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BRIEF REPORT

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Antibiotic Prescribing in United States Nursing Homes, 2013–2017

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In this national cohort of older adults residing long-term in US nursing homes between 2013 and 2017, we calculated period prevalence estimates for antibiotic prescribing, rates of prescribing, and days of therapy. Among 1 375 062 residents, 66.2% were prescribed at least 1 antibiotic during the nursing home stay. The most prevalent antibiotic classes were fluoroquinolones, sulfonamides and related agents, and first-generation cephalosporins. Levofloxacin, ciprofloxacin, and sulfamethoxazole-trimethoprim were the most prevalent antibiotics. These results can inform antibiotic stewardship interventions to reduce antibiotic overprescribing, improve appropriateness, and reduce related adverse outcomes in nursing homes.

Keywords. antibacterial agents; Medicare; nursing homes; older adults.

Combating antibiotic resistance and promoting antibiotic stewardship are national public health priorities [1]. Improvements to antibiotic use are especially needed among nursing home (NH) residents. Antibiotics are among the most frequently prescribed medications in NHs [2–4], up to 85% of antibiotics are inappropriate or unnecessary [5], and NH residents are particularly vulnerable to adverse outcomes resulting from antibiotic use. Importantly, antibiotic-related adverse outcomes include the development of antibiotic-resistant infections, such as *Clostridioides difficile* infection, which not only affect residents who are prescribed antibiotics, but can be transmitted to other residents in the NH facility. Several factors contribute to antibiotic resistance and adverse effects, including overprescribing when no antibiotics are indicated, use of broad-spectrum antibiotics that carry a high risk of infection with *C difficile* or multidrug-resistant organisms rather than lower-risk alternatives, and unnecessarily long durations of therapy [6, 7]. National estimates of the most prevalent antibiotics and days of antibiotic therapy for residents in United States (US) NHs are important to inform future research efforts, antibiotic stewardship interventions, and policies aimed at reducing inappropriate antibiotic prescribing. Yet, prior studies have not included longitudinal data, are not representative of all US NHs, or have focused only on specific types of infections.

Our objectives were to calculate the period prevalence of antibiotic use, rate of antibiotic prescribing, and antibiotic days of therapy (DOT) among >1 million US long-stay NH residents. Based on prior studies [2, 8], we hypothesized that fluoroquinolones, first-generation cephalosporins, and penicillins would be the most prevalent antibiotic classes.

METHODS

Data Sources

We linked Minimum Data Set (MDS) version 3.0 assessments with Medicare data. The MDS is a standardized government-mandated clinical assessment that records health information such as clinical conditions, functional status, and cognitive status for residents in NHs certified by the Centers for Medicare and Medicaid Services (CMS). The Medicare Beneficiary Summary File contained demographic and plan enrollment information. Medicare Part D claims contained antibiotic drug dispensing data. The study received institutional review board approval. Informed consent was not required.

Study Design and Study Population

We designed this longitudinal retrospective cohort to generalize to a target population of older Medicare beneficiaries residing long-term in US NHs between 2013 and 2017. Eligible participants were long-stay NH residents enrolled in Medicare Part D between 1 January 2013 and 31 December 2017. Long-stay NH residents had at least 101 days in any NH. For residents with >1 long-stay episode during the study period, we randomly sampled 1 episode per person. We only included long-stay NH residents because prescription drug dispensings are unobservable in Part D claims during short-term post–acute care. Residents aged <65 years at NH admission or missing key demographic or clinical characteristics were excluded. To begin follow-up at a consistent point during the NH stay, individuals whose 101st day in the NH was prior to 1 January 2013 were also excluded. Residents were followed

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from day 101 in the NH until NH discharge, death, or end of the study period, whichever occurred first.

Resident Characteristics

Demographics (age, sex, and race/ethnicity) were obtained from the Medicare Beneficiary Summary File. We reported the length of NH stay based on the validated Residential History File. Clinical characteristics of interest were obtained from the MDS and included multimorbidity based on the Charlson Comorbidity Index; functional status based on the Morris 28-point scale of independence in activities of daily living; health instability based on the Changes in Health, End-Stage Disease, and Symptoms and Signs score; diagnosis of Alzheimer disease and related dementias; and cognitive function based on the Cognitive Function Scale (Supplementary Table 1).

Statistical Methods

We calculated period prevalence estimates to assess any use (yes/no) of antibiotics during long-stay NH episodes, by antibiotic class (Supplementary Table 2) and the top 20 antibiotics prescribed. Only antibiotics administered via oral or injectable (eg, intravenous, intramuscular) routes were considered in analyses. To account for differences in person-time contributed by residents, we also calculated rates of prescribing based on the number of residents prescribed antibiotics per 1000 person-years. Finally, we reported DOTs per 1000 days of care to estimate the length of exposure to antibiotics during long-stay NH episodes. We used normal approximation and a Poisson distribution to compute 99% confidence limits (CLs). Antibiotic DOTs were calculated as the sum of antibiotic days, where 1 day of receiving a single antibiotic counted as an antibiotic day. If residents received multiple antibiotics on the same day, we totaled the days for each antibiotic. For example, if a resident received 2 antibiotics on the same day, there would be 2 DOTs. Data were analyzed using SAS version 9.4 (SAS Institute, Cary, North Carolina) and Stata version 17 (StataCorp LLC, College Station, Texas).

RESULTS

Study Population

The study population included 1 375 062 long-stay NH residents who contributed 2 349 937 person-years of follow-up time, 465 018 (33.8%) residents with no antibiotic prescribing, and 910 044 (66.2%) with at least 1 antibiotic prescribed during the long-stay episode (Supplementary Figure 1). Overall, 925 843 (67.3%) residents were female, 1 107 275 (80.5%) were non-Hispanic White, and the mean age was 82.4 (standard deviation [SD], 8.4) years (Supplementary Table 3). Residents with at least 1 antibiotic prescribed were slightly older (mean age, 82.6 [SD, 8.3] vs 81.9 [SD, 8.5] years), and a greater proportion were female (69.1% vs 64.0%), were non-Hispanic White (82.3% vs 77.1%), and had longer NH stays (mean, 712.3 [SD, 620.9] vs 451.7 [SD, 567.8] days) compared to residents with no antibiotic prescribing. Multimorbidity, diagnosis of Alzheimer disease and related dementias, functional status, health instability, and cognitive function were similar across groups (Supplementary Table 3).

Prevalence and Rate of Antibiotic Prescribing

Between 2013 and 2017, the median (quartile 1 [Q1], quartile 3 [Q3]) number of antibiotic dispensings per resident was 2 (0, 5) and residents received 10 (0, 27) DOTs. The overall rate of antibiotic prescribing was 387 residents per 1000 person-years and rate of DOTs was 41.6 days per 1000 days of care.

The most prevalent antibiotic classes prescribed to long-stay NH residents were fluoroquinolones (36.2% [99% CL, 36.1%, 36.2%]), sulfonamides and related agents (16.2% [99% CL, 16.1%, 16.3%]), and first-generation cephalosporins (15.9% [99% CL, 15.9%, 16.0%]) (Table 1). Levofloxacin (22.1% [99% CL, 22.0%, 22.2%]), ciprofloxacin (19.4% [99% CL, 19.3%, 19.4%]), and sulfamethoxazole-trimethoprim (15.9% [99% CL, 15.8%, 16.0%]) were the most prevalent antibiotics (Table 2). The most prevalent antibiotic classes and medications also had the highest rates of residents prescribed per 1000 person-years (Tables 1 and 2). Antibiotic classes with the highest rates of DOTs included fluoroquinolones (8.3 [99% CL, 8.2, 8.3] days per 1000 days of care), sulfonamides and related agents (6.0 [99% CL, 6.0, 6.0] days per 1000 days of care), and first-generation cephalosporins (4.3 [99% CL, 4.3, 4.3] days per 1000 days of care) (Table 1), while the antibiotics with the highest rate of DOTs included nitrofurantoin (5.5 [99% CL, 5.4, 5.5] days per 1000 days of care), sulfamethoxazole-trimethoprim (4.7 [99% CL, 4.7, 4.7] days per 1000 days of care), and levofloxacin (4.2 [99% CL, 4.2, 4.2] days per 1000 days of care) (Table 2). Among the top 20 antibiotics, the median length of antibiotic dispensings ranged from 3 days to 7 days (Supplementary Table 4).

DISCUSSION

In this retrospective cohort, two-thirds of long-stay residents in US NHs were prescribed antibiotics between 2013 and 2017. The most prevalent antibiotic classes prescribed to long-stay residents were fluoroquinolones, sulfonamides and related agents, and first-generation cephalosporins, which are commonly used to treat urinary tract infections (UTIs) and pneumonia in NHs. Interestingly, the top antibiotics differed based on the measure selected, prevalence versus rate of antibiotic DOTs. Our nationally representative results provide important foundational evidence on antibiotic prescribing in US NHs and can inform future research, antibiotics stewardship initiatives, and policies to improve prescribing practices.

Table 1. Antibiotic Classes Prescribed to Long-Stay Nursing Home Residents With Medicare Part D Coverage, 2013–2017

	N = 1 375 062 Residents		
Antibiotic Class/Medication	Residents Prescribed, No. (% [99% CLs])	Residents Prescribed per 1000 PY (99% CLs)	Antibiotic DOT per 1000 Days of Care (99% CLs)
Fluoroquinolones	497 133 (36.2 [36.1, 36.2])	212 (211, 212)	8.3 (8.2, 8.3)
Sulfonamides and related agents	222 611 (16.2 [16.1, 16.3])	95 (94, 95)	6.0 (6.0, 6.0)
First-generation cephalosporins	219 115 (15.9 [15.9, 16.0])	93 (93, 94)	4.3 (4.3, 4.3)
Macrolides	187 376 (13.6 [13.6, 13.7])	80 (79, 80)	2.0 (2.0, 2.0)
Third-generation cephalosporins	175 484 (12.8 [12.7, 12.8])	75 (74, 75)	1.8 (1.8, 1.8)
Nitrofurantoin	170 071 (12.4 [12.3, 12.4])	72 (72, 73)	5.5 (5.4, 5.5)
Penicillins + β-lactamase inhibitors	162 132 (11.8 [11.7, 11.9])	69 (69, 69)	2.3 (2.3, 2.3)
Tetracyclines	149 836 (10.9 [10.8, 11.0])	64 (63, 64)	4.2 (4.2, 4.2)
Penicillins	128 992 (9.4 [9.3, 9.4])	55 (55, 55)	1.9 (1.9, 1.9)
Second-generation cephalosporins	70 771 (5.1 [5.1, 5.2])	30 (30, 30)	1.0 (1.0, 1.0)
Metronidazole	63 474 (4.6 [4.6, 4.7])	27 (27, 27)	1.2 (1.2, 1.2)
Lincosamides	55 853 (4.1 [4.0, 4.1])	24 (24, 24)	0.8 (.7, .8)
IV glycopeptide and lipoglycopeptides	41 763 (3.0 [3.0, 3.0])	18 (18, 18)	1.2 (1.2, 1.2)
Other β-lactams ± β-lactamase inhibitors[a]	31 455 (2.3 [2.3, 2.3])	13 (13, 14)	0.4 (.4, .4)
Aminoglycosides	22 701 (1.7 [1.6, 1.7])	10 (10, 10)	0.3 (.3, .3)
Oxazolidinones	11 382 (0.8 [.8, .8])	5 (5, 5)	0.2 (.2, .2)
Fourth-generation cephalosporins	11 081 (0.8 [.8, .8])	5 (5, 5)	0.1 (.1, .1)
Oral vancomycin	8037 (0.6 [.6, .6])	3 (3, 4)	0.2 (.2, .2)
Fosfomycin	4294 (0.3 [.3, .3])	2 (2, 2)	0.1 (.1, .1)
Other antibiotics[a]	2988 (0.2 [.2, .2])	1 (1, 1)	0.1 (.1, .1)

Antibiotic classes are presented in descending order based on prescribing prevalence. Residents contributed 2 349 937 PY of follow-up time.

Abbreviations: CLs, confidence limits; DOT, days of therapy; IV, intravenous; PY, person-years.

[a]Supplementary Table 2 lists antibiotics included in each class.

Table 2. Top 20 Antibiotics Prescribed to Long-Stay Nursing Home Residents With Medicare Part D Coverage, 2013–2017

		N = 1 375 062 Residents		
Rank	Antibiotic	Residents Prescribed, No. (% [99% CLs])	Residents Prescribed per 1000 PY (99% CLs)	Antibiotic DOT per 1000 Days of Care (99% CLs)
1	Levofloxacin	303 845 (22.1 [22.0, 22.2])	129 (129, 130)	4.2 (4.2, 4.2)
2	Ciprofloxacin	266 110 (19.4 [19.3, 19.4])	113 (113, 114)	3.8 (3.8, 3.9)
3	Sulfamethoxazole-trimethoprim	218 380 (15.9 [15.8, 16.0])	93 (92, 93)	4.7 (4.7, 4.7)
4	Cephalexin	214 067 (15.6 [15.5, 15.6])	91 (91, 92)	4.2 (4.2, 4.2)
5	Azithromycin	181 095 (13.2 [13.1, 13.2])	77 (77, 78)	1.7 (1.7, 1.7)
6	Nitrofurantoin	170 071 (12.4 [12.3, 12.4])	72 (72, 73)	5.5 (5.4, 5.5)
7	Amoxicillin-clavulanate	151 771 (11.0 [11.0, 11.0])	65 (64, 65)	2.1 (2.1, 2.1)
8	Doxycycline	140 080 (10.2 [10.1, 10.3])	60 (59, 60)	3.3 (3.3, 3.3)
9	Ceftriaxone	133 881 (9.7 [9.7, 9.8])	57 (57, 57)	1.1 (1.1, 1.1)
10	Amoxicillin	98 623 (7.2 [7.1, 7.2])	42 (42, 42)	1.3 (1.3, 1.3)
11	Cefuroxime	68 087 (5.0 [4.9, 5.0])	29 (29, 29)	0.9 (.9, .9)
12	Metronidazole	63 474 (4.6 [4.6, 4.7])	27 (27, 27)	1.2 (1.2, 1.2)
13	Clindamycin	55 742 (4.1 [4.0, 4.1])	24 (24, 24)	0.8 (.7, .8)
14	IV vancomycin	41 751 (3.0 [3.0, 3.1])	18 (18, 18)	1.2 (1.2, 1.2)
15	Cefdinir	35 533 (2.6 [2.5, 2.6])	15 (15, 15)	0.5 (.5, .5)
16	Ampicillin	27 860 (2.0 [2.0, 2.1])	12 (12, 12)	0.4 (.4, .4)
17	Moxifloxacin	19 721 (1.4 [1.4, 1.5])	8 (8, 9)	0.2 (.2, .2)
18	Ertapenem	18 326 (1.3 [1.3, 1.4])	8 (8, 8)	0.2 (.2, .2)
19	Cefpodoxime	15 532 (1.1 [1.1, 1.2])	7 (7, 7)	0.2 (.2, .2)
20	Gentamicin	15 428 (1.1 [1.1, 1.1])	7 (6, 7)	0.2 (.2, .2)

Residents contributed 2 349 937 PY of follow-up time.

Abbreviations: CLs, confidence limits; DOT, days of therapy; IV, intravenous; PY, person-years.

Most previous studies examining antimicrobial prescribing in US NHs used cross-sectional data. These studies reported that antimicrobial use based on 1-day point prevalence surveys ranged from 7% to 11% [2–4, 9, 10], prevalence across NH stays ranged from 49% to 79% [11], and rate of DOTs ranged from 30 to 530 DOT per 1000 days of care [8, 9, 11], though the study populations, methods for data collection, and medications included in analyses differed. Using longitudinal data, our study overcomes the limitations of others using cross-sectional data, which may not capture antibiotic use over time. This study also reports national estimates of antibiotic prescribing among US NH residents with Medicare Part D and may be more representative than studies conducted in a limited number of states or NHs.

Similar to past studies, we found that fluoroquinolones, first-generation cephalosporins, and combinations of sulfonamides and trimethoprim-including derivatives were among the most prevalent antibiotic classes [2–4, 8–11]. However, the top antibiotics differed based on prescribing prevalence and rate of antibiotic DOTs. For example, nitrofurantoin was the sixth most prevalent antibiotic prescribed, but had the highest rate of DOTs. Prescribing multiple courses (eg, for separate infections) or longer courses of antibiotics (eg, for long-term infection prophylaxis) during a resident's NH stay would increase the rate of DOTs, but not prescribing prevalence. Indeed, dispensings for nitrofurantoin were slightly longer (median [Q1, Q3] days' supply of 7 [5, 14] days) compared to levofloxacin or ciprofloxacin (7 [2, 7] days), cephalexin (7 [3, 10] days), or sulfamethoxazole-trimethoprim (7 [5, 10] days), although the proportion of residents with 2 or more dispensings of nitrofurantoin (6.1%) was lower than for other antibiotics (levofloxacin 11.0%, ciprofloxacin 9.2%, cephalexin 7.5%, sulfonamides 7.4%). By reporting multiple estimates of antibiotic prescribing, including prevalence, rate of prescribing, and rate of DOTs, this study provides more detailed information that can inform future antibiotic stewardship efforts.

Evidence related to antibiotic stewardship programs in NHs leaves significant room for improvement [12]. A majority of studies have focused on UTI, overlooking other infections where antibiotics are commonly prescribed. Furthermore, antibiotic stewardship programs are often difficult to sustain in NHs due to limited resources and other complicating factors (eg, staff turnover, medical complexity of residents) [13]. Thus, interventions that focus on improving prescribing for a smaller number of antibiotic classes may improve the treatment of more infections than those focused on just UTI, but may be more feasible than interventions that include all antibiotic classes. Stewardship programs that target antibiotics with the highest prevalence could improve care for a large number of residents because most antibiotic prescribing in NHs is estimated to be inappropriate or unnecessary [5]. Another potential approach is to focus on antibiotic classes with the highest DOTs. Excessive duration of exposure to antibiotics (ie, through prolonged antibiotic courses or unnecessary long-term prophylaxis) can increase the likelihood of colonization with resistant organisms, transmission to other residents within the facility, and ultimately greater morbidity, mortality, and healthcare costs [14]. A third potential approach is to target prescribing for antibiotics that carry a high risk of infection with *C difficile* or multidrug-resistant organisms, including fluoroquinolones, third- and fourth-generation cephalosporins, β-lactam/β-lactamase inhibitor combinations, lincosamides, and carbapenems [2, 7]. Improving the appropriateness of prescribing for these classes could reduce the serious adverse outcomes associated with *C difficile* infections and multidrug-resistant organisms including mortality, prolonged hospitalizations, and higher healthcare costs [15]. Additional research is needed to better understand if one of these strategies should be a preferred approach, considering intervention efficacy, cost-effectiveness, the potential for sustainability in practice, and differences in NHs' resources, prescribing practices, and resistance profiles/antibiograms.

Limitations

This study has several potential limitations. First, due to the nature of our administrative data, information on antibiotic indications, sites of infection, test results (eg, vital signs, culture and sensitivity, imaging), and medication administration records were not available. We also did not distinguish dispensings as new antibiotic starts or continuation of therapy (eg, for prophylaxis). Such information is important for future research examining the appropriateness of antibiotic prescribing in NHs. Second, results may not generalize to NH residents without Medicare Part D or receiving short-term postacute care. Third, results do not account for potential changes in NH antibiotic prescribing after 2017 (eg, following the CMS Infection Prevention and Control Program regulations or the coronavirus disease 2019 pandemic).

In summary, the period prevalence of antibiotic prescribing in US NHs was 66.2% between 2013 and 2017. Results from this study can inform future antibiotic stewardship interventions to reduce antibiotic overprescribing, improve appropriateness, and reduce related adverse outcomes in NHs.

Supplementary Data

Supplementary materials are available at *The Journal of Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Notes

Data availability. Data were obtained through a data use agreement with the Centers for Medicare and Medicaid Services (CMS) and therefore cannot be shared by the authors. However, other researchers can establish their own data use agreement and obtain the datasets employed through the Research Data Assistance Center (ResDAC), a CMS contractor that provides free assistance to researchers interested in CMS data.

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All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

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