the capacity and/or capability of some ID physicians and/or clinical pharmacists and be impractical for community and critical access

hospitals, as well as nonacute settings such as ambulatory and LTC facilities. As a result, in practice, AS programs are being led by a variety of health care professionals, in a variety of settings.<sup>22-25</sup> Regardless of leadership model, it is imperative to engage interested, local, and respected physician, pharmacist, and nursing champions to help foster collaboration across specialty areas and to lend support for strong, empowered leadership at the front line of patient care. Those engaged in building, leading, and evaluating AS programs should seek to acquire the core skills as outlined in the SHEA white paper, *Guidance for the Knowledge and Skills Required for Antimicrobial Stewardship Leaders* as listed in Table 3.<sup>22</sup>

3. Drug expertise. Most pharmacists are not formally trained in ID, and the majority of health care facilities do not have access to an ID pharmacist who is comfortable with AS.<sup>22,26</sup> Health care facilities should consider appointing general clinical pharmacists to fill this role but should then require and fund additional training in AS from entities such as the SIDP Making a Difference in Infectious Diseases program, or SHEA.<sup>27,28</sup> Alternative methods can also be used to gain access to ID physicians and pharmacists, including pooling resources, employing external stewardship consultants onsite or via telehealth, or seeking additional expertise by joining multihospital improvement collaboratives.<sup>12,29</sup> When remote expertise is used, it is important to have an AS program leader who is on staff at the hospital.<sup>12</sup>
4. Action. Although IPs and HEs may not be involved in preauthorization or prospective audit and feedback interventions, they do engage a diverse range of clinical disciplines across practice settings in HAI prevention. IPs have substantial contact with bedside nurses, often together reviewing patients who develop HAIs as part of routine daily activities. They can leverage these strong collegial relationships to influence and facilitate nursing's supporting role in initiating antibiotic timeouts, performing antibiotic reconciliation during patient transitions of care, and educating patients and families about safe and appropriate antibiotic use.<sup>30-33</sup> For example, a recent study found that nurse prompting of antimicrobial review during daily rounds can lead to significant reduction in antimicrobial agent use, providing another mechanism of sustaining antimicrobial awareness.<sup>34</sup> Additionally, IPs and HEs often participate in unit-based safety teams (eg, the Comprehensive Unit-Based Safety Program) and can facilitate an interprofessional, unit-based discussion of AS needs by inviting relevant AS team members to join the meetings. Furthermore, collaborative efforts to have the stewardship team contact the IPC team when they identify and/or approve antibiotic therapy for patients with infections caused by certain MDROs, and IP assistance in training bedside nurses in appropriate culture techniques are examples of how IPs and stewards can expand the capacity of both teams. Similar to IPC interventions and actions, flexibility and tailoring AS approaches to local needs is essential.
5. Tracking. Although not responsible for monitoring antibiotic prescribing, IPC programs do perform surveillance for emerging pathogens and resistance patterns, as well as rapid response to every possible transmission. Use of the CDC National Healthcare Safety Network Antimicrobial Use and Resistance module is highly effective because it provides a mechanism for facilities to report and analyze antimicrobial agent use as part of AS efforts at their facility.<sup>35</sup> Standardized antimicrobial administration ratio values can serve as a starting point for medication use evaluations by AS programs. To successfully report to the Antimicrobial Use and Resistance module, stewardship teams will need to work closely with their IPC team to ensure that appropriate data structures are developed and kept in alignment

for reporting. There are important implications for antimicrobial agent use based on how units are grouped, including standardized antimicrobial administration ratio values only being calculated for specific unit types. Therefore, to obtain the most value from these data, the stewardship and IPC teams need to be in constant contact regarding facility structure and other reporting considerations. These data will also benefit the IPC team because antibiotic use patterns are often a key element in outbreak investigations. Stewardship programs also have data sources beyond the National Healthcare Safety Network and can often provide electronic antibiotic use summaries on the patient level, aiding the work of IPs and HEs.

6. Reporting. Although not responsible for reporting information on antibiotic use, IPC programs are responsible for HAI surveillance and providing feedback of infection rates (eg, MDRO and CDI) and audit data (eg, hand hygiene adherence) to clinicians and other stakeholders. CDI prevention is a high priority for IPC and AS programs, so sharing and disseminating antibiotic use and CDI infection rates is essential to prevention efforts.<sup>2</sup> Providing feedback that is timely, frequent, individualized, nonpunitive, and customized can be very influential in reducing HAIs and antimicrobial agent use.<sup>33,36-38</sup> As more robust antibiotic use benchmarking tools are more fully developed, there is a vital role of IPC programs to help educate and guide local reporting patterns. Similar to HAI data, data on stewardship efforts should be reported not just to providers, but also to appropriate facility committees, such as the IPC, patient safety, and medical executive committees, as well as the board of directors.
7. Education. Health care provider engagement is an essential component for successful IPC and antibiotic resistance prevention work. Creating educational strategies to address each discipline's clinical interests and make the case for why IPC and AS is of value to them and their patients is essential.<sup>39</sup> Education should be team oriented and problem based, and are most effective when they include workshops, bedside teaching, and simulation-based training.<sup>40</sup> We encourage the participation of IPs and HEs in designing and delivering AS-related education to health care providers as well as to patients and their families. This can often be done in collaboration with the AS team to reach a broader and more diverse audience with a single consistent message of preventing infection and reducing MDROs. A logical area for IPC education participation is to ensure that front-line physicians and nurses are aware of the indications for testing as well as the risks associated with inappropriate testing. Some specific examples include indications for obtaining and appropriate collection of urine cultures, indications for obtaining culture from endotracheal tubes, and indications for testing for CDI infections.

In addition to the CDC core elements, APIC, SHEA, and SIDP further believe that microbiology laboratory staff members and clinical microbiologists play an essential role in successful IPC and AS programs, including:

- Diagnosis. The accurate and timely services provided by a microbiology laboratory supports the application of medical knowledge and judgment to achieve the best outcomes for patients with an ID. The lab provides information to help determine whether a patient is infected, what the pathogen is, and in most cases the susceptibility of the organism. The laboratory provides interpretation and translation of the results into the day-to-day infection management.<sup>41</sup> Recent advances in molecular diagnostic technologies have significantly reduced the delay in ID diagnosis, can identify and precisely characterize emerging pathogens, and trace the source of outbreaks in a manner of

**Table 1**The Centers for Disease Control and Prevention core elements of antimicrobial stewardship for hospitals and long-term care facilities<sup>9,10,12</sup>

Element	Description
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 for working to improve antibiotic agent use
Action	Implementing at least 1 recommended action with the goal of improving antimicrobial agent use
Tracking	Monitoring antibiotic prescribing and resistance patterns
Reporting	Regular reporting of information on antibiotic agent use and resistance to doctors, nurses, and relevant staff
Education	Educating clinicians about resistance and optimal prescribing

**Table 2**The Centers for Disease Control and Prevention core elements of outpatient antimicrobial stewardship<sup>11</sup>

Element	Description
Commitment	Demonstrate dedication to and accountability for optimizing antibiotic prescribing and patient
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	Monitoring 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 3**Categories of knowledge and skills required for antimicrobial stewardship leaders<sup>22</sup>

1. General principles of antimicrobial stewardship
2. Approaches to stewardship interventions
3. Microbiology and laboratory diagnostics
4. Common infectious syndromes
5. Measurement and analysis
6. Informatics/information technology
7. Program building and leadership
8. Special populations and nonacute hospital settings
9. Infection control

days.<sup>42</sup> It is essential for IPs, HEs, and the AS team to understand the scope of these rapid diagnostic tests and work together to develop processes and interventions to assist clinicians in interpreting and responding appropriately to results.<sup>2</sup>

- **Guidance.** To achieve the best results, microbiology cultures should have an appropriate indication (right test at the right time), be properly collected, and transported to a laboratory in a timely manner before antibiotic agents are administered. The influence of proper specimen collection is key in providing clinicians accurate information to improve patient outcomes. A clinician needs to have confidence that the results are accurate, clinically relevant, and significant.<sup>43,44</sup>
- **Advisement.** To effectively use molecular diagnostic technology for enhancement of IPC practices, it is important to understand the scope of these rapid diagnostic tests and to appreciate the need for judicious interpretation in collaboration with a clinical microbiologist.<sup>42</sup>

## SUMMARY

The issues surrounding the prevention and control of infections are intrinsically linked with the issues associated with the use of antimicrobial agents and the proliferation and spread of MDROs. The vital work of IPC and AS programs cannot be performed independently and requires interdependent and coordinated action across multiple and overlapping disciplines and clinical settings. Deliberate strategic relationship-building actions will be required of IPC and AS program leaders to bring groups together to achieve the larger purpose of keeping patients safe from infection and ensuring that effective antibiotic therapy is available for future generations.

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## References

1. Moody J, Cosgrove SE, Olmstead R, Septimus E, Aureden K, Oriola S, et al. Antimicrobial stewardship: a collaborative partnership between infection preventionists and health care epidemiologists. *Am J Infect Control* 2012;40:94–5.
2. Barlam TF, Cosgrove SE, Abbo LM, MacDougall C, Schuetz AN, Septimus EJ, et al. Implementing an antibiotic stewardship program: guidelines by the Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America. *Clin Infect Dis* 2016;62:e51–77.
3. Dellit TH, Owens RC, McGowan JE, Gerding DN, Weinstein RA, Burke JP, et al. Infectious Disease Society of America and the Society for Healthcare Epidemiology of America guideline for developing an institutional program to enhance antimicrobial stewardship. *Clin Infect Dis* 2007;44:159–77.
4. Centers for Disease Control and Prevention (CDC). Antibiotic resistance threats in the United States 2013. 2013. Available from: <http://www.cdc.gov/drugresistance/pdf/ar-threats-2013-508.pdf>. Accessed August 11, 2017.
5. O'Neill J. The review on antimicrobial resistance. Antimicrobial resistance: tackling a crisis for the health and wealth of nations. December 2014. Available from: <http://amr-review.org/>. Accessed September 5, 2017.
6. The White House. National action plan for combating antibiotic-resistant bacteria, 2015. Available from: [https://www.whitehouse.gov/sites/default/files/docs/national\\_action\\_plan\\_for\\_combating\\_antibiotic-resistant\\_bacteria.pdf](https://www.whitehouse.gov/sites/default/files/docs/national_action_plan_for_combating_antibiotic-resistant_bacteria.pdf). Accessed August 11, 2017.
7. The White House Briefing Room. Fact sheet: over 150 animal and health stakeholders join white house efforts to combat antibiotic resistance. 2015. Available from: <https://www.whitehouse.gov/the-press-office/2015/06/02/fact-sheet-over-150-animal-and-health-stakeholders-join-white-house-effo>. Accessed August 11, 2017.
8. Presidential Advisory Council on Combating Antibiotic Resistant Bacteria (PACCARB). About us. Available from: <https://www.hhs.gov/ash/advisory-committees/paccarb/index.html>. Accessed November 1, 2017.
9. Centers for Disease Control and Prevention (CDC). Core elements of hospital antibiotic stewardship programs. 2014. Available from: <http://www.cdc.gov/getsmart/healthcare/pdfs/core-elements.pdf>. Accessed August 11, 2017.
10. Centers for Disease Control and Prevention (CDC). Core elements of antibiotic stewardship programs for nursing homes. 2015. Available from: <http://www.cdc.gov/longtermcare/prevention/antibiotic-stewardship.html>. Accessed August 11, 2017.
11. Centers for Disease Control and Prevention (CDC). Core elements of outpatient antibiotic stewardship. 2016. Available from: [https://www.cdc.gov/getsmart/community/pdfs/16\\_268900-a\\_coreelementsoutpatient\\_508.pdf](https://www.cdc.gov/getsmart/community/pdfs/16_268900-a_coreelementsoutpatient_508.pdf). Accessed August 11, 2017.
12. Centers for Disease Control and Prevention (CDC). Implementation of antibiotic stewardship core elements at small and critical access hospitals. 2017a. Available from: <https://www.cdc.gov/getsmart/healthcare/implementation/core-elements-small-critical.html>. Accessed August 11, 2017.

13. National Quality Forum. Antibiotic stewardship in acute care: a practical playbook. NQF, Washington, DC 2016. Available from: <http://www.qualityforum.org/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=82501>. Accessed August 11, 2017.
14. Centers for Medicare and Medicaid Services. CMS finalizes improvements in care, safety, and consumer protections for long-term care facility residents. 2016. Available from: <https://www.cms.gov/Newsroom/MediaReleaseDatabase/Press-releases/2016-Press-releases-items/2016-09-28.html?DLPage=1&DLEntries=10&DLSort=0&DLSortDir=descending>. Accessed November 12, 2017.
15. The Joint Commission. New antimicrobial stewardship standard. Available from: [https://www.jointcommission.org/assets/1/6/New\\_Antimicrobial\\_Stewardship\\_Standard.pdf](https://www.jointcommission.org/assets/1/6/New_Antimicrobial_Stewardship_Standard.pdf). Accessed July 6, 2017.
16. The Joint Commission. EP deletion: MM.09.01.01, EP 3 going away. Available from: <https://www.jointcommission.org/issues/article.aspx?Article=YorQ4E0NZh1S0mOxW2H%2FtFfcVycrphOFImQsZM%2BlvPc%3D>. Accessed November 11, 2017.
17. Septimus E, Weinstein RA, Perl T, Goldmann DA, Yokoe DS. Approaches for preventing healthcare-associated infections: go long or go wide? *Infect Control Hosp Epidemiol* 2014;35:797-801.
18. Baur D, Gladstone BP, Burkert F, Carrara E, Foschi F, Döbele S, et al. Effect of antibiotic stewardship on the incidence of infection and colonisation with antibiotic-resistant bacteria and *Clostridium difficile* infection: a systematic review and meta-analysis. *Lancet Infect Dis* 2017;17:990-1001.
19. Valiquette L, Cossette B, Garant M-P, Diab H, Pepin J. Impact of a reduction in the use of high-risk antibiotics on the course of an epidemic of *Clostridium difficile*-associated disease caused by the hypervirulent NAP1/027 strain. *Clin Infect Dis* 2007;45:S112-21.
20. Dodds Ashley ES, Keye KS, DePestel DD, Hermsen ED. Antimicrobial stewardship: philosophy versus practice. *Clin Infect Dis* 2014;59:S112-21.
21. Kelly AA, Jones MM, Echevarria KL, Kralovic SM, Samore MH, Goetz MB, et al. A report of the efforts of the Veterans Health Administration national antimicrobial stewardship initiative. *Infect Control Hosp Epidemiol* 2017;38:513-20.
22. Cosgrove SE, Hermsen ED, Rybak MJ, File TM, Parker SK. Guidance for the knowledge and skills required for antimicrobial stewardship leaders. *Infect Control Hosp Epidemiol* 2014;35:1444-51.
23. Srinivasan A. Engaging hospitalists in antimicrobial stewardship: the CDC perspective. *J Hosp Med* 2011;6:S31-3.
24. Scales K, Zimmerman S, Reed D, Beeber AS, Kistler CE, Preisser JS, et al. Nurse and medical provider perspectives on antibiotic stewardship in nursing homes. *J Am Geriatr Soc* 2016;65:165-71.
25. Manning ML, Pogorzelska-Maziarz M. Healthcare system leaders' perspectives on infection preventionist and registered nurse engagement in antibiotic stewardship. *Am J Infect Control* 2017; accepted for publication 10/2017.
26. Heil EL, Kuti JL, Bearden DT, Gallagher JC. The essential role of pharmacists in antimicrobial stewardship. *Infect Control Hosp Epidemiol* 2016;37:753-4.
27. MAD\_ID, Making a difference in infectious diseases. Antimicrobial stewardship training programs for pharmacist and physicians. Available from: <http://mad-id.org/>. Accessed November 11, 2017.
28. Society of Infectious Diseases Pharmacists. Antimicrobial stewardship certificate program for pharmacist. Available from: <https://www.sidp.org/>. Accessed November 11, 2017.
29. Stenehjem E, Hyun DY, Septimus E, Yu KC, Meyer M, Raj D, et al. Antibiotic stewardship in small hospitals: barriers and solutions. *Clin Infect Dis* 2017;65:691-6.
30. Manning ML, Pfeiffer J, Larson EL. Combating antibiotic resistance: the role of nursing in antibiotic stewardship. *Am J Infect Control* 2016;44:1454-7.
31. 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. Available from: <http://www.nursingworld.org/ANA-CDC-AntibioticStewardship-WhitePaper>. Accessed September 5, 2017.
32. Olson CA, Tooman TR, Alvarado CJ. Knowledge systems, health care teams, and clinical practice: a study of successful change. *Adv Health Sci Educ Theory Pract* 2010;15:491-516.
33. Pakyz AL, Moczygomba LR, VanderWielen LM, Edmond MB, Stevens MP, Kuzel AJ. Facilitators and barriers to implementing antimicrobial stewardship strategies: results from a qualitative study. *Am J Infect Control* 2014;42:S257-63.
34. Raybardhan S, Chung B, Ferreira D, Britton M, Shin P, Kan T, et al. Nurse prompting for prescriber-led review of antimicrobial use in the critical care unit: A quality improvement intervention with controlled interrupted time series analysis. Poster presented at: IDWeek; October 5, 2017; San Diego, CA. Available from: <https://idsa.confex.com/idsa/2017/webprogram/Paper65336.html>. Accessed December 5, 2017.
35. Centers for Disease Control and Prevention. Antimicrobial Use and Resistance (AUR) Module 2017b. Available from: <https://www.cdc.gov/nhsn/pdfs/pscmanual/11pscaurcurrent.pdf>. Accessed November 11, 2017.
36. Hyson SJ. Meta-analysis: audit and feedback features impact effectiveness on quality of care. *Med Care* 2009;47:356-63.
37. Solomon DH, Van Houten L, Glynn RJ, Baden L, Curtis K, Schragger H, et al. Academic detailing to improve use of broad-spectrum antibiotics at an academic medical center. *Arch Intern Med* 2001;161:1897-902.
38. Lesprit P, Landelle C, Brun-Buisson C. Clinical impact of unsolicited post-prescription antibiotic review in surgical and medical wards: a randomized controlled trial. *Clin Microbiol Infect* 2013;19:E91-7.
39. Fakhri MG, Krein SL, Edson B, Watson SR, Battles JB, Saint S. Engaging health care workers to prevent catheter-associated urinary tract infection and avert patient harm. *Am J Infect Control* 2014;42:S223-9.
40. Zingg W, Holmes A, Dettenkofer M, Goetting T, Secci F, Clack L, et al. Hospital organization, management, and structure for prevention of health-care-associated infection: a systematic review and expert consensus. *Lancet Infect Dis* 2015;15:212-24.
41. Dik J, Poelman R, Friedrich AW, Panday PN, Lo-Ten-Foe JR, van Assen S, et al. An integrated stewardship model: antimicrobial, infection prevention and diagnostic (AID). *Future Microbiol* 2015;11:93-102.
42. Das S, Shibib DR, Vernon MO. The new frontier of diagnostics: molecular assays and their role in infection prevention and control. *Am J Infect Control* 2017;45:158-69.
43. Morency-Potvin P, Schwartz DN, Weinstein RA. Antimicrobial stewardship: how the right microbiology laboratory can right the ship. *Clin Microbiol Rev* 2017;30:381-407.
44. Mullin KM, Kovacs CS, Fatica C, Einloth C, Neuner EA, Guzman JA, et al. A multifaceted approach to reduction of catheter-associated urinary tract infections in the intensive care unit with an emphasis on "stewardship of culturing." *Infect Control Hosp Epidemiol* 2017;38:186-8.