HHS Public Access

Author manuscript

Am J Infect Control. Author manuscript; available in PMC 2021 January 01.

Published in final edited form as:

Am J Infect Control. 2020 January ; 48(1): 13–18. doi:10.1016/j.ajic.2019.07.015.

Characteristics of Nursing Homes with Comprehensive Antibiotic Stewardship Programs, Results of a National Survey

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Abstract

Background: Antibiotic stewardship in nursing homes (NHs) is a high priority due to intense antibiotic use and increased risk of adverse events. Updated Centers for Medicare and Medicaid Services (CMS) regulations required NHs to establish antibiotic stewardship programs (ASPs). This study describes the current state of NH ASPs.

Methods: A nationally representative survey of NHs was conducted in 2018. ASP comprehensiveness, infection preventionist (IP) training, participation in Quality Innovation Network-Quality Improvement Organization (QIN-QIO) activities, and facility and staff characteristics were analyzed using weighted descriptive statistics and multinomial regression models.

Results: Of 861 NHs, 33.2% had comprehensive (6–7 policies), 41.1% had moderately comprehensive (4–5 policies), and 25.6% had not comprehensive ASPs (≤3 policies). Data collection on antibiotic use was most reported (91.4%); restricting use of specific antibiotics was least reported (19.0%). Comprehensive ASPs were associated with QIN-QIO involvement; moderate and comprehensive ASPs were associated with IP training and high occupancy.

Discussion: Immediately following CMS regulation changes, a majority of NHs had moderately comprehensive or comprehensive ASPs. Rates for each policy and infection control-trained IPs increased from previous studies.

Conclusions: NH ASPs are becoming more comprehensive. Infection control training and partnerships with QIN-QIOs can support NHs to increase ASP comprehensiveness.

Keywords

antibiotic stewardship; antibiotic stewardship programs; nursing homes; infection control

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Conflicts of Interest
Nothing to disclose

Background

Over 4 million Americans use nursing home (NH) or skilled nursing facility services each year, and of these, about 1.3 million are NH residents.[1,2] Elderly NH residents are highly susceptible to infections due to the higher likelihood of compromised physiologic barriers, immunosuppression, malnutrition, dehydration, comorbidities, and functional impairments.[3–7] Subsequently, antibiotic use in this setting is high, with up to 70% of residents receiving an antibiotic; studies have found as many as 75% of those antibiotics were prescribed inappropriately, without adequate documentation or evidence of infection.[8–15] Inappropriate use and overuse of antibiotics can lead to increased risk of infections from *Clostridium difficile* and multidrug resistant organisms as well as antibiotic resistance.[16–19] NH residents are also at higher risk of adverse drug reactions, polypharmacy, and decreased antibiotic efficacy due to altered pharmacokinetics.[13,20–22]

Antibiotic stewardship programs (ASPs) seek, through coordinated policies and practices, to promote appropriate use of antibiotics in an effort to reduce adverse patient outcomes and prevent resistance. Studies in acute care settings have found that ASPs can be effective at reducing these risks.[23–26] In 2014, the Centers for Disease Control (CDC) published recommendations for hospitals to establish their ASPs around the core elements of leadership, accountability, drug expertise, action, tracking, reporting and education;[27] these recommendations were also extended to the NH setting.[28] In recognition of the high importance of antibiotic stewardship in NHs, revised Centers for Medicare and Medicaid Services (CMS) Requirements for Participation required NHs to have “an ASP that includes antibiotic use protocols and a system to monitor antibiotic use” as of November 28, 2017.[29] In addition to the CDC core elements, NHs can use a number of guidelines and templates published by experts and professional organizations to build their ASP.[30,31] Also, Quality Innovation Networks-Quality Improvement Organizations (QIN-QIOs) have been funded by CMS to provide resources for NHs to use when developing their ASP.[32]

Implementation of antibiotic stewardship faces challenges in all healthcare settings,[33] but NHs are even more resource-challenged, especially in areas of staffing and infrastructure. NHs have fewer staff compared to acute care settings, lower levels of staff training and high turnover, which can be barriers for implementing infection control and management programs.[22,34–37] Diagnoses of infection in this population are further complicated by the often atypical presentation of symptoms.[13,38] However, NHs frequently do not have access to on-site physicians or advanced practice providers for NHs, and decisions to prescribe antibiotics are made remotely, thus relying heavily on non-prescriber NH staff assessment and interprofessional communication.[22,36,39–41]

A related national survey conducted in 2013–2014 found that only about half (51%) of CMS-certified NHs collected data on antibiotic utilization and even fewer (46%) had written guidelines for antibiotic initiation.[42] These figures are expected to change as facilities work to meet new requirements. Given the relative autonomy NHs had in which policies and how many they would choose to adopt when establishing their ASPs, we sought to examine how comprehensive NH ASPs were and which facility and staffing characteristics were associated with comprehensiveness.

Methods

Sample and Data Collection

In 2017–2018, a national survey of NHs was conducted. Directors of nursing (DONs) were contacted at eligible facilities, which were non-specialized, free-standing NHs with at least 30 beds. Facilities were identified from 2014 Certification and Survey Provider Enhanced Report (CASPER) data to ensure they were operational and would have facility level data for analysis. The sample was stratified by QIN-QIO region, National Healthcare Safety Network (NHSN) enrollment status (30% were enrolled), and participation in our previous survey.[43] Eligible facilities were contacted in seven waves from November 2017 to October 2018. Respondents could complete the survey on paper or on a web-based form. Gift cards were offered as incentives. Further details of the survey development and data collection methods have been discussed elsewhere.[44] The study was approved by the Columbia University institutional review board.

Measures

Survey items included ASP policies currently implemented at the facility, infection preventionist (IP) training and certification, on-site staffing of advanced practice registered nurses (APRNs), physician assistants (PAs) and pharmacists, turnover of IPs, DONs, or NH administrators, and involvement in QIN-QIO initiatives.

ASP comprehensiveness was defined by the number out of 7 specific policies, based on CDC core elements, that NH staff reported having in place: (1) collect data on antibiotic use, (2) use antibiotic prescribing guidelines or therapeutic formularies, (3) restrict use of specific antibiotics, (4) communicate antibiotic use information when residents are transferred, (5) review cases to assess appropriateness of antibiotic administration and/or indication, (6) provide feedback to clinicians on antibiotic use and prescribing, and (7) provide educational resources for improving antibiotic use.[28] Those reporting 3 or fewer policies were defined as “not comprehensive,” and those with 6 or more were defined as “comprehensive.” All others, those with 4 or 5 policies in place, were considered “moderately comprehensive.”

Respondents were also asked to select all that applied among different categories of specific training and certification in infection control. Responses were hierarchically grouped as follows: the IP was certified in infection control; the IP had completed local, state, national, or professional society training courses; the IP had completed some other infection control training not included in the previous two categories; or the IP had no specific infection control training.

The availability of clinical staff (APRN, PA, pharmacist) on-site was defined as whether each staff member type was reported working at the facility part-time or full-time; on-call staff were not considered. APRNs and PAs were combined as one category, and pharmacists were analyzed separately. Staff turnover was evaluated based on how many DONs, administrators, and IPs (who were most frequently registered nurses [RNs] or licensed practical nurses) had been at the organization over the course of three years, with three or more of each in the previous three-year period being considered high turnover.

The survey was linked to CASPER data, which included the following NH characteristics: ownership profit status (for profit or not), Medicare-certified bed count greater than 100 beds, greater than 75% occupancy, and percent of residents with Medicaid and Medicare as the primary payer. The survey was also linked to census region to identify if the facility was located in a metropolitan county or not.

Analyses

Survey respondents and non-respondents were compared using descriptive statistics,[44] and Pearson's χ^2 or one-way ANOVA tests as appropriate were used to identify associations between NH characteristics and ASP comprehensiveness. A multinomial logistic regression model was computed to determine the characteristics associated with comprehensive and moderately comprehensive ASPs compared to not comprehensive ones. Probability weights were constructed based on the sampling strata along with nonresponse predictors like ownership type (for profit, nonprofit, or government-owned) and urban-rural indicators (metropolitan, rural adjacent, or rural remote); these adjusted for differences due to study inclusion and participation and were used in all analyses. All analyses were performed using SAS 9.4 (SAS Institute Inc., Cary, NC).

Results

Complete surveys were received from 892 NHs out of 1,820 sampled, an overall response rate of 49%. Those with complete data for items related to infection management policies, infection control training, staff turnover, on-site availability of advanced practice providers and pharmacists, QIN-QIO participation and CASPER facility characteristics were included in the analyses (n = 861, weighted n = 14,865).

Table 1 shows weighted descriptive statistics of ASP comprehensiveness and the specific infection management policies that NH staff reported were implemented at their facility. Thirty-three percent of respondents had a comprehensive ASP, 41.1% had a moderately comprehensive ASP, and 25.6% had a not comprehensive ASP. Four facilities reportedly had none of the policies in place. Overall, the rates of inclusion of specific policies ranged from 19.0% for restriction of specific antibiotics to 91.4% for data collection on antibiotic use. These were also respectively the least and the most frequently implemented policies reported in each ASP comprehensiveness group. The two policies with the biggest differences of inclusion between groups were providing educational resources (98.4% for comprehensive programs vs. 21.5% for not comprehensive) and providing antibiotic use and prescription feedback to clinicians (99.0% for comprehensive programs vs. 21.5% for not comprehensive).

Table 2 shows weighted bivariate statistics for staffing and other facility characteristics by ASP comprehensiveness groups. The rates of facility QIN-QIO participation increased with increasing ASP comprehensiveness, 25.9% among those whose ASP was not comprehensive, 34.8% among those with moderately comprehensive ASPs, and 48.1% for those with comprehensive ASPs ($P < .01$). Similarly, among those who had participated in QIN-QIO activities, 40.2% with not comprehensive, 61.6% with moderately comprehensive,

and 74.2% with comprehensive ASPs reported that those initiatives focused on antimicrobial stewardship ($P < .01$) (data not shown).

A higher percentage of NHs with not comprehensive ASPs, 43.8%, were located in the Southern census region compared to 30.4% of those with moderately comprehensive ASPs and 30.7% of those with comprehensive ASPs ($P < 0.1$). Higher percentages of NHs with comprehensive and moderately comprehensive ASPs, 73.3% and 75.1% respectively, were located in metropolitan counties compared to 62.3% with not comprehensive ASPs ($P < 0.1$). This was similar for occupancy; 73.1% with comprehensive ASPs, 71.8% with moderately comprehensive ASPs had >75% occupancy compared to 56.5% with not comprehensive ASPs ($P < 0.1$). Only 64.4% of NHs with moderately comprehensive ASPs were for profit compared to 72.7% with comprehensive and 73.6% with not comprehensive ASPs ($P = 0.03$).

The three ASP comprehensiveness groups differed on a number of measured staffing characteristics. A higher percentage of NHs with not comprehensive ASPs, 32.3%, had high IP turnover compared to 23.5% with moderately comprehensive and 20.2% with comprehensive programs ($P = 0.02$). We observed increasing rates of IP certification in infection control across groups, from 2.8% in not comprehensive ASP NHs, to 7.8% in moderately comprehensive ASP NHs, to 10.9% in comprehensive ASP NHs ($P = 0.01$). Similarly, rates of IP state or professional organization training also increased with increasing comprehensiveness, from 27.8% (not comprehensive) to 37.0% (moderately comprehensive) to 40.6% (comprehensive), and for other infection control training, from 7.4% to 10.0% to 13.6% ($P < .01$). Conversely, NHs with not comprehensive ASPs had the highest rates of an IP with no specific infection control training, 62.0%, followed by 45.2% of those with moderately comprehensive ASPs and 34.9% of those with comprehensive ASPs ($P < .01$). Rates of having on-site pharmacists and on-site APRNs or PAs were over 10 percentage points lower for NHs with not comprehensive programs compared to those with either moderately comprehensive or comprehensive programs, 35.0% versus 45.2% or 47.3% for pharmacists ($P = 0.03$) and 58.6% versus 70.1% or 70.8% for APRN/PAs ($P = 0.02$).

Table 3 shows multinomial regression estimates for NH facility characteristics including participation in QIN-QIO initiatives and staffing characteristics. QIN-QIO participants had 1.94 times greater odds (95% CI [1.215, 3.090]) of having a comprehensive ASP compared to a not comprehensive one. Facilities located in metropolitan counties were more likely to have a moderately comprehensive ASP than a not comprehensive one (OR = 1.63, 95% CI [1.030, 2.585]). NHs with greater than 75% occupancy were more likely to have moderately comprehensive (OR = 1.82, 95% CI [1.180, 2.808]) and comprehensive ASPs (OR = 1.77, 95% CI [1.103, 2.849]) compared to not comprehensive ones. A one percentage point increase in residents with Medicaid as primary payer was associated with slightly lower odds of having a moderately comprehensive ASP (OR = 0.99, 95% [CI 0.972, 0.998]) over a not comprehensive one. Facility size (100+ beds or not), chain membership, for-profit ownership status, location by census region were not significantly associated with increasing ASP comprehensiveness.

NHs whose IP was reportedly certified in infection control had 4.89 times greater odds of having comprehensive ASPs (95% CI [1.412, 16.91]) compared to those with no specific training. Those with an IP with local, state, or professional organization training had 1.68 times greater odds (95% CI [1.051, 2.677]) of having a moderately comprehensive ASP and 2.07 times greater odds (95% CI [1.275, 3.355]) of having a comprehensive ASP. Those whose IP had other infection control training also had 3.04 times greater odds of having a comprehensive program (95% CI [1.371, 6.740]). The staffing of pharmacists and APRN/PAs on-site were not significantly associated with increase ASP comprehensiveness.

Discussion

This study presents nationally representative data on NH ASP comprehensiveness concurrent with and immediately following the implementation deadline for the new CMS requirements.[29] Similar to other studies who evaluated antibiotic stewardship implementation directly using the framework of the CDC core elements,[45,46] we examined comprehensive ASPs through a number of specific policies and practices that fell under 4 of the 7 core elements (action, tracking, reporting, and education). Overall, 6 out of 7 antibiotic stewardship policies had implementation rates of 63% or higher, and only 4 NHs reported not having any of the policies in place, showing progress in the development of NH ASPs compared to a previous national survey.[42,43]

In line with other research, the policy that was most frequently reported to be implemented was collecting data on antibiotics use or tracking. State-based assessments from 2011 to 2017 found that many NHs were already collecting data on antibiotic prescriptions, though there was wide variation by state, from 23% with antibiotic tracking policies in Tennessee in 2016–17 to 98.5% of NHs tracking antibiotic starts in Wisconsin in 2015.[45,47–52] Similarly, in the 2016 annual national survey of NHs enrolled in the NHSN long-term care facility component, 95% reported that they tracked antibiotic use.[46]

The policy that was least adopted overall was restricting the use of specific antibiotics; in the comprehensive ASP group, where all other policies had 98% or higher rates of adoption, only 45% reported implemented this policy. Many of the factors that may drive high antibiotic use in long-term care settings may also be reflected in the relatively low uptake of this policy; these include the increased infection risk in this population coupled with risk aversion from providers as well as perceptions that antibiotics are standard care and less burdensome than other therapies.[21,22,36,54,55] While different providers have reported generally positive perceptions of antibiotic stewardship in qualitative studies, they also frequently mention pressures from patients or family to administer antibiotics.[54,56,57]

Differences in the implementation rates of ASP policies might reflect variations in resource intensiveness, or NHs may have begun incrementally building their ASPs starting with policies for which resources were more readily accessible like tracking antibiotics use.[58] Rates of NHs that gave feedback on prescriptions to providers was very different between comprehensive ASPs and not comprehensive ASPs, and a systematic review has found that this practice can increase the effects of antibiotic stewardship interventions.[59] Also, comparatively few NHs with not comprehensive ASPs provided educational materials on

improving antibiotic use. Publicly available resources from the CDC, QIN-QIOs, and professional associations may be useful to close this gap.[60–63]

Our study found a positive association between participation in QIN-QIO activities and increasing ASP comprehensiveness. Currently, QIN-QIOs offer educational resources on antibiotic stewardship through their websites, and list contact information for personnel who can provide support.[62] QIN-QIOs have also been partnering with CDC and CMS to assist NHs in tracking and reporting *C. difficile* events through NHSN.[32,64,65] The impact of these partnerships with NHs to promote and support ASPs needs more research, especially as the future of funding aimed at antibiotic stewardship under the QIN-QIO scope of work is uncertain.[66,67]

We found a positive association between NHs having an IP with any type of infection control training and the likelihood of the facility having a more comprehensive ASP and a negative association for those not having infection control training. The relative lack of training of NH staff compared to hospital settings has been noted as a barrier for infection control and antibiotic stewardship,[34,68] and 46% of facilities we surveyed reported that their IP had no specific infection control training. This rate is much lower than previously reported rates, which ranged from 97% in a 2003 Maryland survey to 61% in a 2013–14 national survey.[34,42]

Access to drug expertise was evaluated through rates of on-site access to pharmacists and APRNs/PAs; these were similar to the 77% of NHs who had access to drug expertise in a national study of NHSN-enrolled NHs,[46] but the rate of on-site access to pharmacists was lower. While, we did not find that on-site access to either of these types of clinicians was significantly associated with increased ASP comprehensiveness, limitations in pharmacist access may impede the ability of NHs to readily implement more comprehensive and effective ASPs. An intervention involving weekly review of antibiotic prescriptions by a team involving pharmacists and physicians and NH IPs was found to reduce prescription rates.[69] Staffing shortages and high turnover in NHs are other well-documented issues and have been found to increase the risk of infection and subsequent hospitalization.[22,34,37,70,71] Although we did not find a significant association with higher IP turnover and ASP comprehensiveness, we recognize that staffing challenges can affect many aspects of implementation for antibiotic stewardship, as these programs may increase the workload of IPs. A greater median number of IP staff hours has been found to be related to increased likelihood of NHs having all 7 core elements in place.[46]

High occupancy and larger Medicare-certified bed sizes were found to be associated with greater odds of increased ASP comprehensiveness. Larger facilities with more residents may have greater need and incentives for effective and comprehensive ASPs, as they may experience a greater infection burden, higher antibiotic usage, and increased incidence of adverse events due to antibiotics. Higher occupancy and crowding in a general hospital ward have been linked to increased risk of MRSA,[72] and NHs are fundamentally more social environments, which can enhance that effect. Also, larger facilities may have comparatively more resources to leverage when implementing their ASPs.

There are limitations to this study. The results were based on self-reported data and may be biased. However, probability weights were used to adjust for potential biases due to differences between respondents and non-respondents and allow the results to be nationally generalizable. Detailed analyses of these differences have been published.[43] Further research is needed to understand the impact of greater comprehensiveness of ASPs on resident outcomes.

Conclusions

ASPs in NHs are showing signs of increased comprehensiveness as indicated by the inclusion of more policies since the implementation of the CMS Final Rule. Certain policies may be more easily adopted while others may require more intensive efforts. For example, readily available educational resources from the CDC, the Agency for Healthcare Research and Quality, and QIN-QIOs can supplement those NHs who are not yet incorporating education in their ASPs. Infection control training for IPs remains a key area for improvement, though there are signs of progress. Additionally, QIN-QIOs could be further utilized to support NHs in expanding their ASPs.

Acknowledgements

We would like to thank nursing home directors of nursing and staff who participated in this survey as well as our recruiting team (Nida Ali, Ashley Chastain, Richard Dorritie, Hector Perez, Stephen Powers, Aleum Tark, and Asia Taylor).

Funding

This work was funded by the National Institute of Nursing Research of the National Institutes of Health [R01NR013687]. All content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. This work was also supported in part by the Robert Wood Johnson Foundation, Future of Nursing Scholars program.

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Highlights

- Most nursing home antibiotic stewardship programs moderately or highly comprehensive
- Increased antibiotic stewardship policy implementation following regulation changes
- More infection preventionists trained in infection control; gaps remain
- Infection control-trained staff needed for comprehensive antibiotic stewardship
- Quality Innovation Networks-Quality Improvements Organizations have positive impact

Table 1:

Policies included in Antibiotic Stewardship Programs (n = 861, weighted n = 14865)

	Overall	Not Comprehensive 25.6%	Moderately Comprehensive 41.1%	Comprehensive 33.2%
Policy, % (SE)				
Collect data on antibiotic use	91.4 (1.0)	74.2 (3.3)	95.3 (1.2)	100.0 (0.0)
Use antibiotic prescribing guidelines or therapeutic formularies	65.7 (1.8)	30.2 (3.5)	60.8 (2.9)	99.1 (0.5)
Restrict use of specific antibiotics	19.0 (1.5)	2.7 (1.2)	0.7 (1.6)	45.1 (3.2)
Communicate antibiotic use information when residents are transferred	71.3 (1.7)	36.6 (3.7)	71.4 (2.6)	97.9 (0.8)
Review cases to assess appropriateness of antibiotic administration and/or indication	80.7 (1.5)	45.4 (3.8)	87.4 (1.9)	99.7 (0.2)
Provide feedback to clinicians on antibiotic use and prescribing	68.9 (1.8)	24.0 (3.2)	72.6 (2.6)	99.0 (0.5)
Provide education resources for improving antibiotic use	63.2 (1.8)	21.5 (3.1)	60.9 (2.9)	98.4 (0.8)

Note: Weighted frequencies and percentages. “Not comprehensive” was 0–3 policies; “moderately comprehensive” was 4–5 policies; “comprehensive” was 6+ policies.

Table 2:

Nursing Home Characteristics by Antibiotic Stewardship Program Policy Comprehensiveness

	Total	Not Comprehensive	Moderately Comprehensive	Comprehensive	
Facility Characteristics, % (SE)					***P***
Participation in QIN-QIO activities	36.9 (1.8)	25.9 (3.3)	34.8 (2.7)	48.1 (3.2)	<.01
Region					
Northeast	17.5 (1.3)	13.6 (2.3)	17.5 (2.0)	20.4 (2.4)	0.12
Midwest	35.4 (1.8)	32.2 (3.5)	39.9 (2.9)	32.2 (3.0)	0.11
South	33.9 (1.9)	43.8 (3.8)	30.4 (2.8)	30.7 (3.1)	<.01
West	13.3 (1.3)	10.4 (2.1)	12.2 (1.9)	16.8 (2.5)	0.12
Located in a metropolitan county	71.2 (1.7)	62.3 (3.6)	75.1 (2.5)	73.3 (2.8)	<.01
For profit	69.5 (1.6)	73.6 (3.0)	64.4 (2.7)	72.7 (2.7)	0.03
Member of chain	56.1 (1.9)	56.6 (3.8)	58.2 (2.9)	53.2 (3.2)	0.51
Bed count >100	51.2 (1.9)	49.5 (3.8)	49.0 (2.9)	55.2 (3.2)	0.32
Occupancy Rate >75%	68.3 (1.8)	56.5 (3.8)	71.8 (2.6)	73.1 (2.9)	<.01
Percent Medicaid, mean (SE)	58.5 (0.9)	62.5 (1.7)	55.2 (1.4)	59.5 (1.3)	0.23
Percent Medicare, mean (SE)	13.6 (0.5)	13.4 (1.1)	14.3 (0.8)	12.8 (0.6)	0.53
Staffing Characteristics, % (SE)					
Director of nursing turnover (≥ 3 in past 3 years)	29.4 (1.7)	35.4 (3.6)	29.4 (2.7)	24.8 (2.8)	0.07
Administrator turnover (≥ 3 in past 3 years)	20.2 (1.5)	25.0 (3.3)	20.0 (2.4)	16.6 (2.3)	0.10
IP turnover (≥ 3 in past 3 years)	24.6 (1.6)	32.3 (3.5)	23.5 (2.8)	20.2 (2.6)	0.02
IP certified in infection control	7.6 (1.0)	2.8 (1.4)	7.8 (1.5)	10.9 (2.0)	0.01
IP state or professional organization training	35.8 (1.8)	27.8 (3.4)	37.0 (2.8)	40.6 (3.1)	0.02
Other infection control training	10.5 (1.2)	7.4 (2.0)	10.0 (1.8)	13.6 (3.2)	<.01
No specific infection control training	46.1 (1.9)	62.0 (3.7)	45.2 (2.9)	34.9 (3.2)	<.01
Pharmacist on-site	43.3 (1.9)	35.0 (3.6)	45.2 (2.9)	47.3 (3.2)	0.03
APRN/PA on-site	67.4 (1.8)	58.6 (3.7)	70.1 (2.7)	70.8 (3.0)	0.02

Note: Weighted frequencies and percentages. “Not comprehensive” was 0–3 policies; “moderately comprehensive” was 4–5 policies; “comprehensive” was 6+ policies.

QIN-QIO, Quality Innovation Network-Quality Improvement Organizations; *ASP*, antibiotic stewardship program; *IP*, infection preventionist; *APRN*, advanced practice registered nurse; *PA*, physician assistant

Table 3:

Multinomial Estimates of Nursing Home Characteristics by Antibiotic Stewardship Program Policy Comprehensiveness

	Moderately Comprehensive OR (95% CI)	Comprehensive OR (95% CI)
Facility Characteristics		
Participation in QIN-QIO activities	1.13 (0.714, 1.793)	1.94 (1.215, 3.090)
Region		
Northeast	reference	reference
Midwest	1.52 (0.819, 2.831)	1.21 (0.620, 2.363)
South	0.74 (0.413, 1.335)	0.70 (0.377, 1.296)
West	1.21 (0.573, 2.563)	1.66 (0.764, 3.588)
Located in a metropolitan county	1.63 (1.030, 2.585)	1.25 (0.754, 2.058)
For profit	0.94 (0.594, 1.487)	1.38 (0.838, 2.269)
Member of chain	1.24 (0.811, 1.881)	1.63 (1.030, 2.585)
Bed count >100	1.00 (0.628, 1.586)	0.94 (0.594, 1.487)
Occupancy Rate >75%	1.82 (1.180, 2.808)	1.77 (1.103, 2.849)
Percent Medicaid	0.99 (0.972, 0.998)	0.99 (0.975, 1.004)
Percent Medicare	0.99 (0.972, 1.013)	0.99 (0.965, 1.008)
Staffing Characteristics		
Director of nursing turnover (≥ 3 in past 3 years)	0.94 (0.593, 1.494)	0.83 (0.492, 1.411)
Administrator turnover (≥ 3 in past 3 years)	0.92 (0.568, 1.504)	0.81 (0.474, 1.396)
IP turnover (≥ 3 in past 3 years)	0.69 (0.421, 1.131)	0.59 (0.348, 1.017)
IP certified in infection control	3.40 (0.975, 11.87)	4.89 (1.412, 16.91)
IP state or professional organization training	1.68 (1.051, 2.677)	2.07 (1.275, 3.355)
Other infection control training	1.79 (0.852, 3.749)	3.04 (1.371, 6.740)
No specific infection control training	reference	reference
Pharmacist on-site	1.36 (0.883, 2.091)	1.28 (0.813, 2.009)
APRN/PA on-site	1.43 (0.901, 2.264)	1.57 (0.942, 2.612)

Note: “Not comprehensive” was the reference group.

QIN-QIO, Quality Innovation Network-Quality Improvement Organizations; *IP*, infection preventionist; *APRN*, advanced practice registered nurse; *PA*, Physician Assistant.