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National trends in the treatment of urinary tract infections among Veterans' Affairs Community Living Center residents

Haley J. Appaneal, PharmD^{1,2,3,4}, Aisling R. Caffrey, PhD, MS^{1,2,3,4}, Vrishali V. Lopes, MS¹, Christopher J. Crnich, MD^{5,6}, David M. Dosa, MD MPH^{1,2,4}, Kerry L. LaPlante, PharmD^{1,2,3,4,7}

¹Infectious Diseases Research Program, Providence Veterans' Affairs Medical Center, Providence, Rhode Island ²Center of Innovation in Long-Term Support Services, Providence Veterans Affairs Medical Center, Providence, Rhode Island ³College of Pharmacy, University of Rhode Island, Kingston, Rhode Island ⁴Brown University School of Public Health, Providence, Rhode Island ⁵William S. Middleton VA Hospital, Madison, Wisconsin ⁶University of Wisconsin School of Medicine and Public Health, Madison, Wisconsin ⁷Warren Alpert Medical School of Brown University, Division of Infectious Diseases, Providence, Rhode Island

Abstract

Objective: To describe urinary tract infection (UTI) treatment among Veterans' Affairs (VA) Community Living Centers (CLCs) nationally and to assess related trends in antibiotic use.

Design: Descriptive study.

Setting and participants: All UTI episodes treated from 2013 through 2017 among residents in 110 VA CLCs. UTI episodes required collection of a urine culture, antibiotic treatment, and a UTI diagnosis code. UTI episodes were stratified into culture-positive and culture-negative episodes.

Methods: Frequency and rate of antibiotic use were assessed for all UTI episodes overall and were stratified by culture-positive and culture-negative episodes. Joinpoint software was used for regression analyses of trends over time.

Results: We identified 28,247 UTI episodes in 14,983 Veterans. The average age of Veterans was 75.7 years, and 95.9% were male. Approximately half of UTI episodes (45.7%) were culture positive and 25.7% were culture negative. *Escherichia coli* was recovered in 34.1% of culture-positive UTI episodes, followed by *Proteus mirabilis* and *Klebsiella* spp, which were recovered in 24.5% and 17.4% of culture-positive UTI episodes, respectively. The rate of total antibiotic use in days of therapy (DOT) per 1,000 bed days decreased by 10.1% per year (95% CI, –13.6% to –6.5%) and fluoroquinolone use (ciprofloxacin or levofloxacin) decreased by 14.5% per year

Author for correspondence: Haley J. Appaneal, haley.appaneal@va.gov.

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(95% CI, −20.6% to −7.8%) among UTI episodes overall. Similar reductions in rates of total antibiotic use and fluoroquinolone use were observed among culture-positive UTI episodes and among culture-negative UTI episodes.

Conclusion: Over a 5-year period, antibiotic use for UTIs significantly decreased among VA CLCs, as did use of fluoroquinolones. Antibiotic stewardship efforts across VA CLCs should be applauded, and these efforts should continue.

Antibiotics are among the most frequently used medications in long-term care facilities (LTCFs); however, up to 75% of antibiotic use in LTCFs may be inappropriate.^{1,2} The greatest contributor to inappropriate antibiotic use in LTCFs is the misuse of antibiotics for urinary tract infections (UTIs).²⁻⁷ The most common problem in the treatment of UTIs among residents is misdiagnosis and treatment of asymptomatic bacteriuria with antibiotics.⁸ Another common problem is the use of agents with overly broad spectra or agents that carry an increased risk of adverse drug events, such as fluoroquinolones.⁹ Data from 2010 and more recent data from 2014–2016 demonstrate that fluoroquinolones are the most commonly used agents used for treatment of UTI among LTCF residents.⁹⁻¹¹ This use has continued despite recommendations specific to LTCF residents that call for restricted use of fluoroquinolones due to their risk for *Clostridium difficile* infection, adverse drug events, and selection of resistance.^{12,13} According to the 2004 and 2011 treatment guidelines of the Infectious Diseases Society of America (IDSA), labeled warnings from the Food and Drug Administration, and expert opinion, fluoroquinolones should only be used for the treatment of acute cystitis when other UTI antibiotics cannot be used due to their propensity for collateral damage.¹⁴⁻¹⁶

Although previous research suggests that antibiotic selection for UTIs may often be suboptimal, large-scale studies of how LTCF residents are treated for UTIs nationally are limited. Quantifying how UTIs are treated is a first step in improving the use of antibiotics.¹⁷ Knowledge of the most commonly used antibiotic agents and the trends in use can inform future efforts to optimize antibiotic use among LTCF residents nationally. Such data can also identify problem areas, allowing the development of targeted interventions to improve antibiotic use, ultimately improving the care of residents with UTIs. Thus, we aimed to describe antibiotic use for UTI among all VA LTCFs (known as Community Living Centers or CLCs) nationally from 2013 to 2017 and to assess trends in antibiotic use.

Methods

We conducted a retrospective study using national VA microbiology and pharmacy data accessed through the VA Informatics and Computing Infrastructure (VINCI). We included all adult residents aged ≥18 years with a UTI episode during an inpatient stay in a VA CLC unit between January 2013 to December 2017. We applied 3 inclusion criteria to identify episodes of UTI: (1) collection of urine culture, (2) initiation of a UTI-related antibiotic on the date the urine culture was taken or within the 3 days after culture collection, and (3) an *International Classification of Diseases, Ninth or Tenth Revision*, diagnosis code for UTI during the admission.¹⁸

We excluded episodes that likely represented treatment of asymptomatic bacteriuria for urologic procedure or pregnancy.¹⁹ Urologic procedures (eg, transurethral resection of the prostate, prostate biopsy, cystoscopy, or urodynamic surgery) were identified using previously reported diagnosis and procedure codes and using text searches of procedure names.^{20,21} All residents with a urologic procedure that occurred within 2 weeks of the date of the index urine culture were excluded. We also excluded women of childbearing age (females aged <45 years at the time of urine culture). To avoid capturing treatment of another potential infection, we excluded episodes in which another positive culture (ie, blood, respiratory, tissue, or bone) was identified within 3 days of the index culture unless it was a positive blood culture for the same organism growing in the urine.²² In the case of multiple UTI episodes during the study period, we excluded subsequent UTI episodes within 30 days of the first episode.

UTI episodes were stratified by urine culture results into culture-negative, culture-positive, and other episodes. Culture-negative UTI episodes were those in which no growth was identified from the urine culture. Culture-positive UTI episodes were defined as those in which no more than 2 typical uropathogens (eg, *Escherichia coli*, *Proteus mirabilis*, *Klebsiella* spp, *Pseudomonas aeruginosa*, *Providencia* spp, *Enterobacter* spp, *Citrobacter* spp, *Morganella morganii*, *Serratia marcescens*, *Enterococcus* spp, and/or *Staphylococcus aureus*) were isolated with quantitative counts $\geq 10^5$ colony-forming units (CFU) per milliliter from the urine culture.^{14,19,23,24} Uropathogens of interest were chosen based on earlier work indicating that these were the most frequently isolated organisms from urine samples obtained from LTCF residents.²⁵ All other UTI episodes were defined as those in which typical uropathogens were isolated with low quantitative counts ($< 10^5$ CFU/mL), > 2 uropathogens were identified, or any other organisms were isolated from the urine culture.

We quantified the frequency and rate of antibiotic use for all UTI episodes overall and stratified by culture-positive and culture-negative UTI episodes. Frequency of use was the proportion of the number UTI episodes treated with a specific antibiotic agent/class divided by the total number of UTI episodes that met study criteria as defined above. The rate of antibiotic use was defined using antibiotic days of therapy (DOT).²² One DOT represents administration of a single agent on a given day regardless of frequency, dose, or route of administration. For each UTI episode, we calculated the DOT for each antibiotic used from the start to the end of the treatment up to 30 days after treatment started. End of treatment was identified from gaps in antibiotic therapy of > 2 consecutive calendar days.

We summed all UTI specific antibiotic use for our study cohort and standardized it to 1,000 bed days of care (DOT per 1,000 bed days). Antibiotics were grouped into the following classes: typical genitourinary tract agents (nitrofurantoin, sulfamethoxazole/trimethoprim, fosfomycin, trimethoprim), fluoroquinolones (ciprofloxacin, levofloxacin), first- and second-generation cephalosporins (cefaclor, cefazolin, cefotetan, cefoxitin, cefuroxime, cephalexin), third- and fourth-generation cephalosporins (cefdinir, cefepime, cefixime, cefotaxime, cefpodoxime, ceftazidime, ceftriaxone), aminopenicillins (amoxicillin, ampicillin, amoxicillin/ clavulanate, ampicillin/sulbactam), carbapenems and piperacillin/tazobactam (imipenem, meropenem, ertapenem, doripenem, piperacillin/tazobactam), other *multidrug-resistant* [MDR] gram-negative agents (amikacin, gentamicin, tobramycin, avibactam/

ceftazidime, aztreonam, ceftazidime/avibactam, tigecycline), anti-methicillin-resistant *Staphylococcus aureus* [MRSA]-directed agents (ceftaroline, daptomycin, linezolid, vancomycin), and other agents.

We identified time trends over the study period using Joinpoint regression models. We used Joinpoint regression program version 4.6.0.0 software (National Cancer Institute, Bethesda, MD) to calculate average annual percent change (AAPC) and 95% confidence intervals (CIs).²⁶ Significance was set at $P < .05$. The AAPC is a weighted average of the average percent change (APC) segments from a Joinpoint model with the weights equal to the duration of each APC segment.

Results

We identified a total of 28,247 UTI episodes diagnosed and treated with antibiotics within 3 days of urine culture among 14,983 Veterans admitted to 110 VA CLCs nationally. The median number of UTI episodes per Veteran was 1.0 (interquartile range [IQR], 1–2) and the median length of stay among 15,829 unique Veteran admissions was 127 days (IQR, 43–717). At the time of the first UTI episode, the average age of Veterans was 75.7 years (± 11.5 standard deviation) and 14,363 (95.9%) were male. Additional baseline characteristics are presented in Table 1.

Urine culture results are presented in Table 2. Overall, 12,905 UTI episodes (45.7%) were culture positive and 7,265 (25.7%) were culture negative. *Escherichia coli* was recovered in 4,400 (34.1%) of culture-positive UTI episodes, followed by *Proteus mirabilis* and *Klebsiella* spp, which were recovered in 3,160 (24.5%) and 2,244 (17.4%) culture-positive UTI episodes, respectively.

Among all UTI episodes, the most frequently used antibiotic agents were ciprofloxacin (8,818 episodes, 31.2%), sulfamethoxazole/trimethoprim (5,908 episodes, 20.9%), and ceftriaxone (4,591 episodes, 16.3%) (Table 3). Ciprofloxacin, sulfamethoxazole/trimethoprim, and ceftriaxone also had the greatest usage in DOT, accounting for 19.4% (DOT=57,579), 14.6% (DOT=43,244), and 8.2% (DOT=24,231) of the total DOT used, respectively. Broad-spectrum intravenous antibiotic agents accounted for ~20% of the total DOT used.

The rate of total antibiotic use decreased significantly by 10.1% per year (95% CI, –13.6 to –6.5%) from 20.7 DOT per 1,000 bed days in 2013 to 13.2 DOT per 1,000 bed days in 2017. The rate of fluoroquinolone (ciprofloxacin and levofloxacin) use in DOT per 1,000 bed days decreased significantly by 14.5% per year (95% CI, –20.6 to –7.8%). The proportion of UTI episodes treated with fluoroquinolones decreased significantly by 6.0% per year (95% CI, –10.4 to –1.3%) over the study period. Fluoroquinolones were used in 2,958 of 6,693 suspected UTI episodes (44.2%) in 2013 and in 1,645 of 4,675 episodes (35.2%) in 2017.

Among culture-positive UTI episodes, ciprofloxacin (4,323 episodes, 33.5%), sulfamethoxazole/trimethoprim (3,015 episodes, 23.4%), and ceftriaxone (2,149 episodes, 16.7%) remained the most frequently used antibiotic agents. Several significant changes in the rate of antibiotic use for culture-positive UTI episodes were observed (Fig. 1). The rate

of total antibiotic use for culture-positive episodes decreased significantly by 9.6% per year (95% CI, -13.1% to -6.0%). The rate of fluoroquinolone use decreased significantly by 14.9% per year (95% CI, -22.0% to -7.3%).

Among culture-negative UTI episodes, ciprofloxacin (1,899 episodes, 26.1%), sulfamethoxazole/trimethoprim (1,203 episodes, 16.6%), and ceftriaxone (1,167 episodes, 16.1%) also remained the most frequently used antibiotic agents. Among culture-negative UTI episodes, 19,376 fluoroquinolone DOT were used, accounting for 25.4% of all fluoroquinolone use (76,162 DOT). Trends in antibiotic use for culture-negative UTI episodes are presented in Figure 2. Significant reductions in the rates of total antibiotic use (by 11.2% per year, 95% CI, -14.8% to -7.4%) and fluoroquinolone use (by 14.8% per year, 95% CI, -19.6% to -9.7%) were observed.

Discussion

In our study of ~15,000 Veterans diagnosed with and treated for UTIs in CLCs nationally, fluoroquinolone use decreased, as did overall antibiotic days of therapy. Results stratified by culture-positive and culture-negative UTI episodes were similar.

Ciprofloxacin, sulfamethoxazole/trimethoprim, and ceftriaxone were the most commonly used antibiotic agents. Previous studies among Veteran cohorts from outpatient and acute-care inpatient settings have also reported that these agents are among the most commonly used antibiotics for UTI.^{27,28} Data from non-VA LTCFs have similarly identified fluoroquinolones as the most commonly used antibiotic class for UTIs.⁹⁻¹¹

As expected, the typical uropathogens, including *E. coli*, *Proteus* spp, and *Klebsiella* spp, were the most commonly identified uropathogens among culture-positive UTI episodes.³¹ Similar to our findings, *E. coli* (53.6%) was the most commonly identified organism among 240 episodes of UTI among residents in 5 Connecticut LTCFs, followed by *Proteus* spp (14.6%) and *Klebsiella* spp (13.9%).²⁵ Of the UTI episodes in our study, ~25% were culture negative, suggesting potential overtreatment. Previous work has confirmed the overtreatment of UTI, in both the presence and absence of positive urine cultures, among older adults without symptoms of a UTI. In a study of 153 older women diagnosed with a UTI, only 87 (57%) had microbiological evidence of a UTI, yet 95% of the 66 patients with negative cultures received antibiotics.³²

Although our findings suggest potential overtreatment, they also demonstrated several impressive reductions in the use of antibiotics for UTI across VA CLCs nationally. Total antibiotic use decreased by ~10% per year from 2013 to 2017 for all UTI episodes and by 10% among culture-positive episodes and 11% among culture-negative episodes. Improving the diagnosis and treatment of UTIs is a well-recognized antibiotic stewardship target among LTCFs.³³ Among VA medical centers, previous work has confirmed an increase in antibiotic stewardship over the study period.³⁴ However, application of antibiotic stewardship principles may vary at the facility level or by region, which warrants future investigation. Previous research has demonstrated variation in antibiotic use at the facility and regional levels in non-VA LTCFs and in VA facilities.³⁵⁻³⁷

Another encouraging trend we observed was the decrease in fluoroquinolone use among all UTI episodes overall and stratified by culture-positive and culture-negative episodes. Overall, the proportion of UTI episodes treated with fluoroquinolones decreased by 6.0% each year, as did the rate of fluoroquinolones use (by 14.5%). Reductions in use may be related to growing evidence of fluoroquinolone-related adverse effects, especially among older patients.^{16,38} In 2008, a boxed warning for an increased risk of tendinitis and tendon rupture with fluoroquinolones was mandated by the Food and Drug Administration (FDA). Since that time, the FDA has issued warnings for other serious adverse effects, including exacerbation of myasthenia gravis, *C. difficile* infection, QT-interval prolongation, severe hypoglycemia, and mental health effects.³⁸ In 2013, the FDA updated label warnings for fluoroquinolones; in 2016, the FDA specifically recommended use of fluoroquinolones be avoided for uncomplicated UTIs unless no alternative treatment options were available.¹⁶ Nitrofurantoin and sulfamethoxazole/trimethoprim are suggested empiric UTI treatment options for older patients without complicated coexisting conditions and mild UTI symptoms.^{13,41,42} However, nitrofurantoin should be avoided in patients with pyelonephritis or a history of UTI due to *P. mirabilis*. Given the high prevalence of *P. mirabilis* we observed across VA CLCs nationally, our results suggest the avoidance of nitrofurantoin as empiric therapy; however, local resistance patterns should guide empiric therapy. Nitrofurantoin may be an option once urine culture results are available.

Although fluoroquinolone use decreased over the study period, our results demonstrated that fluoroquinolones are still a preferred treatment choice. Fluoroquinolones remained the most frequently used antibiotic class for UTIs over the entire study period, even in 2017 (35.2% of episodes). These findings may be related to our complicated study population of mostly older male Veterans. All UTIs in males are generally considered complicated.^{19,23} Moreover, ~45% of Veterans in our study had comorbid benign prostatic hyperplasia, which can lead to complicated UTIs and prostatitis related to obstructed and turbulent urine flow.³⁹ Fluoroquinolones achieve reliable tissue concentrations in the prostate and are considered first-line in men with severe UTI symptoms or concern for prostate involvement.³⁹ Although our findings do demonstrate impressive reductions in fluoroquinolone use for UTIs among VA CLCs nationally, there may be room for further reducing fluoroquinolone use. Focused antibiotic stewardship efforts to further fluoroquinolone use that have been successful in single-center studies include the removal of fluoroquinolones from local formularies and order sets.^{40,41} Overall, ~76,000 fluoroquinolone DOT occurred over our study period, and 25% of that use was for culture-negative UTI episodes. Thus, negative cultures may be an easy target for antibiotic stewardship in CLCs to further reduce fluoroquinolone use in residents who do not have symptoms of urinary infection.

This retrospective study has several limitations. We defined UTIs as a urine culture plus antibiotic treatment in the presence of a UTI diagnosis code. We were unable to capture treatment practices for UTIs in which no cultures were obtained, for UTIs that were culture-positive and treated without a UTI diagnosis code, and for UTIs that were treated outside the VA CLC setting. We assumed that antibiotic administrations were intended for the treatment of a UTI because the antibiotic indication is often missing, however treatment could be for another infection type. To minimize this possibility, we excluded UTI episodes in which there were concomitant positive cultures from other sources and required a diagnosis code

for UTI. Another limitation is that we were interested in the real-world treatment of UTIs; thus, we did not attempt to distinguish treatment of asymptomatic bacteriuria versus truly symptomatic UTI. We did attempt to exclude asymptomatic bacteriuria in the presence of urologic procedure or pregnancy. Additionally, we were unable to capture urinary catheter use and thus unable to quantify the prevalence of catheter use in our population. It is possible that catheter use declined over the study period and may account in part for the observed decreases in antibiotic use. Finally, the generalizability of our findings to other populations may be limited because our population was ~96% male.

In conclusion, our study of >28,000 UTI episodes in VA CLCs nationally demonstrated a decrease in overall antibiotic use for UTIs, including the use of fluoroquinolone antibiotics. Antibiotic stewardship efforts across VA CLCs should be applauded and efforts should continue, especially toward reducing the overtreatment of UTI, in both the presence and absence of positive urine cultures, in patients without urinary symptoms.

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References

1. Nicolle LE, Bentley DW, Garibaldi R, Neuhaus EG, Smith PW. Antimicrobial use in long-term-care facilities. *Infect Control Hosp Epidemiol* 2000;21:537–545. [PubMed: 10968724]
2. 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;61:289–290. [PubMed: 23405923]
3. Juthani-Mehta M, Quagliarello V, Perrelli E, Towle V, Van Ness PH, Tinetti M. Clinical features to identify urinary tract infection in nursing home residents: a cohort study. *J Am Geriatr Soc* 2009;57:963–970. [PubMed: 19490243]
4. Nicolle LE, Strausbaugh LJ, Garibaldi RA. Infections and antibiotic resistance in nursing homes. *Clin Microbiol Rev* 1996;9:1–17. [PubMed: 8665472]
5. Smith PW, Bennett G, Bradley S, et al. SHEA/APIC guideline: infection prevention and control in the long-term care facility, July 2008. *Infect Control Hosp Epidemiol* 2008;29:785–814. [PubMed: 18767983]
6. Tambyah PA. Catheter-associated urinary tract infections: diagnosis and prophylaxis. *Int J Antimicrob Agent* 2004;24 Suppl 1:S44–S48.
7. Loeb M, Simor AE, Landry L, et al. Antibiotic use in Ontario facilities that provide chronic care. *J Gen Intern Med* 2001;16:376–383. [PubMed: 11422634]
8. Rotjanapan P, Dosa D, Thomas KS. Potentially inappropriate treatment of urinary tract infections in two Rhode Island nursing homes. *Arch Intern Med* 2011;171:438–443. [PubMed: 21403040]
9. Bradley S. Optimal use of antibiotics for urinary tract infections in long-term care facilities: successful strategies prevent resident harm. *Pa Patient Saf Advis* 2017;14.
10. Phillips CD, Adepoju O, Stone N, et al. Asymptomatic bacteriuria, antibiotic use, and suspected urinary tract infections in four nursing homes. *BMC Geriatr* 2012;12:73. [PubMed: 23176555]
11. Kistler CE, Zimmerman S, Scales K, et al. The antibiotic prescribing pathway for presumed urinary tract infections in nursing home residents. *J Am Geriatr Soc* 2017;65:1719–1725. [PubMed: 28369756]

12. Nicolle LE. Urinary tract infection in long-term-care facility residents. *Clin Infect Dis* 2000;31:757–761. [PubMed: 11017826]
13. Datta R, Juthani-Mehta M. Uncomplicated cystitis in nursing home residents: a practical guide to diagnosis and management. *J Am Med Dir Assoc* 2018;19:733–735. [PubMed: 30149841]
14. Gupta K, Hooton TM, Naber KG, et al. International clinical practice guidelines for the treatment of acute uncomplicated cystitis and pyelonephritis in women: a 2010 update by the Infectious Diseases Society of America and the European Society for Microbiology and Infectious Diseases. *Clin Infect Dis* 2011;52:e103–e120. [PubMed: 21292654]
15. Hooton TM, Besser R, Foxman B, Fritsche TR, Nicolle LE. Acute uncomplicated cystitis in an era of increasing antibiotic resistance: a proposed approach to empirical therapy. *Clin Infect Dis* 2004;39:75–80. [PubMed: 15206056]
16. Alternatives to fluoroquinolones. *JAMA* 2016;316:1404–1405. [PubMed: 27701658]
17. Barlam TF, Cosgrove SE, Abbo LM, 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–e77. [PubMed: 27080992]
18. Clinical classifications software (CCS), Healthcare Cost and Utilization Project (HCUP). Agency for Healthcare Research and Quality website. www.hcup.us.ahrq.gov/toolssoftware/ccs/ccs.jsp. Published 2009 Accessed July 3, 2019.
19. Nicolle LE, Bradley S, Colgan R, et al. Infectious Diseases Society of America guidelines for the diagnosis and treatment of asymptomatic bacteriuria in adults. *Clin Infect Dis* 2005;40:643–654. [PubMed: 15714408]
20. Schroeck FR, Sirovich B, Seigne JD, Robertson DJ, Goodney PP. Assembling and validating data from multiple sources to study care for veterans with bladder cancer. *BMC Urol* 2017;17:78. [PubMed: 28877694]
21. Hollenbeck BK, Ye Z, Dunn RL, Montie JE, Birkmeyer JD. Provider treatment intensity and outcomes for patients with early-stage bladder cancer. *J Natl Cancer Inst* 2009;101:571–580. [PubMed: 19351919]
22. National Healthcare Safety Network (NHSN). Antimicrobial use and resistance (AUR) module. Centers for Disease Control and Prevention website. <http://www.cdc.gov/nhsn/PDFs/pscManual/11pscAURcurrent.pdf>. Published January 2014 Accessed November 2014.
23. Nicolle LE, and AMMI Canada Guidelines Committee. Complicated urinary tract infection in adults. *Can J Infect Dis Med Microbiol* 2005;16:349–360. [PubMed: 18159518]
24. Genao L, Buhr GT. Urinary tract infections in older adults residing in long-term care facilities. *Ann Longterm Care* 2012;20:33–38. [PubMed: 23418402]
25. Das R, Perrelli E, Towle V, Van Ness PH, Juthani-Mehta M. Antimicrobial susceptibility of bacteria isolated from urine samples obtained from nursing home residents. *Infect Control Hosp Epidemiol* 2009;30:1116–1119. [PubMed: 19785518]
26. Clegg LX, Hankey BF, Tiwari R, Feuer EJ, Edwards BK. Estimating average annual per cent change in trend analysis. *Stat Med* 2009;28:3670–3682. [PubMed: 19856324]
27. Spivak ES, Burk M, Zhang R, et al. Management of bacteriuria in Veterans' Affairs hospitals. *Clin Infect Dis* 2017;65:910–917. [PubMed: 28531289]
28. Drekonja DM, Rector TS, Cutting A, Johnson JR. Urinary tract infection in male veterans: treatment patterns and outcomes. *JAMA Intern Med* 2013;173:62–68. [PubMed: 23212273]
29. Hooton TM, Bradley SF, Cardenas DD, et al. Diagnosis, prevention, and treatment of catheter-associated urinary tract infection in adults: 2009 International Clinical Practice Guidelines from the Infectious Diseases Society of America. *Clin Infect Dis* 2010;50:625–663. [PubMed: 20175247]
30. Beveridge LA, Davey PG, Phillips G, McMurdo ME. Optimal management of urinary tract infections in older people. *Clin Interv Aging* 2011;6:173–180. [PubMed: 21753872]
31. Rowe TA, Juthani-Mehta M. Diagnosis and management of urinary tract infection in older adults. *Infect Dis Clin North Am* 2014;28:75–89. [PubMed: 24484576]
32. Gordon LB, Waxman MJ, Ragsdale L, Mermel LA. Overtreatment of presumed urinary tract infection in older women presenting to the emergency department. *J Am Geriatr Soc* 2013;61:788–792. [PubMed: 23590846]

33. Morrill HJ, Caffrey AR, Jump RL, Dosa D, LaPlante KL. Antimicrobial stewardship in long-term care facilities: a call to action. *J Am Med Dir Assoc* 2016;17:183 e181–e116.
34. Kelly AA, Jones MM, Echevarria KL, et al. A report of the efforts of the Veterans' Health Administration National Antimicrobial Stewardship Initiative. *Infect Control Hosp Epidemiol* 2017;38:513–520. [PubMed: 28118861]
35. Daneman N, Bronskill SE, Gruneir A, et al. Variability in antibiotic use across nursing homes and the risk of antibiotic-related adverse outcomes for individual residents. *JAMA Intern Med* 2015;175:1331–1339. [PubMed: 26121537]
36. Aspinall SL, Berlin JA, Zhang Y, Metlay JP. Facility-level variation in antibiotic prescriptions for veterans with upper respiratory infections. *Clin Therapeut* 2005;27:258–262.
37. Huttner B, Jones M, Huttner A, Rubin M, Samore MH. Antibiotic prescription practices for pneumonia, skin and soft tissue infections and urinary tract infections throughout the US Veterans' Affairs system. *J Antimicrob Chemother* 2013;68:2393–2399. [PubMed: 23681271]
38. In brief: more fluoroquinolone warnings. *Med Lett Drugs Ther* 2018;60:136. [PubMed: 30133426]
39. Schaeffer AJ, Nicolle LE. Urinary tract infections in older Men. *N Engl J Med* 2016;374:2192.
40. Hecker MT, Fox CJ, Son AH, et al. Effect of a stewardship intervention on adherence to uncomplicated cystitis and pyelonephritis guidelines in an emergency department setting. *PLoS One* 2014;9:e87899. [PubMed: 24498394]
41. Fagan M, Lindbaek M, Reiso H, Berild D. A simple intervention to reduce inappropriate ciprofloxacin prescribing in the emergency department. *Scand J Infect Dis* 2014;46:481–485. [PubMed: 24552583]
42. Detweiler K, Mayers D, Fletcher SG. Bacteruria and urinary tract infections in the elderly. *Urol Clin North Am* 2015;42:561–568. [PubMed: 26475952]
43. Jump RLP, Crnich CJ, Mody L, Bradley SF, Nicolle LE, Yoshikawa TT. Infectious diseases in older adults of long-term care facilities: update on approach to diagnosis and management. *J Am Geriatr Soc* 2018;66:789–803. [PubMed: 29667186]

Fig. 1.

Trends in the rate of antibiotic use among culture-positive urinary tract infections in VA Community Living Centers nationally, 2013–2017. Note. AAPC, average annual percent change; CI, confidence interval; UTI, urinary tract infection; MDR, multidrug resistant; MRSA, methicillin-resistant *Staphylococcus aureus*. AAPCs represent the average percent change per year in rate of antibiotic use in DOT per 1,000 bed days. *Significant trend at $P < .05$. Solid blue columns represent the rate of antibiotic use per year in DOT per 1,000 bed days (range, 9.4–6.2 DOT per 1,000 bed days). Lines with markers represent the rate of antibiotic use by class per year in DOT per 1,000 bed days.

Fig. 2.

Trends in rate of antibiotic use among culture-negative urinary tract infections in VA Community Living Centers nationally, 2013–2017. Note. AAPC, average annual percent change; CI, confidence interval; DOT, days of therapy; UTI, urinary tract infection; MDR, multidrug resistant. AAPCs represent the average percent change per year in rate of antibiotic use in DOT per 1,000 bed days. *Significant trend at $P < .05$. Solid blue columns represent the rate of all antibiotic use per year in DOT per 1,000 bed days (range, 4.8–2.9 DOT per 1,000 bed days). Lines with markers represent the rate of antibiotic use by class per year in DOT per 1,000 bed days.

Table 1.

Baseline Characteristics of Veterans With Urinary Tract Infections in VA Community Living Centers Nationally, 2013–2017

Patient Characteristics ^a	No.	%
Demographics		
Age in years, mean and standard deviation ^b	75.7	11.5
Male gender	14,363	95.9
Comorbidities		
Hypertension	11,339	75.7
Dementia	9,076	60.6
Diabetes	7,143	47.7
Benign prostatic hyperplasia	6,791	45.3
Atherosclerosis	6,467	43.2
Nutritional deficiencies	6,370	42.5
Chronic respiratory disease	6,124	40.9
Congestive heart failure	4,980	33.2
Chronic renal disease	5,069	33.8
Complication of device, implant or graft ^c	2,587	17.3
Adverse effects of medical care ^d	1,681	11.2

Note. VA, Veterans' Affairs.

^a Characteristics presented for 14,983 unique Veterans at the time of the first UTI episode included over the study period.

^b Age measured at time of urine culture collection.

^c Includes breakdown, leakage, or complication of urinary catheter.

^d Includes all misadventures to patients during surgical or medical care, medical devices associated with adverse incidents in diagnostic and therapeutic use, and surgical or medical care causing abnormal reaction or complication to the patient, such as urinary catheterization as a cause of complication.

Table 2.

Urine Culture Results Obtained From 28,247 Episodes of Urinary Tract Infection in VA Community Living Centers Nationally, 2013–2017

Organism	No.	%
Culture positive^a	12,905	45.7
<i>Escherichia coli</i>	4,400	34.1
<i>Proteus mirabilis</i>	3,160	24.5
<i>Klebsiella</i> spp	2,244	17.4
<i>Pseudomonas aeruginosa</i>	1,136	8.8
<i>Providencia</i> spp	526	4.1
<i>Enterobacter</i> spp	404	3.1
<i>Citrobacter</i> spp	305	2.4
<i>Morganella morganii</i>	300	2.3
<i>Serratia marcescens</i>	126	1.0
<i>Enterococcus</i> spp	1,403	10.9
<i>Staphylococcus aureus</i>	594	4.6
Culture-negative ^b	7,265	25.7
Other ^c	8,077	28.6

Note. VA, Veterans' Affairs; UTI, urinary tract infection; CFU, colony-forming units.

^a Culture-positive UTI episodes were defined as those in which no more than 2 typical uropathogens were isolated with quantitative counts $\geq 10^5$ CFU/mL from the urine culture. Organism percentages are of culture-positive UTI episodes.

^b Culture-negative UTI episodes were those in which no growth was identified from the urine culture.

^c All other UTI episodes were defined as those in which typical uropathogens were isolated with low quantitative counts ($< 10^5$ CFU/mL), >2 uropathogens were identified, or any other organisms were isolated from the urine culture.

Table 3.
Antibiotic Use by Agent for Urinary Tract Infections in VA Community Living Centers Nationally, 2013–2017

Antibiotic Agent	Antibiotic Use, DOT	% of Total Antibiotic Use	Frequency of Use, No. ^a	% of Total UTI Episodes
Ciprofloxacin	57,579	19.4	8,818	31.2
Sulfamethoxazole/Trimethoprim	43,244	14.6	5,908	20.9
Ceftriaxone	24,231	8.2	4,591	16.3
Amoxicillin/Clavulanate	22,873	7.7	3,161	11.2
Cephalexin	18,855	6.4	2,566	9.1
Levofloxacin	18,583	6.3	3,179	11.3
Piperacillin/tazobactam	17,659	6.0	2,983	10.6
Nitrofurantoin	15,222	5.1	1,953	6.9
Cefpodoxime	9,431	3.2	1,242	4.4
Vancomycin	8,312	2.8	1,120	4.0
Amoxicillin	7,849	2.7	1,036	3.7
Cefepime	7,711	2.6	1,200	4.2
Ertapenem	7,487	2.5	934	3.3
Cefuroxime	7,326	2.5	934	3.3
Other agents	...	<2% of total	...	Exposure in <2% of UTIs
Total		296,176 DOT		28,247 UTIs

Note. DOT, days of therapy; UTI, urinary tract infection.

^aFrequency of antibiotic use is not mutually exclusive, as UTI episodes could be treated with >1 antibiotic.