

Antimicrobial Stewardship in Long-term Care Facilities

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KEYWORDS

- Long-term care • Antimicrobial stewardship • Antimicrobial resistance • Elderly
- Infection prevention

KEY POINTS

- Long-term care facilities (LTCF) house a unique patient population, who are often elderly with several preexisting medical conditions.
- Residents of LTCF are often colonized with multidrug-resistant organisms, and antibiotic stewardship is essential to limit the further emergence of resistance.
- Antimicrobial stewardship is a new but necessary concept in LTCFs.
- Stewardship strategies from acute care settings may be adapted to function with the available resources utilized in LTCFs.

INTRODUCTION

Antimicrobial resistance has been identified as a major public health crisis. National summary data from the Centers for Disease Control and Prevention (CDC) estimate that more than 2 million illnesses are attributable to resistant infections.¹ As a result of increasing prevalence of virulent and drug-resistant organisms, including *Clostridium difficile*, methicillin-resistant *Staphylococcus aureus* (MRSA), and drug-resistant gram-negative organisms, there has been a call for the implementation of antimicrobial stewardship programs (ASPs) across the health care spectrum.² ASP refers to the development of programs that addresses the “appropriate selection, dosing, route, and duration of antimicrobial therapy”. Guidelines for the development of stewardship programs generally target stewardship activities in the acute care setting.³ The success of stewardship programs in the hospital setting has been described, with reductions in the rate of *C. difficile* infection, antibiotic usage, and improved pharmacy expenditures.^{4–6} Implementation of similar programs in

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long-term care facilities (LTCF) has been limited, despite the heavy use of antibiotics and high prevalence of resistant organisms in these settings.⁷ To add to an already complicated picture, the population in the United States continues to age, with an estimated 21% of the population in 2040 consisting of adults 65 years of age and older.⁸ As increased usage of LTCFs looms, the burden of inappropriate usage of antimicrobials in this health care setting will also increase in the absence of appropriate guidance.

THE BURDEN OF INFECTION IN LTCF

There are more than 15,000 nursing homes in the United States, with an estimated 1.5 million residents.⁹ Previous epidemiologic studies have reported an infection prevalence rate of 5.3%, based on a single-day survey, and infection incidence rates ranging from 3.6 to 5.2/1000 resident days.^{10–12} The most commonly reported infections in nursing homes are urinary tract infections (UTIs), lower respiratory tract infections, including pneumonia, skin and soft tissue infections, and gastroenteritis. Infections are among the most frequent causes of transfer to acute care hospitals, and 30-day hospital readmissions from LTCF are associated with increased mortality in this population.^{13–16}

The burden of multidrug-resistant organisms has also been identified as a key issue in this population, often a consequence of the overuse of antibiotics.¹⁷ There is a higher incidence of invasive MRSA in adults greater than or equal to 65 years old, as compared with their younger counterparts.¹⁸ Surveillance of various facilities has shown high prevalence of both colonization and infection with resistant organisms such as MRSA and multidrug-resistant gram-negative pathogens.^{19–21} Among LTCF residents, infections with antibiotic-resistant organisms are associated with more severe infection, hospitalization, increased risk of death, and increased cost of care.^{22–24} With a growing population of residents transferring between hospitals and LTCFs, the risk for resistance to emerge and spread within LTCFs has increased. In a study assessing movement of patients between health care settings, more than 50% of individuals identified with a carbapenem-resistant organism during a hospitalization were discharged to post-acute care facilities such as LTCFs.²⁵ Failure to control spread of resistance in LTCFs can also affect surrounding hospitals. An MRSA outbreak in one LTCF led to increasing prevalence of this organism in several adjacent California hospitals.²⁶

The antimicrobial overuse in LTCF exposes residents to the potential and realized harm that is caused by antibiotics, such as *C. difficile* infection.^{27–29} In a study of nursing homes in Rhode Island, 72% of patients received an antibiotic that was inappropriate according to established guidelines, with 67% receiving antibiotic therapy longer than the recommended duration, with a resultant increased incidence of *C. difficile* infection. In the geriatric population, it has already been shown that antimicrobials are one of the most commonly prescribed medications, with a significant associated adverse drug event risk.²⁹

CHALLENGES WITH ANTIMICROBIAL USE IN LTCF

ASPs in LTCFs have to address the unique challenges in identifying and managing infections in this population. The prevalence of asymptomatic bacteriuria (ASB) ranges from 23% to 50% in noncatheterized LTCF residents, to 100% among those with long-term urinary catheters, and ASB in the older adult is accompanied by pyuria in more than 90% of cases.³⁰ However, symptomatic UTIs in LTCF residents may present atypically. A study assessing the clinical signs and symptoms of older adults (older than 75 years) with bacteremic UTIs found that 10/37 (27%) did not mount a fever greater than 37.9°C, and 48.6% failed to report any localizing urinary tract symptoms (eg,

dysuria, urgency, or frequency).³¹ Given the unreliable clinical assessment for infections in LTCF residents and the diagnostic challenges in differentiating ASB from infection, suspected UTIs account for 30% to 60% of antibiotic prescriptions in LTCFs.^{32,33}

Adding to the challenge of diagnosing infections in LTCF is having clinical providers located off-site, and making management decisions based on the assessments communicated by front-line staff. The use of surrogate assessments and the lack of access to provider follow-up likely drive antibiotic use and frequent hospital transfers. Many facilities have limited diagnostic testing (eg, laboratory or radiology) available, with services contracted to off-site facilities leading to delays in obtaining specimens, processing, and reporting results back to providers.

PATTERNS OF ANTIMICROBIAL USE IN LTCF

Antimicrobials, specifically antibiotics, are among the most frequently prescribed medications in LTCFs and have the second highest rate of adverse drug events following antipsychotic medications.^{34,35} In a study of antimicrobial use in 73 nursing homes, the pooled mean rate was 4.8 antimicrobial courses/1000 resident days (range 0.4–23.5).³² Other studies have shown that 47% to 79% of LTCF residents are exposed to at least one antibiotic course over a 12-month period.^{7,36} Factors accounting for the facility-level variability in antimicrobial use may include provider prescribing habits, types of resident services provided within the facility (eg, custodial LTCF vs post-acute skilled), and resident case-mix index.^{37–39} Estimates on the amount of inappropriate antimicrobial use in LTCFs vary widely, from 25% to 75%, depending on how appropriateness is defined.^{34,40}

To guide health care practitioners in the rational assessment of infections in this vulnerable population, clinical guidelines have been published, which outline the evaluation for residents suspected of having an infection.⁴¹ Minimum criteria that should be present before initiating antimicrobial therapy, known as the “Loeb criteria”, have also been proposed to improve antimicrobial use (**Box 1**).⁴² Surveillance definitions for infections in LTCFs, referred to as the “McGeer criteria”, have also been published to support infection surveillance activities in LTCF (**Box 2**).^{43,44} However, despite the creation of these guidance documents to assist clinicians with the diagnosis and management of common infections, the implementation of these guidelines remains a challenge. One study showed that only 12.7% of prescriptions were adherent to the Loeb criteria within 12 nursing home evaluations.³⁶ A cluster, randomized controlled trial, which operationalized diagnostic and therapeutic algorithms based on the Loeb criteria for the management of UTI in 24 nursing homes, found a 31% reduction in antimicrobial use for UTI among intervention homes compared with controls.³³ However, despite a reduction in antibiotic use for UTI, the overall antibiotic consumption did not differ between the 2 groups, suggesting that use may have shifted to other indications. Continued inappropriate treatment of infections that do not meet clinical criteria has been attributed to the perception of the need to treat, despite the lack of objective evidence.⁴⁵

IMPLEMENTING ANTIMICROBIAL STEWARDSHIP INTERVENTIONS IN LTCFS

ASP refers to the development of programs that addresses the “appropriate selection, dosing, route, and duration of antimicrobial therapy”.^{3,46,47} Recently, CDC outlined core elements for hospital antibiotic stewardship program that can be tailored to the infrastructure and capacity of different sized facilities, including LTCFs. The core elements emphasized leadership commitment, accountability for improving antibiotic use, need for drug expertise, implementing action through targeted policies and

Box 1**Loeb minimum criteria for the initiation of antibiotics in long-term care facility residents**

Skin and Soft Tissue Infections

New or increasing purulent drainage and/or ≥ 2 of the following:

Fever

Temperature $>37.9^{\circ}\text{C}$ (100°F) or

Increase of 1.5°C (2.4°F) from baseline temperature

Redness

Tenderness

Warmth

New or increasing swelling of the affected site

Respiratory infections

In residents with temperature $>38.9^{\circ}\text{C}$ (102°F), ≥ 1 of the following:

Respiratory rate >25 breaths/min

Productive cough

In residents with temperature $>37.9^{\circ}\text{C}$ (100°F), but $\leq 38.9^{\circ}\text{C}$ (102°F)

Cough and ≥ 1 of the following:

Pulse >100 beats/min

Delirium

Rigors

Respiratory rate >25

In afebrile residents with chronic obstructive pulmonary disease and age >65 years old

New or increased cough with purulent sputum production

In afebrile residents without chronic obstructive pulmonary disease

New cough with purulent sputum production and ≥ 1 of the following:

Respiratory rate >25

Delirium

Urinary Tract Infections

Without indwelling urinary catheters

Acute dysuria or

Fever ($>37.9^{\circ}\text{C}$ [100°F]) and ≥ 1 of the following:

New or worsening urgency

Frequency

Suprapubic pain

Gross hematuria

Costovertebral angle tenderness

Urinary incontinence

With chronic indwelling urinary catheter

≥ 1 of the following

Fever ($>37.9^{\circ}\text{C}$ [100°F])

New costovertebral angle tenderness

Rigors

New onset delirium

Fever without obvious focus of infection

Fever ($>37.9^{\circ}\text{C}$ [100°F]) and ≥ 1 of the following

New onset of delirium

Rigors

Data from Loeb M, Bentley D, Bradley S, et al. Development of minimum criteria for the initiation of antibiotics in residents of long-term-care facilities: results of a consensus conference. *Infect Control Hosp Epidemiol* 2001;22:120–4.

Box 2

Definitions included in the McGeer and Revised McGeer criteria

Respiratory tract infections

Common cold syndromes/pharyngitis

Influenzalike illness

Pneumonia

Other lower respiratory tract infections

Urinary tract infections

Eye, ear, nose, and mouth infections

Conjunctivitis

Ear infection

Mouth/perioral infections

Sinusitis

Skin infections

Cellulitis/soft tissue/wound infections

Fungal skin infections

Herpes simplex, herpes zoster infections

Scabies

Gastrointestinal tract illnesses

Gastroenteritis

Norovirus

Clostridium difficile infection

Systemic infections

Primary bloodstream infections

Unexplained febrile episodes

Data from McGeer A, Campbell B, Emori TG, et al. Definitions of infection for surveillance in long-term care facilities. *Am J Infect Cont* 1991;19(1):1–7; and Stone ND, Ashraf M, Calder J, et al. Surveillance definitions of infections in longterm care facilities: revisiting the McGeer criteria. *Infect Control Hosp Epidemiol* 2012;33(10):965–77.

guidelines, tracking and reporting to staff on prescribing and resistance, and offering education.⁴⁸ Recommendations for infection prevention and control in the LTCF setting include using ASP as part of the ongoing infection prevention program.^{40,49}

The staffing structure within LTCFs may be considerably different from acute care facilities, with the largest proportion of in-person staffing consisting of nursing, with variable models of physician presence. Although some facilities maintain their own internal physician staffing models, many have physicians who are off site and unable to interact with LTCF residents on a daily basis, leading to dependence on nursing staff, often nursing assistants, for the initial recognition of signs and symptoms suggestive of infection. As the request for diagnostic testing and antimicrobial prescriptions are often called in by the physician before having the opportunity to examine the patient, education about diagnostic criteria and appropriate culture techniques need to occur at all levels of staffing. Identifying key participants and ASP champions is essential to initiating change within an institution. At a minimum, consider engaging the following nursing home personnel in the implementation of any stewardship activities: administrative leadership, clinical leadership including the medical director and the director of nursing services, the infection prevention and control coordinator, the consultant pharmacist, as well as representatives from the medical and nursing staff. Although including an infectious disease (ID) specialist would be ideal, including any physician with an interest in antimicrobial stewardship may be a more practical approach, especially in areas where ID specialists are not readily available. Senior level nursing may be able to provide the front-line support in assuring adherence to guidelines for initial diagnostic procedures, whereas post-prescription review of antibiotic therapy may be performed by a physician or pharmacist if available.

Management Strategies

A baseline evaluation of the quantity of antimicrobials prescribed expressed as days of therapy per 1000 patient days, to allow for interfacility comparison, should be conducted. Further evaluation into the use of specific agents and their indications should occur to determine which stewardship interventions are most necessary.

Existing guidelines for antimicrobial use developed by IDSA and SHEA should be tailored to meet local needs. Any guideline needs to be supplemented with education to ensure proper dissemination and use. Materials and methods to initiate an antimicrobial stewardship program may include

- Sessions with the ASP team and the providers of care, to educate on a more personal basis, which may provide an avenue for prescribers to directly ask questions.
- Antibiotic dosing guidelines to be created based on a facility's formulary, which would be readily available to prescribers, with information on drug interactions as part of the guidelines, given the frequency of polypharmacy in this population.
- Educational modules for nursing assistants and nursing staff on the criteria for initiation of antimicrobial usage.
- Educational modules for residents and family members, given that there can be pressure applied to the prescriber to give an inappropriate antimicrobial, when one is not indicated, due to external pressure exerted.
- Diagnostic and treatment guidelines can be adapted from currently published sources on common infectious problems, such as pneumonia, UTIs, and skin and soft tissue infections, and made available to all pertinent care-giving staff.
- Guidelines and educational modules focusing on preventable problems that also lead to infection may also be a part of an LTCF stewardship program; for example, following best practices for infection control, prevention of pressure

ulcer formation, and aspiration prevention will avoid the infectious complications that often follow.

By engaging several different educational strategies, important and applicable guideline information can be disseminated in a fairly easy manner, although retention of the material requires repeated education campaigns.

PREPRESCRIPTION AUTHORIZATION

With preprescription authorization, physicians contact a stewardship team before prescribing select antimicrobials. Preprescription authorization ensures that patients receive the most appropriate empiric antimicrobial therapy and reduces the number of unnecessary antimicrobial starts. Unfortunately, it can be resource intensive in real time and may lead to delays in the initiation of therapy. This may be particularly true in LTCF where clinicians are often off site.

POST-PRESCRIPTION REVIEW WITH FEEDBACK

Post-prescription review with feedback entails a review of antimicrobials prescribed at some time point after more clinical and microbiology laboratory information is available. Although it usually occurs at 48 to 72 hours, it can occur at any time period and still proves valuable even if it occurs once or twice a week because of limited resources. As there is greater flexibility in the timing of interventions with post-prescription review and feedback, this may be more feasible in LTCFs. Feedback likely requires phone calls or secure e-mails to providers as notes left in charts are unlikely to be seen in a timely manner.

SUCCESSFUL ANTIMICROBIAL STEWARDSHIP INTERVENTIONS IN LTCFS

Although still relatively new in LTCF settings, the impact of such an ASP has already demonstrated positive results. The implementation of such programs led to a 30% decrease in systemic antibiotic usage, both in oral and intravenous medications, in addition to a decrease in the rate of positive *C. difficile* tests, in one institution.⁵⁰ Although this study used an ID service, simply distributing appropriate educational material targeting the most common infections in LTCFs has shown to improve antibiotic usage, as demonstrated by Monette and colleagues⁵¹; a 20% decrease in prescriptions that were not adherent to guidelines was seen in the group of prescribers who were given the educational material, as opposed to control.

Areas of Future Needed Work

- Robust studies examining the efficacy of various programs and how they fit into individual facility types with differing resources.
- Attention to the issues of transmission between the LTCFs and the acute care facilities serving the same community.
- Increased implementation of the nationally available guidelines in LTCFs.

SUMMARY

The selection pressure resulting from the overuse of antibiotics is a significant driver of adverse events in the LTCF setting. In addition, as patients move back and forth between acute care and long-term care, the burden of multidrug resistance and frequent infections is shared across the health care spectrum. By adapting stewardship principles that have

already been shown to be effective in the acute care setting to LTCFs, an impact can be made on the health of the overall population and in this vulnerable population.

REFERENCES

1. Centers for Disease Control and Prevention. Antibiotic resistance threats in the United States, 2013. Atlanta (GA): Centers for Disease Control and Prevention; 2013. Available at: <http://www.cdc.gov/drugresistance/threat-report-2013/pdf>.
2. Bartlett JG. A call to arms: the imperative for antimicrobial stewardship. *Clin Infect Dis* 2011;53(1):S4–7.
3. Dellit TH, Owens RC, McGowan JE, et al. Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship. *Clin Infect Dis* 2007;44:159–77.
4. Malani AN, Richards PG, Kapila S, et al. Clinical and economic outcomes from a community hospital's antimicrobial stewardship program. *Am J Infect Control* 2013;41(2):145–8.
5. Aldeyab MA, Kearney MP, Scott MG, et al. An evaluation of the impact of antibiotic stewardship on reducing the use of high-risk antibiotics and its effect on the incidence of *Clostridium difficile* infection in hospital settings. *J Antimicrob Chemother* 2012;67(12):2988–96.
6. Goff DA, Bauer KA, Reed EE, et al. Is the “low hanging fruit” worth picking for antimicrobial stewardship programs? *Clin Infect Dis* 2012;55(4):587–92.
7. Van Buul LW, van der Steen JT, Veenhuizen RB, et al. Antibiotic Use and Resistance in Long Term Care Facilities. *J Am Med Dir Assoc* 2012;13:568.e1–13.
8. Administration on Aging. A profile of older Americans. Washington, DC: Department of Health & Human Services, Administration on Aging; 2012. Available at: http://www.aoa.gov/AoARoot/Aging_Statistics/Profile/2012/4.aspx. Accessed September, 2013.
9. FastStats. CDC. Available at: <http://www.cdc.gov/nchs/fastats/nursing.htm>. Accessed September 1, 2013.
10. Tsan L, Langberg R, Davis C, et al. Nursing home-associated infection in Department of Veterans Affairs community living centers. *Am J Infect Control* 2010;38(6):461–6.
11. Stevenson KB, Moore J, Colwell H, et al. Standardized infection surveillance in long-term care: interfacility comparisons from a regional cohort of facilities. *Infect Control Hosp Epidemiol* 2005;26:231–8.
12. Koch AM, Eriksen HM, Elstrøm P, et al. Severe consequences of healthcare-associated infections among residents of nursing homes: a cohort study. *J Hosp Infect* 2009;71:269–74.
13. Teresi JA, Holmes D, Bloom HG, et al. Factors differentiating hospital transfers from long-term care facilities with high and low transfer rates. *Gerontologist* 1991;31:795–806.
14. Ouslander JG, Diaz S, Hain D, et al. Frequency and diagnoses associated with 7- and 30-day readmission of skilled nursing facility patients to a nonteaching community hospital. *J Am Med Dir Assoc* 2011;12:195–203.
15. Boockvar KS, Gruber-Baldini AL, Burton L, et al. Outcomes of infection in nursing home residents with and without early hospital transfer. *J Am Geriatr Soc* 2005;53:590–6.

16. Ahmed AA, Hays CL, Liu B, et al. Predictors of in-hospital mortality among hospitalized nursing home residents: an analysis of the National Hospital Discharge Surveys 2005-2006. *J Am Med Dir Assoc* 2010;11:52-8.
17. Loeb MB, Craven S, McGeer A, et al. Risk factors for resistance to antimicrobial agents among nursing home residents. *Am J Epidemiol* 2003;157:40-7.
18. Centers for Disease Control and Prevention. Active Bacterial Core Surveillance Report, Emerging Infections Program Network, Methicillin-Resistant *Staphylococcus aureus*, 2011. Atlanta (GA): Centers for Disease Control and Prevention; 2011. Accessed September 2013.
19. Rogers MA, Mody L, Chenoweth C, et al. Incidence of antibiotic-resistant infection in long-term residents of skilled nursing facilities. *Am J Infect Control* 2008;36:472-5.
20. O'Fallon E, Pop-Vicas A, D'agata E. The emerging threat of multidrug-resistant gram-negative organisms in long-term care facilities. *J Gerontol A Biol Sci Med Sci* 2009;64A(1):138-41.
21. Furano JP, Hebden J, Standiford H, et al. Prevalence of methicillin-resistant *Staphylococcus aureus* and *Acinetobacter baumannii* in a long-term acute care facility. *Am J Infect Control* 2008;36:468-71.
22. Ma HM, Wah JL, Woo J. Should nursing home-acquired pneumonia be treated as nosocomial pneumonia? *J Am Med Dir Assoc* 2012;13(8):727-31.
23. Suetens C, Niclaes L, Jans B, et al. Methicillin-resistant *Staphylococcus aureus* colonization is associated with higher mortality in nursing home residents with impaired cognitive status. *J Am Geriatr Soc* 2006;54(12):1854-60.
24. Capitano B, Nicolau DP. Evolving epidemiology and cost of resistance to antimicrobial agents in long-term care facilities. *J Am Med Dir Assoc* 2003;4:S90-9.
25. Perez F, Endimiani A, Ray AJ, et al. Carbapenem-resistant *Acinetobacter baumannii* and *Klebsiella pneumoniae* across a hospital system: impact of post-acute care facilities on dissemination. *J Antimicrob Chemother* 2010;65:1807-18.
26. Lee BY, Bartsch SM, Wong KF, et al. The Importance of Nursing Homes in the Spread of Methicillin-resistant *Staphylococcus aureus* (MRSA) Among Hospitals. *Med Care* 2013;51:205-15.
27. Rotjananpan P, Dosa D, Thomas K. Potentially inappropriate treatment of urinary tract infections in two rhode island nursing homes. *Arch Intern Med* 2011;171(5):438-43.
28. Juthani-Mehta M, Tinetti M, Perrelli E, et al. Diagnostic accuracy of criteria for urinary tract infection in a cohort of nursing home residents. *J Am Geriatr Soc* 2007;55:1072-7.
29. Gerwitz JH, Field TS, Harrold LR. Incidence and preventability of adverse drug events among older persons in the ambulatory setting. *JAMA* 2003;289:1107-11.
30. Juthani-Mehta M. Asymptomatic bacteriuria and urinary tract infection in older adults. *Clin Geriatr Med* 2007;23:585-94.
31. Woodford HJ, Graham C, Meda M, et al. Bacteremic urinary tract infections in hospitalized older patients – are any currently available diagnostic criteria sensitive enough? *J Am Geriatr Soc* 2011;59:567-8.
32. Benoit SR, Nsa W, Richards CL, et al. Factors associated with antimicrobial use in nursing homes: a multilevel model. *J Am Geriatr Soc* 2008;56:2039-44.
33. Loeb M, Brazil K, Lohfield L, et al. Effect of a multifaceted intervention on number of antimicrobial prescriptions for suspected urinary tract infections in residents of nursing homes: cluster randomised controlled trial. *British Med J* 2005;331:669.

34. Nicolle LE, Bentley DW, Garibaldi R, et al. Antimicrobial use in long-term-care facilities. SHEA Long-Term-Care Committee. *Infect Control Hosp Epidemiol* 2000;21:537–45.
35. Gurwitz JH, Field TS, Avorn J, et al. Incidence and preventability of adverse drug events in nursing homes. *Am J Med* 2000;109:87–94.
36. Olsho LE, Bertrand RM, Edwards AS, et al. Does adherence to the loeb minimum criteria reduce antibiotic prescribing rates in nursing homes? *J Am Med Dir Assoc* 2013;14:309.e1–7.
37. Richards CL Jr, Darradji M, Weinberg A, et al. Antimicrobial use in post-acute care: a retrospective descriptive analysis in seven long-term care facilities in Georgia. *J Am Med Dir Assoc* 2005;6:109–12.
38. Mylotte JM, Keagle J. Benchmarks for antibiotic use and cost in long-term care. *J Am Geriatr Soc* 2005;53:1117–22.
39. Mylotte JM, Neff M. Trends in antibiotic use and cost and influence of case-mix and infection rate on antibiotic-prescribing in a long-term care facility. *Am J Infect Control* 2003;31:18–25.
40. Smith PW, Watkins K, Miller H, et al. Antibiotic stewardship programs in long-term care facilities. *Ann Longterm Care* 2011;19:20–5.
41. High KP, Bradley SF, Gravenstein S, et al. Clinical practice guideline for the evaluation of fever and infection in older adult residents of long-term care facilities: 2008 update by the Infectious Diseases Society of America. *J Am Geriatr Soc* 2009;57:375–94.
42. Loeb M, Bentley D, Bradley S, et al. Development of minimum criteria for the initiation of antibiotics in residents of long-term-care facilities: results of a consensus conference. *Infect Control Hosp Epidemiol* 2001;22:120–4.
43. McGeer A, Campbell B, Emori TG, et al. Definitions of infection for surveillance in long-term care facilities. *Am J Infect Control* 1991;19:1–7.
44. Stone ND, Ashraf M, Calder J, et al. Surveillance definitions of infections in long-term care facilities: revisiting the McGeer criteria. *Infect Control Hosp Epidemiol* 2012;33(10):965–77.
45. Walker S, McGeer A, Simor AE, et al. Why are antibiotics prescribed for asymptomatic bacteriuria in institutionalized elderly people? A qualitative study of physicians' and nurses' perceptions. *Can Med Assoc J* 2000;163:273–7.
46. Moody J, Cosgrove SE, Olmsted R, et al. Antimicrobial stewardship: a collaborative partnership between infection preventionists and health care epidemiologists. *Am J Infect Control* 2012;40(2):94–5.
47. MacDougal C, Polk RE. Antimicrobial stewardship programs in health care systems. *Clin Microbiol Rev* 2005;18(4):638–56.
48. CDC. Core Elements of Hospital Antibiotic Stewardship Programs. Atlanta (GA): US Department of Health and Human Services, CDC; 2014. Available at: <http://www.cdc.gov/getsmart/healthcare/implementation/core-elements.html>.
49. Smith PW, Bennett G, Bradley S, et al. SHEA/APIC Guideline: infection prevention and control in the long-term care facility. *Am J Infect Control* 2008;36:504–35.
50. Jump RL, Olds DM, Seifi N, et al. Effective antimicrobial stewardship in a long-term care facility through an infectious disease consultation service: keeping a LID on antibiotic use. *Infect Control Hosp Epidemiol* 2012;33(12):1185–92.
51. Monette J, Miller MA, Monette M, et al. Effect of an educational intervention on optimizing antibiotic prescribing in long-term care facilities. *J Am Geriatr Soc* 2007;55:1231–5.