Published in final edited form as:

J Am Med Dir Assoc. 2020 January ; 21(1): 97–103. doi:10.1016/j.jamda.2019.10.020.

Changes in U.S. Nursing Home Infection Prevention and Control Programs from 2014 to 2018

Mansi Agarwal, PhD, MPH¹, Andrew W. Dick, PhD², Mark Sorbero, MS³, Lona Mody, MD, PhD⁴, Patricia W. Stone, PhD, RN¹

¹Columbia University School of Nursing, New York, NY, USA

²RAND Corporation, Boston, MA, USA

³RAND Corporation, Pittsburgh, PA, USA

⁴University of Michigan, Ann Arbor, MI, USA

Abstract

Objective: Burgeoning rates of antibiotic resistance have resulted in a shift in national focus to improve infection prevention and control programs in US nursing homes. We sought to evaluate the changes in nursing home infection prevention and control programs over time.

Design: Retrospective comparative analysis of national nursing home survey data from 2014 and 2018.

Setting & Participants: We used survey data from two nationally representative samples of US nursing homes (945 NHs in 2014 and 888 in 2018).

Methods: Three indices measuring antibiotic stewardship, outbreak control, and urinary tract infection prevention (ranging from 0-100) were developed to measure the change in infection prevention and control programs. Multivariable linear regression models were used to identify facility and infection preventionist characteristics associated with each index. Decomposition models were used to identify contributions of factors on the differences in each index over time.

Results: From 2014 to 2018, we saw strengthening of antibiotic stewardship practices by 33 percentage points, outbreak control practices by 13 percentage points and urinary tract infection prevention practices by 6 percentage points. While we found several predictors of these improvements, much of the improvement was due to the difference in time.

Conclusions and Implications: Policy mandates and greater national attention are likely important factors in improving nursing home infection prevention and control practices. Further work is needed to evaluate the effect of these programs on resident outcomes.

Corresponding author: Mansi Agarwal, Columbia University School of Nursing, 560 West 168th St, Rm 601, New York, NY 10032, ma3204@cumc.columbia.edu, Phone: 212-342-3912.

Conflicts of Interest

No conflicts of interest for any of the authors.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Brief Summary:

Nursing home infection control programs saw strengthening of antibiotic stewardship, outbreak control and urinary tract infection prevention practices over time. National initiatives are likely important factors.

Keywords

Infection control; nursing homes; policy change; antibiotic stewardship

Introduction

Antibiotic resistance has quickly become one of the world's leading threats to public health. In 2013, the World Health Organization (WHO) and the Centers of Disease Control and Prevention (CDC) released reports declaring that resistance to the most commonly used antibiotics is widespread and that action must be taken to contain drug resistance.^{1, 2} In response, the United States (US) federal government created the Task Force on Combating Antibiotic-Resistant Bacteria and established the Presidential Advisory Council on Combating Antibiotic-Resistant Bacteria to tackle antibiotic resistance.³ By 2015, the White House had developed a National Action Plan with five strategic goals, the first of which was to "slow the emergence of resistant bacteria and prevent the spread of resistant infections".⁴ The CDC targeted reduction in the incidence of certain infections by 2020, including a 50% reduction in *Clostridium difficile* infection (CDI).⁴ Drug resistance and CDI risk are strongly associated with antibiotic use.

The most effective method of slowing drug resistance and reducing CDI is by strengthening infection prevention and control programs, including antibiotic stewardship. Antibiotic stewardship programs work by reducing antibiotic use and promoting appropriate treatment regimens. They have been shown to be effective in reducing CDI and drug resistant infections in acute care settings.^{12, 13} However, antibiotic stewardship programs in long-term care settings have not been proven as successful as in hospital settings, which may be due to the lack of extensive studies.^{14, 15} Recommended guidelines on implementation of antibiotic stewardship programs have been published, mostly targeted towards acute care settings.

In 2015, the CDC published the "The Core Elements of Antibiotic Stewardship for Nursing Homes", customizing the general guidelines for the more specialized nursing home (NH) setting. NHs provide care to almost 1.4 million residents on any given day, 85% of whom are 65 years or older. NH settings face unique challenges in infection prevention and control in large part because infection risk is high among older adults due to increasing acuity of care, burgeoning short stay population, comorbidities, close proximity to other residents particularly when using shared spaces, and use of indwelling devices. As a result, there has been a persistent burden of infections in US NHs, with an estimated 1-3 million infections each year, the most common being urinary tract infections (UTIs).^{22, 23} CDI and drug resistant infections are also common within NHs and both are strongly associated with prior antibiotic use. Almost 70% of NH residents are prescribed at least one course of antibiotics

per year and a significant proportion (up to 75%) of antibiotics prescribed are deemed clinically inappropriate.²⁶

Recognizing the need for improved infection prevention and control in NHs, the Centers for Medicare and Medicaid Services (CMS) revised the Requirements for Participation for NHs through a phased implementation plan: by November 2016, all NHs must have an infection prevention and control program in place; by November 2017, an antibiotic stewardship program in place; and by November 2019, a trained infection preventionist in place (Section §483.80). In addition, through regional contractors known as Quality Innovation Network-Quality Improvement Organizations (QIN-QIOs), CMS also funded the CDI Reporting & Reduction Project, which promoted NH enrollment in the CDC's National Healthcare Safety Network Long-term Care Facility Component (NHSN) to report and track infections.

Our aim was to evaluate the impact of these policy initiatives on NH infection prevention and control programs and describe the predictors of infection prevention and control evidence-based practice adoption across NHs. We conducted a comparative analysis of national NH survey data in 2014 and 2018 and identified the extent to which three aspects of infection prevention and control programs (antibiotic stewardship, UTI prevention and management, and infection outbreak control) changed during that time. However, because we could not directly measure the effect of the CMS policies, we used time as a proxy measure and adjusted our models with measurable NH factors. Furthermore, given the CMS policy that NHs have a trained infection preventionist, we also assessed the impact of infection control training on changes in the NH infection prevention and control programs.

Study data and methods

Data sources and study population

We analyzed data from two cross-sectional surveys, a 2014 survey conducted in 2013-2014 and a 2018 survey conducted in 2017-2018. For both surveys, a randomized sample of non-specialized, free-standing NHs with at least 30 beds were identified from concurrent Certification and Survey Provider Enhanced Reporting (CASPER) data, which is a CMS database of NH characteristics and quality. In the 2014 survey, 2500 NHs were sampled. In the 2018 survey, we included 988 NHs that participated in the 2014 survey and an additional random sample of 832 NHs, stratified by QIN-QIO region and NHSN enrollment, for a total of 1820 NHs.

Measures

Both surveys included questions regarding the NH infection prevention and control program, demographics and training of the person in charge of the program, and turnover of leadership staff. We created a 2018 survey indicator, allowing us to distinguish which responses were from the earlier and later time periods.

The practices and programs queried were based on standard guidelines for infection prevention and control programs in long-term care settings. Measures that characterize the person in charge of the program, hereafter referred to as the infection preventionist, included professional training and specialized infection control training. We measured staff turnover

as a dichotomous variable for 3 or more of each type of staff (Infection Preventionist, Director of Nursing, or Administrator) in the past 3 years.

Survey data were linked to available concurrent CASPER data (2013 data for the 2014 survey and 2017 data for the 2018 survey) and Nursing Home Compare Five-Star Quality Rating System (NH Compare) data. CASPER provided facility characteristics including bed size, occupancy level, staffing levels (as measured by hours per resident day), ownership, part of a multi-facility organization, region, and urbanicity. Urbanicity was coded based on 2013 Rural-Urban Continuum Codes in three categories: Metropolitan (RUCC codes 1-3), rural adjacent (codes 4,6,8) and rural remote (codes 5,7,9).³⁵ Quality measures drawn from NH Compare included the overall quality rating as a continuous variable and indicators for infection control and quality of care citations received by an institution within the past year.

Outcomes

Indices were developed to evaluate the change in three sets of infection prevention and control practices in NH (Table 2). The Antibiotic Stewardship index included 5 components, based on the CDC Core Elements; the Outbreak Control and the UTI Prevention indices each included 7 components, based on recommended evidence-based guidelines. For each index, a standardized intensity score was calculated by summing the number of components present in each NH, dividing by the maximum amount, and multiplying by 100 so that each index ranged from 0 (no components) to 100 (all components).

Statistical analysis

We used Pearson's chi-square tests and Wilcoxon tests to describe differences between the 2014 and 2018 NH and staff characteristics and the mean intensity of the infection prevention and control practices. We then estimated multivariable linear regressions for each intensity index to characterize the association between time period, facility characteristics, infection preventionist training, and infection prevention and control intensity. Collinearity tests were performed on the covariates included in the multivariable models. All models controlled for differences in the survey samples from 2014 and 2018. As the 2016 CMS regulations require employment of trained infection preventionists, we predicted that there would be a significant increase in the presence of infection prevention and control practices from 2014 to 2018 due to increased training.

We used the Oaxaca-Blinder decomposition method to characterize the extent to which changes in infection control training and facility characteristics were associated with changes in policy intensities. This method creates counterfactual regression equations to estimate the contributions of covariates on the mean difference between two groups, that is, the infection prevention and control intensity difference between the 2014 NHs and the 2018 NHs. We decomposed changes in each of the three intensity indices by 1) the infection preventionist measures and 2) facility characteristics.

We ran sensitivity analyses by estimating analogous models limiting the sample to the NHs that participated in both the 2014 and 2018 surveys. In addition, we developed restricted models for all sets of analyses eliminating infection preventionist training, which was

mandated by the 2016 CMS regulations and was therefore on the causal pathway for infection prevention and control program improvements.

Regression analyses were performed using SAS, version 9.4 and the decomposition analysis was conducted in STATA Version 14 using the “Oaxaca” command.³⁶

Results

Characteristics of the study sample

We received surveys from 988 NHs from 2014 and 892 NHs from 2018 (response rates of 39% and 49%, respectively). Due to missing data, our final analytical sample included 1833 surveys, with 945 from 2014, 888 from 2018, and 437 NHs with completed responses in both 2014 and 2018. There were some differences between the 2 samples as shown in Table 1. In 2018 compared to 2014, participating NHs were more likely to be non-profit or government facilities (29% and 8% vs. 25% and 5%, $p=0.003$) and more likely to be located in West or Northeast regions (18% and 22% vs. 13% and 22%, $p=0.018$). The 2018 sample also had fewer beds (113 vs 118, $p=0.021$), lower occupancy rates (79% vs 82%, $p=0.003$), and higher Registered Nurse staffing rates (0.83 vs 0.74, $p<0.001$).

There were differences in infection preventionist training from 2014 to 2018 as well. Infection preventionists had more infection control training through all methods of training (p value <0.001) in the 2018 period. Staff turnover decreased for all leadership staff from the 2014 to 2018 (avg. 24% vs 37%, all p values <0.001).

Change in NH Infection Prevention and Control Programs over Time

The change in time of the components of each of the three infection prevention and control indices are shown in Table 2. The prevalence of all Antibiotic Stewardship practices increased from 2014 to 2018 (all p values <0.01) with the greatest percent change being in policies to restrict use of antibiotics (179% increase). Outbreak Control practices also increased from 2014 to 2018 except for cohorting infected residents in the event of a outbreak ($p=0.37$). UTI Prevention practices saw the lowest increase in practices with only use of urinary catheter reminders or stop orders ($p<0.01$) and use of condom catheters for men ($p<0.01$) having a statistically significant increase. However, the prevalence of NHs with no practices in each index decreased from 2014 to 2018: Antibiotic Stewardship from 20% to 1% ($p<0.01$), Outbreak Control practices from 4% to 0.8% ($p<0.01$), and UTI Prevention practices from 1% to 0.3% ($p<0.01$).

As shown in Figure 1, overall all three sets of practices increased from 2014 to 2018. The highest increase was in Antibiotic Stewardship practices (31.8% in 2014 to 65.3% in 2018), followed by Outbreak Control (55.1% in 2014 to 68.5% in 2018) and UTI Prevention (49.8% in 2014 to 56.3% in 2018).

Predictors of Infection Prevention and Control Program Strengthening

In our multivariate analyses, we found several predictors of infection prevention and control strengthening, the strongest of which was the 2018 survey indicator (i.e. time) which had significant positive effects on the intensity of Antibiotic Stewardship ($\mu=32.04$), Outbreak

Control ($\mu=11.86$), and UTI Prevention practices ($\mu=5.20$), after controlling for facility and infection preventionist characteristics (all p values <0.001) (Table 3).

Specialized infection control training of any kind had a strong significant effect on all infection prevention and control practices when compared with NHs in which the infection preventionist had no specialized training (all p values <0.001). We found there to be no effect of professional registered nurse training or staff turnover on infection prevention and control practices.

There were smaller but significant positive associations between overall quality rating and NH bed size for all three policy indices (all p values <0.001). In addition, higher levels of Antibiotic Stewardship were associated with higher occupancy rates ($\mu=0.099$, $p=0.010$), for profit ownership as compared to nonprofit ($\mu=2.742$, $p=0.041$) and having received a quality of care citation in the past year ($\mu=2.401$, $p=0.040$). Staffing levels, being part of a multi-facility organization, region, NH setting and past infection control citation were not associated with Antibiotic Stewardship. In regard to Outbreak Control, higher occupancy rates ($\mu=0.125$, $p=0.009$) and metropolitan and rural remote settings ($\mu=5.268$, $p<0.001$ and $\mu=4.462$, $p=0.037$, respectively) compared to rural adjacent setting were associated with more practices. NHs part of multi-facility organizations had lower intensity of Outbreak Control ($\mu=-3.694$, $p<0.001$). UTI Prevention was greater in NHs that were government-run ($\mu=4.447$, $p=0.024$) or located in metropolitan areas ($\mu=4.314$, $p<0.001$). NHs in the South compared to the West had lower levels of UTI prevention practices ($\mu=-4.438$, $p=0.001$).

Decomposition of Infection Prevention and Control Programs

Mean differences in the three infection prevention and control intensities were decomposed to evaluate the attributable factors for the large improvements in the practices from 2014 to 2018 (Table 4). Improvements in infection preventionist training explained 5% (1.77 out of the 33.46 percentage point change) of the increase in Antibiotic Stewardship, 13% (1.83 out of the 13.38 percentage point change) in Outbreak Control, and 16% (1.08 out of the 6.49 percentage point change) of the improvement in UTI prevention. Changes in facility characteristics did not contribute significantly to the improvements in the infection prevention and control program. The majority of the mean differences, 95% of the improvement in Antibiotic Stewardship, 89% of the improvement in Outbreak Control and 80% of the improvement in UTI Prevention were unexplained by changes in the values of the covariates from 2014 to 2018. Thus, most of the increase in the infection prevention and control intensities from 2014 to 2018 were due to factors not explicitly included in our models.

Sensitivity Analyses

In the restricted models without the infection preventionist training, we found only slight increases (1.5 to 2 percentage point increases) in the effect sizes of the 2018 indicator on the three infection prevention and control practices. To check for robustness of our results, we ran both sets of multivariate analyses limiting our sample to only NHs that participated in both the 2014 and 2018 surveys. In all models, the coefficients of the 2018 indicator were similar to the coefficients produced by the full sample models (data not shown).

Discussion

In this study, we found substantial strengthening of infection prevention and control programs in NHs from 2014 to 2018. Our models found improvements in infection prevention and control that were not attributable to specified facility or infection preventionist characteristics, suggesting that the 2016 CMS Requirement for Participation has been effective in improving NH programs. Furthermore, our sensitivity analyses suggest that the improvements in NH infection prevention and control practices are robust longitudinally across NHs that participated at both time points.

As predicted, the largest improvement in NH infection prevention and control programs occurred in Antibiotic Stewardship practices. The decomposition analysis showed that 95% of the increase in Antibiotic Stewardship was unexplained in our models and therefore attributed to time or factors such as changes in federal initiatives that could not be included in our models. Increased public awareness of antibiotic resistance as well as the publication of numerous national guidelines for antibiotic stewardship led to CMS mandating antibiotic stewardship plans in long term care settings as part of the 2016 Requirements for Participation.

Our results suggest that these efforts may have been instrumental in advancing infection prevention and control programs; however, the impact on reduction of antibiotic use, CDI, and drug resistant infections remains to be seen.

Similar national efforts for preventing UTIs are being implemented but have primarily focused on catheter-associated UTIs. While UTIs are the most common infection reported in NHs, there are relatively lower rates of catheter-associated UTIs due to low catheterization rates. Similar to the adaptation of antibiotic stewardship from acute care settings to long-term care settings, adoption of effective UTI prevention policies may require specialized recommendations for the NH population. For example, in this study, we found that infection control training led to an improvement in UTI prevention practices which may be key to improving UTI prevention in elderly NH populations.

Although mandated by CMS, infection control training for the NH infection preventionist is still lagging. Furthermore, the CMS policy regarding training is vague, not specifying content, length or requirements. Only recently, in March 2019, has the CDC offered a free, online training course for NH staff. In line with previous research, our results show that specialized infection control training is highly associated with uptake of antibiotic stewardship and the other infection prevention and control practices. NHs with an infection preventionist with specific infection control training were 5-13 times more likely to have stronger infection prevention and control programs than those with infection preventionists with no specialized training (Table 2). Furthermore, we found that any type of formal training program was significantly better than no training or other types of less formalized training. Given these results and those shown in other studies, high priority should be given to training NH staff on infection control.

Our study had several limitations. First, the surveys relied on self-reported data and it is possible, due to the CMS requirements, that respondents over-reported the presence of

infection prevention and control program practices. Indeed, we found no change in infection control citations or the severity of these citations (data not shown) between 2014 and 2018. However, it is not clear if the survey process for issuing citations was consistent across time periods. Furthermore, responders may have had stronger infection prevention and control programs as compared to non-responders. However, in examining quality of NH responders and non-responders at both time periods, we found no differences in NH Five-Star Quality Rating.³³ Second, the 2018 survey data were collected only 2-3 years after the CMS policy changes were implemented. Given that the CMS Requirements of Participation are implemented in a phased roll-out and that a trained infection preventionist is not required until November 2019, the full effects of these policies may yet to be realized; thus, they could be stronger than presented here.

Third, and most importantly, as CMS policies were implemented across the US at the same time for all NHs, we had no geographic or temporal variation with which we could directly estimate their effects. We were only able to identify differences in NH adoption of infection prevention and control practices from before (2014) until after (2018) the CMS regulations while controlling for other observable factors. Thus, even though our models adjusted for NH facility characteristics and quality measures that are known to impact NH infection control practices, the change over time could be due to other unobservable factors. Furthermore, decomposition analysis is a descriptive tool that characterizes the association between changes in the values of sets of covariates with changes in the outcome. Interpretation of those associations as causal should be made with caution. However, the timing of the CMS policy changes between the survey periods suggests they played an important role in the large improvements in NH infection prevention and control programs. Future evaluations are needed to examine more directly the effect of the CMS regulations on NH practices such as qualitative interviews with NH staff as well as long term longitudinal quantitative studies examining resident outcomes such as CDI and drug resistant infection rates, antibiotic use and antibiotic prescribing practices before and after the policy changes.

Conclusions and Implications

Improving infection prevention and control in NHs remains a national priority. Our work indicates that the CMS regulations may have improved the quality of NH infection prevention and control programs. Further evaluation of the impact of these policies on resident outcomes would be beneficial.

Acknowledgements:

We'd like to acknowledge the nursing homes that participated in both surveys, as well as our recruitment team for survey data collection including: Nida Ali, Ashley Chastain, Richard Dorritie, Hector Perez, Stephen Powers, Aluem Tark, and Asia Taylor.

Funding sources: This work was supported by the National Institutes of Nursing Research (Grant 2R01NR013687-05).

References

1. World Health Organization. Antimicrobial resistance: global report on surveillance. Geneva, Switzerland: World Health Organization, 2014.

2. Centers for Disease Control & Prevention. Antibiotic resistance threats in the United States, 2013. Atlanta, GA: Centers for Disease Control & Prevention, 2013.
3. U.S. Department of Health & Human Services. Presidential Advisory Council on Combating Antibiotic-Resistant Bacteria (PACCARB); 2017 <https://www.hhs.gov/ash/advisory-committees/paccarb/index.html>. Accessed June 24 2019.
4. White House. National action plan to combat antibiotic-resistant bacteria. ; 2015 https://obamawhitehouse.archives.gov/sites/default/files/docs/national_action_plan_for_combating_antibiotic-resistant_bacteria.pdf. Accessed June 24 2019.
5. Evans CT, Safdar N. Current Trends in the Epidemiology and Outcomes of Clostridium difficile Infection. Clin Infect Dis 2015;60 Suppl 2:S66–71. [PubMed: 25922403]
6. Stevens V, Dumyati G, Fine LS, et al. Cumulative antibiotic exposures over time and the risk of Clostridium difficile infection. Clin Infect Dis 2011;53(1):42–48. [PubMed: 21653301]
7. Bell BG, Schellevis F, Stobberingh E, et al. A systematic review and meta-analysis of the effects of antibiotic consumption on antibiotic resistance. BMC Infect Dis 2014;14:13. [PubMed: 24405683]
8. Brown KA, Fisman DN, Moineddin R, et al. The magnitude and duration of Clostridium difficile infection risk associated with antibiotic therapy: a hospital cohort study. PLoS One 2014;9(8):e105454. [PubMed: 25157757]
9. Drekonja DM, Filice GA, Greer N, et al. Antimicrobial stewardship in outpatient settings: a systematic review. Infect Control Hosp Epidemiol 2015;36(2):142–152. [PubMed: 25632996]
10. Feazel LM, Malhotra A, Perencevich EN, et al. Effect of antibiotic stewardship programmes on Clostridium difficile incidence: a systematic review and meta-analysis. Journal of Antimicrobial Chemotherapy 2014;69(7):1748–1754. [PubMed: 24633207]
11. Kaki R, Elligsen M, Walker S, et al. Impact of antimicrobial stewardship in critical care: a systematic review. J Antimicrob Chemother 2011;66(6):1223–1230. [PubMed: 21460369]
12. Baur D, Gladstone BP, Burkert F, 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(9):990–1001. [PubMed: 28629876]
13. Karanika S, Paudel S, Grigoras C, et al. Systematic Review and Meta-analysis of Clinical and Economic Outcomes from the Implementation of Hospital-Based Antimicrobial Stewardship Programs. Antimicrob Agents Chemother 2016;60(8):4840–4852. [PubMed: 27246783]
14. Feldstein D, Sloane PD, Feltner C. Antibiotic Stewardship Programs in Nursing Homes: A Systematic Review. J Am Med Dir Assoc 2018;19(2):110–116. [PubMed: 28797590]
15. Nicolle LE. Antimicrobial stewardship in long term care facilities: what is effective? Antimicrob Resist Infect Control 2014;3(1):6. [PubMed: 24521205]
16. 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(10):e51–77. [PubMed: 27080992]
17. Centers for Disease Control & Prevention. The core elements of antibiotic stewardship for nursing homes. Atlanta, GA: US Department of Health and Human Services, CDC; 2015.
18. Morrill HJ, Caffrey AR, Jump RL, et al. Antimicrobial Stewardship in Long-Term Care Facilities: A Call to Action. J Am Med Dir Assoc 2016;17(2):183 e181–116.
19. Harris-Kojetin LD, Sengupta M, Lendon JP, et al. Long-term care providers and services users in the United States, 2015–2016 In: National Center for Health Statistics, ed. 3 Washington, DC: Vital & health statistics; 2019.
20. Montoya A, Cassone M, Mody LJCigm. Infections in nursing homes: epidemiology and prevention programs. 2016;32(3):585–607.
21. High KP, Juthani-Mehta M, Quagliarello VJCID. Infectious diseases in the nursing home setting: challenges and opportunities for clinical investigation. 2010;51(8):931–936.
22. Dwyer LL, Harris-Kojetin LD, Valverde RH, et al. Infections in Long-Term Care Populations in the United States. Journal of the American Geriatrics Society 2013;61(3):341–349.
23. Herzig CTA, Dick AW, Sorbero M, et al. Infection Trends in US Nursing Homes, 2006–2013. J Am Med Dir Assoc 2017;18(7):635 e639–635 e620.

24. Hunter JC, Mu Y, Dumyati GK, et al. Burden of nursing home-onset *Clostridium difficile* infection in the United States: estimates of incidence and patient outcomes Open forum infectious diseases. 3 Oxford University Press; 2016.
25. Cassone M, Mody LJCgr. Colonization with multidrug-resistant organisms in nursing homes: scope, importance, and management. 2015;4(1):87–95.
26. Crnich CJ, Jump R, Trautner B, et al. Optimizing antibiotic stewardship in nursing homes: a narrative review and recommendations for improvement. 2015;32(9):699–716.
27. Centers for Medicare & Medicaid Services. Medicare and Medicaid Programs; Reform of Requirements for Long-Term Care Facilities. Final rule. Federal Register 2016;81(192):68688. [PubMed: 27731960]
28. Slayton RB, Toth D, Lee BY, et al. Vital Signs: Estimated Effects of a Coordinated Approach for Action to Reduce Antibiotic-Resistant Infections in Health Care Facilities - United States. MMWR Morb Mortal Wkly Rep 2015;64(30):826–831. [PubMed: 26247436]
29. Centers for Disease Control and Prevention. National Healthcare Safety Network (NHSN): Tracking Infections in Long-term Care Facilities; <http://www.cdc.gov/nhsn/ltc/>. Accessed September 23, 2018.
30. Centers for Medicare & Medicaid Services. CMS launches next phase of new Quality Improvement Program; 2014 <https://www.cms.gov/Newsroom/MediaReleaseDatabase/Press-releases/2014-Press-releases-items/2014-07-18.html>. Accessed December 30, 2015.
31. QIO Program. QIOs in Action: Reducing the Risks of *Clostridioides difficile*; 2019 <https://qioprogram.org/qionews/articles/qios-action-reducing-risks-clostridioides-difficile>. Accessed October 15 2019.
32. Herzig CT, Stone PW, Castle N, et al. Infection Prevention and Control Programs in US Nursing Homes: Results of a National Survey. J Am Med Dir Assoc 2016;17(1):85–88. [PubMed: 26712489]
33. Stone PW, Agarwal M, Ye F, et al. Integration of Palliative Care and Infection Management at End-of-Life in US Nursing Homes. Journal of pain and symptom management 2019.
34. 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(9):785–814. [PubMed: 18767983]
35. United States Department of Agriculture. Rural-Urban Continuum Codes; 2019 <https://www.ers.usda.gov/data-products/rural-urban-continuum-codes/documentation/>. Accessed October 16 2019.
36. Jann B. The Blinder–Oaxaca decomposition for linear regression models. The STATA Journal 2008;8(4):453–479.
37. Nathan C, Cars O. Antibiotic resistance--problems, progress, and prospects. N Engl J Med 2014;371(19):1761–1763. [PubMed: 25271470]
38. Meddings J, Saint S, Krein SL, et al. Systematic Review of Interventions to Reduce Urinary Tract Infection in Nursing Home Residents. J Hosp Med 2017;12(5):356–368. [PubMed: 28459908]
39. Mody L, Greene MT, Meddings J, et al. A National Implementation Project to Prevent Catheter-Associated Urinary Tract Infection in Nursing Home Residents. JAMA Intern Med 2017;177(8):1154–1162. [PubMed: 28525923]
40. Centers for Medicare & Medicaid Services. CMS & CDC Offer a specialized, online Infection Prevention and Control Training For Nursing Home Staff in the Long-Term Care Setting; 2019 <https://www.cms.gov/newsroom/fact-sheets/cms-cdc-offer-specialized-online-infection-prevention-and-control-training-nursing-home-staff-long>. Accessed June 24 2019.
41. Thompson ND, Brown C, Eure T, et al. Characteristics of Nursing Homes Associated With Self-reported Implementation of Centers for Disease Control and Prevention (CDC) Core Elements of Antibiotic Stewardship Open Forum Infectious Diseases. 5 Oxford University Press US; 2018:S523–S524.
42. Stone PW, Herzig CTA, Agarwal M, et al. Nursing Home Infection Control Program Characteristics, CMS Citations, and Implementation of Antibiotic Stewardship Policies: A National Study. Inquiry 2018;55:46958018778636. [PubMed: 29806527]

43. Kaur J, Stone PW, Travers JL, et al. Influence of staff infection control training on infection-related quality measures in US nursing homes. *Am J Infect Control* 2017;45(9):1035–1040. [PubMed: 28625699]
44. O'Neill C, Harrington C, Kitchener M, et al. Quality of care in nursing homes: an analysis of relationships among profit, quality, and ownership. *Med Care* 2003;41(12):1318–1330. [PubMed: 14668664]
45. Manning ML, Septimus EJ, Ashley ESD, et al. Antimicrobial stewardship and infection prevention-leveraging the synergy: A position paper update. *Am J Infect Control* 2018;46(4):364–368. [PubMed: 29592832]

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Figure 1.
Intensity of infection prevention and control practices in US nursing homes in 2014 and 2018.

NOTES: UTI = Urinary tract infection.

Table 1.

Facility & staff characteristics of nursing homes who participated in the 2014 and 2018 surveys.

	2014	2018	p value
	n = 945	n = 888	
Facility Characteristics, %			
Ownership			
For profit	69.31	62.50	0.003
Government	5.40	8.45	
Nonprofit	25.29	29.05	
Multi-facility organization	55.03	55.07	0.986
Region			
Midwest	34.50	32.77	0.018
Northeast	22.01	22.18	
South	30.16	26.58	
West	13.33	18.47	
Setting			
Metropolitan	72.38	68.13	0.048
Rural Remote	16.83	17.45	
Rural Adjacent	10.79	14.41	
Infection control citation	34.50	37.73	0.150
Quality of care citation	63.39	62.95	0.847
CMS Five Star Overall Quality Rating, mean (SD)	3.38 (1.34)	3.43 (1.37)	0.351
Number of beds, mean (SD)	118.55 (70.03)	113.28 (68.42)	0.021
Percent occupancy, mean (SD)	81.91 (15.41)	79.55 (16.73)	0.003
Staffing levels, hours per resident day, mean (SD)			
Certified nursing assistant	2.48 (0.94)	2.53 (0.69)	0.122
Licensed practical nurse	0.80 (0.48)	0.82 (0.47)	0.786
Registered nurse	0.74 (0.37)	0.83 (0.48)	<0.001
Infection Preventionist Characteristics, %			
Professional Training			
Registered nurse	20.74	17.57	0.085
Other	79.26	82.43	
Specific Infection Control Training			
Certified in Infection Control (CIC)	2.65	7.43	<0.001
State of local training course with certificate	23.70	26.58	
National or local training course through professional society	5.50	10.92	
Other	3.70	10.81	
No Specific Infection Control Training	64.44	44.26	
3+ Infection Preventionists in past 3 years	38.10	24.55	<0.001
3+ Administrators in past 3 years	34.92	20.50	<0.001

	2014	2018	p value
	n = 945	n = 888	
3+ DONs in past 3 years	38.10	28.38	<0.001

NOTES: CMS = Centers for Medicare & Medicaid Services; DON = Director of Nursing.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 2.

Components of infection prevention and control practices in nursing homes who participated in the 2014 and 2018 surveys.

	2014	2018	p value
	n = 945	n = 888	
<u>Antibiotic Stewardship Policies, %</u>			
Collection of Data on Antibiotic Use	49.52	91.55	<0.01
Antibiotic Prescribing Guidelines/Therapeutic Formularies	28.25	66.10	<0.01
Policies to Restrict Use of Antibiotics	6.98	19.48	<0.01
Review of Cases for Antibiotic Appropriateness	42.86	80.86	<0.01
Providing Feedback to Clinicians on Antibiotic Prescribing	31.75	68.69	<0.01
None of the Above	20.32	1.01	<0.01
<u>Outbreak Control Policies, %</u>			
Cohorting Infected Residents	65.71	67.68	0.37
Confining Residents to Rooms	73.86	86.60	<0.01
Use of Rapid Diagnostic Methods for Case Detection	27.09	49.32	<0.01
Closing the Facility to New Admissions	32.91	49.66	<0.01
Instructing Infected Staff to Stay Home	84.76	92.79	<0.01
Administering Prophylaxis	46.88	60.02	<0.01
Quarantining Units on Which Outbreaks Occur	54.50	73.31	<0.01
None of the Above	4.23	0.79	<0.01
<u>UTI Prevention Policies, %</u>			
Hydration Protocols	79.26	76.01	0.09
Staff Education on Perineal Care	96.08	97.64	0.06
Urinary Catheter Reminder or Stop Order	42.43	64.30	<0.01
Leg Bag Cleaning Policy	44.02	46.73	0.24
Condom Catheters for Men	6.67	12.61	<0.01
Indwelling Catheters Replaced and Specimen Collected Prior to Antibiotic Therapy	58.41	61.71	0.15
Portable Bladder Ultrasound Scanner for Post Void Residual	21.69	35.02	<0.01
None of the Above	1.27	0.34	0.03

Table 3.

Associations between survey period, facility characteristics, infection preventionist training, staff turnover and infection prevention and control practices.

	Antibiotic Stewardship Practices		Outbreak Control Practices		UTI Prevention Practices	
	Estimate	p value	Estimate	p value	Estimate	p value
2018 Survey Indicator	32.042	<0.001	11.858	<0.001	5.200	<0.001
Infection Preventionist Training						
Professional Training						
Registered Nurse	-0.315	0.823	0.703	0.631	1.187	0.311
Other	Ref		Ref		Ref	
Specific Infection Control Training						
Certified in Infection Control (CIC)	14.000	<0.001	10.242	<0.001	9.340	<0.001
State of local training course with certificate	6.839	<0.001	8.008	<0.001	5.348	<0.001
National or local training course through professional society	7.988	<0.001	10.967	<0.001	6.413	<0.001
Other	6.661	<0.001	7.189	<0.001	1.922	0.298
No Specific Infection Control Training	Ref		Ref		Ref	
Staff Turnover (3 or more in the past 3 years)						
Infection Preventionists	0.890	0.490	-0.773	0.564	-0.716	0.504
Administrators	-2.006	0.135	1.003	0.472	0.769	0.491
Directors of Nursing	0.114	0.931	-1.222	0.375	-1.236	0.262
Facility Characteristics						
Number of beds	0.028	0.004	0.044	0.008	0.022	0.010
Percent occupancy	0.099	0.010	0.125	0.009	0.020	0.528
Staffing levels, hours per resident day						
Certified nursing assistant	-0.215	0.798	1.139	0.190	0.219	0.753
Licensed practical nurse	0.008	0.995	-1.442	0.305	1.271	0.259
Registered nurse	0.219	0.889	1.321	0.417	-0.054	0.967
Ownership						
For profit	2.742	0.041	0.257	0.853	0.010	0.993
Government	0.438	0.854	-1.318	0.593	4.477	0.024
Nonprofit	Ref		Ref		Ref	
Multi-facility organization	0.958	0.407	-3.694	<0.001	-1.496	0.119
Region						
Midwest	1.150	0.511	-2.343	0.197	-1.152	0.428
Northeast	-2.598	0.192	2.062	0.318	-1.848	0.264
South	-0.501	0.787	-3.641	0.059	-4.438	0.001
West	Ref		Ref		Ref	
Setting						
Metropolitan	1.838	0.301	5.268	<0.001	4.314	<0.001

	Antibiotic Stewardship Practices		Outbreak Control Practices		UTI Prevention Practices	
	Estimate	p value	Estimate	p value	Estimate	p value
Rural Remote	0.391	0.849	4.462	0.037	0.883	0.605
Rural Adjacent	Ref		Ref		Ref	
Infection control citation	1.283	0.283	−0.103	0.934	0.817	0.411
Quality of care citation	2.401	0.040	2.156	0.084	1.774	0.076
CMS Five Star Overall Quality Rating	2.031	<0.001	1.053	0.025	1.108	<0.001

NOTES: All results presented are from multivariable models, adjusting for all characteristics shown in the table, including differences in survey respondents from 2014 and 2018. The outcomes range from 0 to 100 so results can be interpreted as percentage point changes in the intensity of each of the outcome indices. CMS = Centers for Medicare & Medicaid Services; UTI = Urinary tract infection.

Table 4.

Decomposition of the mean difference in infection prevention and control intensities in US NHs between 2014 and 2018.

	Antibiotic Stewardship Practices			Outbreak Control Practices			UTI Prevention Practices		
2014 Mean	31.873			55.102			49.796		
2018 Mean	65.338			68.485			56.290		
Mean Difference	33.465			13.383			6.494		
Detailed Decomposition of Mean Difference									
Explanatory Variables	Coefficient	SE	P value	Coefficient	SE	P value	Coefficient	SE	P value
Infection Preventionist Training	1.773	0.338	<0.001	1.826	0.345	<0.001	1.085	0.270	<0.001
Facility Characteristics	−0.350	0.344	0.310	−0.301	0.419	0.473	0.210	0.303	0.488
Total	1.423	0.484	<0.001	1.525	0.555	<0.001	1.295	0.417	<0.001
Total "Unexplained"	32.042	1.168	<0.001	11.858	1.206	<0.001	5.200	0.961	<0.001

NOTES: SE = Standard error; UTI = Urinary tract infection.