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Antimicrobial Use in a Cohort of US Nursing Homes, 2017

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IMPORTANCE Controlling antimicrobial resistance in health care is a public health priority, although data describing antimicrobial use in US nursing homes are limited.

OBJECTIVE To measure the prevalence of antimicrobial use and describe antimicrobial classes and common indications among nursing home residents.

DESIGN, SETTING, AND PARTICIPANTS Cross-sectional, 1-day point-prevalence surveys of antimicrobial use performed between April 2017 and October 2017, last survey date October 31, 2017, and including 15 276 residents present on the survey date in 161 randomly selected nursing homes from selected counties of 10 Emerging Infections Program (EIP) states. EIP staff reviewed nursing home records to collect data on characteristics of residents and antimicrobials administered at the time of the survey. Nursing home characteristics were obtained from nursing home staff and the Nursing Home Compare website.

EXPOSURES Residence in one of the participating nursing homes at the time of the survey.

MAIN OUTCOMES AND MEASURES Prevalence of antimicrobial use per 100 residents, defined as the number of residents receiving antimicrobial drugs at the time of the survey divided by the total number of surveyed residents. Multivariable logistic regression modeling of antimicrobial use and percentages of drugs within various classifications.

RESULTS Among 15 276 nursing home residents included in the study (mean [SD] age, 77.6 [13.7] years; 9475 [62%] women), complete prevalence data were available for 96.8%. The overall antimicrobial use prevalence was 8.2 per 100 residents (95% CI, 7.8-8.8). Antimicrobial use was more prevalent in residents admitted to the nursing home within 30 days before the survey date (18.8 per 100 residents; 95% CI, 17.4-20.3), with central venous catheters (62.8 per 100 residents; 95% CI, 56.9-68.3) or with indwelling urinary catheters (19.1 per 100 residents; 95% CI, 16.4-22.0). Antimicrobials were most often used to treat active infections (77% [95% CI, 74.8%-79.2%]) and primarily for urinary tract infections (28.1% [95% CI, 15.5%-30.7%]). While 18.2% (95% CI, 16.1%-20.1%) were for medical prophylaxis, most often use was for the urinary tract (40.8% [95% CI, 34.8%-47.1%]). Fluoroquinolones were the most common antimicrobial class (12.9% [95% CI, 11.3%-14.8%]), and 33.1% (95% CI, 30.7%-35.6%) of antimicrobials used were broad-spectrum antibiotics.

CONCLUSIONS AND RELEVANCE In this cross-sectional survey of a cohort of US nursing homes in 2017, prevalence of antimicrobial use was 8.2 per 100 residents. This study provides information on the patterns of antimicrobial use among these nursing home residents.

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Supplemental content

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The control and prevention of antimicrobial resistance infections is a public health priority[1-6] Due to a confluence of risks for colonization or infection with antimicrobial-resistant organisms among residents, nursing homes are a potential reservoir for antimicrobial resistance.[7,8] Traditional long-term residential care is provided alongside a growing number of residents admitted for short-term postacute care encompassing skilled nursing, rehabilitation, wound care, and invasive medical devices.[8-11] There is a recognized need for evidence-based nursing home-focused antimicrobial stewardship policies.

In response to the National Action Plan for Combating Antibiotic-resistant Bacteria goal to improve antibiotic stewardship in health care to slow the emergence of resistant bacteria,[4,5] federal efforts aim to strengthen US nursing homes' infection prevention- and antibiotic stewardship-infrastructure and policies. These efforts include a framework promulgated by the Centers for Disease Control and Prevention (CDC) to identify and implement antibiotic stewardship practices[12] and the Centers for Medicare & Medicaid Services (CMS) requirement that nursing homes develop an antibiotic stewardship program.[13]

The effect of these initiatives on the use of antimicrobials in nursing homes remains largely unknown. There is no national surveillance infrastructure to report nursing home antimicrobial use data, and because nursing homes typically do not have on-site pharmacies,[14] obtaining antimicrobial use data sets is challenging. Antimicrobial stewardship activities coupled with measurement of antimicrobial use[2-4] is necessary for effective prevention of antimicrobial resistance in nursing homes. Prevalence surveys are useful for generating data about the essential measures of antimicrobial use frequency and descriptive epidemiology in health care settings.[15] A point-prevalence survey was conducted to estimate the prevalence and describe the epidemiology of antimicrobial use in US nursing homes.

Key Points

Question How often and which types of antimicrobials were used among US nursing home residents in 2017?

Findings In this cross-sectional survey that included 15 276 residents of 161 nursing homes, the point prevalence of antimicrobial use was 8.2 per 100 nursing home residents. The most common indication was treatment or prevention of urinary tract infection (29%), and 33% were broad-spectrum antibiotics.

Meaning This study provides information on prevalence and patterns of antimicrobial use in a cohort of nursing homes in 2017.

Methods

In 2017, the CDC and the Emerging Infections Program (EIP)[16]—a network of 10 state health departments in California, Colorado, Connecticut, Georgia, Maryland, Minnesota, New Mexico, New York, Oregon, and Tennessee, and their academic partners—performed a multisite point-prevalence survey in nursing homes. The CDC National Center for Emerging Zoonotic and Infectious Diseases human subjects advisor determined the prevalence survey to be a public health surveillance activity. Participating EIP state health departments or academic partners submitted the prevalence survey protocol in accordance with their local human subjects research requirements or determined it was not human subjects research, with individual informed consent not required.

Nursing Homes and Residents

Each EIP site determined their nursing home recruitment areas using county or state geographic boundaries. A list of the CMS-certified nursing homes in recruitment areas were created by CDC staff using data from the CMS Nursing Home Compare website.[17] EIP staff contacted facilities in random order to provide information about the prevalence survey and request voluntary participation. Nursing homes were contacted up to 10 times. If no participation decision was obtained after the tenth contact attempt, the nursing home was classified as a nonresponder.

All survey dates occurred on Monday through Friday between April 2017 and October 2017 (to limit the effect of seasonal influenza), with the last survey date on October 31 and included all residents of the nursing home at 8:00 AM on the survey date. Newly admitted residents (admission on the same day or day before the survey date) were excluded.

Data Collection

Standardized data collection forms with detailed form instructions were used and developed with input from investigators for the European Centre for Disease Prevention and Control (ECDC) Long-term Care Prevalence Survey Team and informed by a CDC pilot prevalence survey.[18]

In each nursing home, a staff member served as the prevalence survey coordinator, and this role was typically filled by the infection prevention and control lead, director of nursing, or medical director. This individual completed a short, self-guided learning module on prevalence survey objectives, timeline, procedures, and responsibilities, and also completed a facility assessment survey on facility characteristics and resident services provided. Additional data about facility characteristics was obtained from Nursing Home Compare by CDC staff.[17]

Trained EIP staff completed all remaining data collection for each eligible resident by reviewing the nursing home written or electronic documentation and medical records. Data collected from medical records included resident admission date, age, race/ethnicity (using fixed categories), and basic clinical data representing each resident's status at the time of the survey. EIP staff determined if each eligible resident received or was scheduled to receive a systemic antimicrobial on the survey date or day before using medical and medication administration records. Systemic was defined as administration via the oral/enteral (including gastrostomy, nasogastric or orogastric, jejunostomy, or gastrojejunal tubes), intramuscular, intravenous, or inhalation route. The World Health Organization Anatomic Therapeutic Chemical (ATC) classification system[19] was used to categorize eligible antimicrobials, which

were primarily antibacterials (J01), antimycotics (J02), antibiotics used for tuberculosis (J04AB), or antivirals (J05) sourced from and available in the United States.

For residents who received a systemic antimicrobial drug at the time of the survey, EIP staff completed a second form to collect data on the antimicrobial name(s), route of administration, site of infection, rationale for use, and the date the drug was first administered in the nursing home. Antimicrobials were considered unique at the drug and route combination. If a drug was known to be started before nursing home admission, the first date of drug use was recorded as the nursing home admission date. Rationale was categorized as either treatment of active infection including empirical treatment of suspected infections, medical prophylaxis including antimicrobials given for nonsurgical procedures (eg, dental procedures) to prevent an infection, surgical prophylaxis, or noninfectious (eg, rifaximin for hepatic encephalopathy). The classification for site of infection and rationale were based solely on nursing home staff documentation present in the medical record; no infection definition or prescribing appropriateness criteria were applied. More than 1 site of infection could be entered per drug-route combination.

Sample Size

Using pilot data,[20] an estimated antimicrobial use prevalence of 11%, ±0.5% margin of error, and a 95% CI, the desirable minimum sample size was 15 000 nursing home residents. Using equal allocation, each EIP site was asked to recruit enough nursing homes to achieve a minimum of 1500 residents or a maximum of 20 nursing homes as a practical end point.

Data Analysis

All data were entered into a CDC-developed, web-based database by EIP staff and imported into SAS software version 9.4 (SAS Institute) for analysis. Summary statistics for nursing homes (eg, number of beds and residents, location, ownership, certification, CMS 5-star quality measures) and resident characteristics were calculated. The frequency of missing values was reported, and missing values were not imputed. The antimicrobial use prevalence per 100 residents was calculated using the number of residents receiving at least 1 eligible systemic antimicrobial agent divided by all eligible residents included in the survey then multiplied by 100; the 95% CI was generated using the Fisher exact method. To identify facility or resident characteristics associated with resident-level antimicrobial use, logistic regression modeling with receipt of an antimicrobial (yes/no) as the binary outcome was used. Each independent variable was evaluated to determine whether there was a significant association with antimicrobial use. All clinically relevant variables with *P* values less than .20 in bivariable analyses were included in a multivariate model. Variables were sequentially removed by level of significance to identify the most-parsimonious and best-fitting final model where all variables reached the *P* value less than .05 threshold using the Wald χ^2 test statistic. Variables were retained in the final model if the *P* value was less than .05; all *P* values were 2-sided. The fit of various models was compared using the quasi Akaike information criterion (QAIC) with smaller values indicating better fit. Modeling accounted for potential clustering (nonindependence) at the nursing home and EIP site (state) level, and collinearity among variables was assessed using the variance inflation factor (VIF) with a VIF of greater than 5 for a variable considered evidence of collinearity. Pearson and deviance residuals were plotted to identify outlier or influential datapoints. Percentages were used to describe the frequency of the types of antimicrobials used, including by route, rationale, site of infection, ATC classifications, and broad-spectrum antibiotics, defined as fluoroquinolones, third- or fourth-generation cephalosporins, β-lactam/β-lactamase inhibitor combinations, and carbapenems.

Results

Nursing Homes and Residents

Of the 1089 nursing homes within the 10 EIP recruitment areas, 321 were contacted, of which 9 did not meet eligibility criteria, 90 declined, 47 did not respond, and 175 agreed to participate (55% participation rate). Fourteen nursing homes that initially agreed to participate subsequently declined, leaving 161 that completed the prevalence survey. As reported elsewhere,[21] nursing homes that participated were similar to nursing homes nationally in CMS Nursing Home Compare, except that nursing homes included in the survey had more beds and residents and lower health inspection scores. There were 15 276 eligible residents in the 161 participating nursing homes. Resident age ranged from 18 to 108 years with a mean (SD) age of 77.6 (13.7) years, and 62% (95% CI, 61.3%-62.8%) of residents were women; resident characteristics are reported in **Table 1**. Selected resident characteristics (eg, sex, age, race, diabetes status, with or without pressure ulcers) were similar to those of US nursing home residents (eTable 1 in the Supplement).

Antimicrobial Use Prevalence and Multivariable Modeling

A total of 1454 systemic antimicrobial drugs were received by 1258 of the 15 276 residents at the time of the survey; most were receiving 1 antimicrobial (1082; 86.0% [95% CI, 84%-87.9%]), 158 received 2 antimicrobials (12.6%; 95% CI, 10.8%-14.5%), and 18 received 3 or 4 antimicrobials (1.5%; 95% CI, 0.8%-2.3%). The pooled mean antimicrobial use prevalence was 8.2 (95% CI, 7.8-8.7) per 100 nursing home residents. The median nursing home specific prevalence was 8.03 per 100 residents (interquartile range, 4.9-11.2).

Antimicrobial use prevalence did not vary substantially by nursing home characteristics (eTable 2 in the Supplement). At the resident level (Table 1), antimicrobial use prevalence was the highest among short-stay residents admitted for post-acute care, residents recently admitted to the nursing home, and residents with devices. Among residents in the nursing home for 30 days or less, prevalence was higher among the 143 residents admitted 1 or 2 days before the survey date (21.0 per 100 residents; 95% CI, 14.6-28.6) compared with admission 3 to 30 days before the survey date (18.9 per 100 residents; 95% CI, 17.4-20.4) (eTable 3 in the Supplement). Among residents with devices, prevalence was highest for those with a central venous catheter, and most (157 of 182 residents [86.3%]) were

Table 1. Nursing Home Resident Characteristics and Crude Antimicrobial Use Prevalence

Characteristic	No. with characteristic (%)	No. receiving ≥1 antimicrobial	Antimicrobial use prevalence per 100 residents (95% CI)
All residents	15 276 (100)	1258	8.2 (7.8-8.6)
Sex			
Men	5801 (38.0)	557	9.6 (8.9-10.4)
Women	9475 (62.0)	701	7.4 (6.9-7.9)
Age, y[a]	n = 15 274		
<65	2598 (17.0)	307	11.8 (10.6-13.1)
65-74	3107 (20.3)	281	9.0 (8.0-10.1)
75-84	3948 (25.9)	344	8.7 (7.9-9.6)
≥85	5621 (36.8)	326	5.8 (5.2-6.4)
Race/ethnicity[b]	n = 14 809		
Other	598 (4.0)	45	7.5 (5.4-9.6)
Hispanic or Latino	993 (6.7)	84	8.4 (6.7-10.2)
Black non-Hispanic	2105 (14.2)	144	6.84 (5.8-8.0)
White non-Hispanic	11 113 (75.0)	937	8.4 (7.9-9.0)
Diabetes			
Yes	4837 (31.7)	506	10.4 (9.6-11.4)
No	10 439 (68.3)	752	7.2 (6.7-7.7)
Days in nursing home prior to survey			
≤30	2710 (17.7)	514	18.8 (17.4-20.3)
31-99	1979 (13.0)	220	11.1 (9.8-12.7)
100-365	3245 (21.2)	220	6.8 (6.0-7.7)
>365	7342 (48.1)	304	4.1 (3.7-4.6)
Type of resident[c]			
Short stay	2980 (19.5)	530	17.8 (16.4-19.3)
Long stay	12 296 (80.5)	728	5.98 (5.5-6.5)
Receiving dialysis in or outside nursing home			
Yes	343 (2.2)	47	13.7 (10.2-17.8)
No	14 933 (97.8)	1211	8.1 (7.7-8.6)
Dependent on wheelchair or bedridden			
No	7095 (46.4)	610	8.6 (8.0-9.3)
Yes	8181 (53.6)	648	7.9 (7.3-8.5)
Urinary catheter			
Other urinary catheter[d]	265 (1.7)	48	18.1 (13.7-23.3)
Indwelling	802 (5.3)	153	19.1 (16.4-22.0)
None	14 209 (93)	1057	7.4 (7.0-7.9)
Central venous catheter			
Yes	290 (1.9)	182	62.8 (56.9-68.3)
No	14 986 (98.1)	1076	7.2 (6.8-7.6)
Tracheostomy tube			
Yes	238 (1.6)	23	9.7 (6.2-14.2)
No	15 038 (98.4)	1235	8.2 (7.8-8.7)
Ventilator			
Yes	108 (0.7)	16	14.8 (8.7-22.9)
No	15 168 (99.3)	1242	8.2 (7.8-8.6)
Percutaneous endoscopic gastrostomy tube			
Yes	748 (4.9)	66	8.8 (6.9-11.1)
No	14 528 (95.1)	1192	8.2 (7.8-8.7)
Any device use[e]			
Yes	1923 (12.6)	393	20.4 (18.7-22.3)
No	13 353 (87.4)	865	6.5 (6.1 - 6.9)

(continued)

Table 1. Nursing Home Resident Characteristics and Crude Antimicrobial Use Prevalence (continued)

Characteristic	No. with characteristic (%)	No. receiving ≥1 antimicrobial	Antimicrobial use prevalence per 100 residents (95% CI)
Pressure ulcer, any stage or unstageable			
Yes	1120 (7.3)	176	15.7 (13.6-18.0)
No	14 156 (92.7)	1082	7.6 (7.2-8.1)
Receiving wound care			
Yes	2839 (18.6)	455	16.0 (14.7-17.4)
No	12 437 (81.4)	803	6.5 (6.0-6.9)

[a] Age data were missing for 2 (0.01%) residents.

[b] Race and ethnicity was obtained from medical record review with 467 (3.1%) missing. The subcategory *Other* indicates American Indian or Alaska Native, Asian, and Native Hawaiian/other Pacific Islander.

[c] Short stay indicates admitted for postacute, rehabilitation, or skilled nursing care with the goal to improve condition and be discharged. Long stay indicates admitted for assistance with activities of daily living and traditional long-term nursing care with the goal to preserve condition. Categories reflect the resident status on the date of the prevalence survey.

[d] Includes condom catheters, suprapubic catheters, or urostomy/nephrostomy tubes.

[e] Includes urinary catheter, central venous catheter, tracheostomy tube, ventilator, or percutaneous endoscopic gastrostomy tube.

receiving an antimicrobial via the intravenous route. Logistic regression modeling of facility and resident characteristics, adjusted for resident age, race/ethnicity, and diabetes status (**Table 2**), revealed the odds of antimicrobial use to be significantly higher among residents with a central venous catheter (adjusted odds ratio [OR], 11.1 [95% CI, 8.5-14.5]), any urinary catheter (adjusted OR, 2.2 [95% CI, 1.8-2.6]), or receiving wound care (adjusted OR, 1.8 [95% CI, 1.5-2.0]) at the time of the survey. Two facility characteristics remained significant in the multivariable model: the percentage of short-stay residents readmitted to hospital after a nursing home admission (CMS quality measure 521) and nursing home location (metropolitan or not) (Table 2). Collinearity among variables was minimal (all VIF ≤1.8), and no outlying or influential data points were detected.

Route of Administration, Rationale, and Site of Infection

Of 1454 the antimicrobials received, 1169 (80.4% [95% CI, 78.3%-82.4%]) were administered by the oral/enteral route, 251 (17.3% [95% CI, 15.4%-19.3%]) intravenous, and 34 (2.3% [95% CI, 1.6%-3.3%]) were administered via the intramuscular or inhaled route. In total, 1120 (77.0% [95% CI, 74.8%-79.2%]) antimicrobials were administered for treatment of an active infection including empirical use, with 262 (18.0% [95% CI, 16.1%-20.1%]) for medical prophylaxis, 52 (3.6% [95% CI, 2.7%-4.7%]) for noninfectious reasons, 7 (0.5% [95% CI, 0.2%-1.0%]) for surgical prophylaxis (related to osteomyelitis, bowel or urinary tract procedures), and 12 (0.8% [95% CI, 0.4%-1.4%]) for unknown/undetermined rationale. The leading indication overall was for urinary tract infection (29.0% [95% CI, 26.7%-31.4%]; n = 422), followed by skin (cellulitis or soft tissue) and wound infection (n = 311; 21.4% [95% CI, 19.3%-23.6%]), and respiratory tract infection (n = 217; 14.9% [95% CI, 13.1%-16.9%]). For 26 (1.8% [95% CI, 1.2%-2.6%]) antimicrobials site of infection site was missing. The leading sites of infection for antimicrobials used for treatment of active infection and medical prophylaxis were similar (**Table 3**).

Antimicrobials Used by WHO ATC Classifications

Fluoroquinolones were the most frequently used class overall (n = 188; 12.9% [95% CI, 11.3-14.8]). Antivirals, including acyclovir (n = 38), valacyclovir (n = 13), or valganciclovir (n = 2), were predominantly used for medical prophylaxis, and antimycotics (fluconazole, n = 40) were predominantly used for the treatment of an active infection; use of both antimicrobial classes was infrequent (**Table 4**). Most antimicrobial medications given for a noninfectious rationale were intestinal anti-infectives (eg, rifaximin, n = 27). Overall, 482 (33.1%; 95% CI, 30.7%-35.6%) antimicrobials were classified as broad-spectrum antibiotics. In total, 67 different antimicrobial agents were used, with cephalexin (n = 132; 9.1% [95% CI, 7.7%-10.7%]) being the most frequently used overall, followed by trimethoprim/sulfamethoxazole (n = 119; 8.2% [95% CI, 6.8%-9.7%]), doxycycline and levofloxacin (both n = 97; 6.7% [95% CI, 5.4%-8.1%]), and ciprofloxacin (n = 89; 6.1% [95% CI, 4.9%-7.5%]). The 5 most frequently used individual antimicrobials, stratified by the most common site of infection, are shown in **Table 5**.

Discussion

In this large, multisite prevalence survey, the antimicrobial use prevalence was 8.2 per 100 residents who received at least 1 antimicrobial on a given day. Prevalence was highest among residents with medical devices and residents admitted to the nursing home within 30 days prior to the survey date, similar to the findings reported on antimicrobial use in nursing homes based on data from 2001-2002.[22] Fluoroquinolones were the most commonly used class. One-third of antimicrobials used were broad-spectrum antibiotics. This survey preceded the CMS requirement[13] for nursing homes to have an antibiotic stewardship program in place in November 2017 and can serve as a baseline to measure the effect of national efforts to reduce antimicrobial use and control resistance.

Prevalence surveys are used in many countries to obtain data on antimicrobial use from health care settings. Indeed, they represent a key activity of the Transatlantic Taskforce on Antimicrobial Resistance (TATFAR).[23] Prevalence survey data are suitable to measure prevalence and describe the types of antimicrobials used; they can be performed serially,[15,23] with a strength being the ability to collect

Table 2. Adjusted Odds Ratio From Multivariable Logistic Regression for Antimicrobial Use in Nursing Home Residents, Including 15 276 Residents With 1258 Receiving at Least 1 Antimicrobial[a]

Characteristic	Adjusted OR (95% CI)	*P* value
Age, y		
≥85	1 [Reference]	
65 to 84	1.3 (1.1-1.5)	.002
<65	1.5 (1.2-1.8)	<.001
Race/ethnicity[b]		
White non-Hispanic	1 [Reference]	
Other	0.8 (0.7-1.0)	.05
Black Non-Hispanic	0.7 (0.6-0.9)	.003
Unknown or missing	0.7 (0.6-1.0)	.09
Diabetes		
No	1 [Reference]	
Yes	1.4 (1.2-1.6)	<.001
Resident type[c]		
Long stay		
Short stay	1.4 (1.2-1.7)	<.001
Central venous catheter		
No	1 [Reference]	
Yes	11.1 (8.5-14.5)	<.001
Any urinary catheter		
No	1 [Reference]	
Yes[d]	2.2 (1.8-2.6)	<.001
Wound care		
No	1 [Reference]	
Yes	1.8 (1.5-2.0)	<.001
Days from nursing home admission to survey date		
>365	1 [Reference]	
100-365	1.5 (1.2-1.8)	<.001
31-99	2.0 (1.6-2.5)	<.001
≤30	3.0 (2.4-3.7)	<.001
Nursing home location[e]		
Metropolitan area	1 [Reference]	
Nonmetropolitan area	1.4 (1.1-1.7)	.007
Short-stay residents rehospitalized after a nursing home admission,%[f]		
Every 10% increase	1.3 (1.1-1.5)	.001

Abbreviation: OR, odds ratio.

[a] The variance inflation factor for all variables in the model was less than or equal to 1.8, and it was highest for short stay (1.7) and days from nursing home admission to survey date (1.8).

[b] The subcategory *Other* indicates American Indian or Alaska Native, Asian, Native Hawaiian/other Pacific Islander, and Hispanic or Latino.

[c] Short stay indicates admitted for postacute, rehabilitation, or skilled nursing care with the goal to improve condition and be discharged. Long stay indicates admitted for assistance with activities of daily living and traditional long-term nursing care with the goal to preserve condition.

[d] Includes indwelling urinary catheter, condom catheter, suprapubic catheter, and the use of urostomy or nephrostomy tubes.

[e] Rural-urban commuting area (RUCA) code classification was used for the nursing home ZIP codes. Metropolitan area includes RUCA primary codes 1-3; nonmetropolitan area includes RUCA primary codes 4-10.

[f] Indicates the Centers for Medicare & Medicaid Services Nursing Home Compare Quality Measure 521 (the percentage of new nursing home admissions or readmissions from a hospital where the resident was then readmitted to a hospital for an unplanned inpatient or observation stay within 30 days of the nursing home entry or reentry).

detailed, person-level information[24] on why and how antimicrobials were used. To illustrate, a series of prevalence surveys among long-term care facilities in European countries[15] recently measured the prevalence of antimicrobial use to be 4.9 per 100 residents. Through these surveys, it was identified that approximately one-fourth of antimicrobials were given for urinary tract infection prophylaxis; urinary tract infection prophylaxis subsequently became a focus for antibiotic use quality improvement.[25] Earlier antimicrobial use prevalence survey efforts have been performed in nursing homes in Norway (2006; prevalence 15.0 per 100 residents)[26] and Northern Ireland (twice in 2009; prevalence of 13.2 and 10.7 per 100 residents),[27] and more recently in the United Kingdom (2007; prevalence range per 100 residents, 6.3 to 9.6 by country),[28] Australia (2018; prevalence 9.9 per 100 residents),[29] and Canada (2019; results not yet published). While differences in the types of facilities and antimicrobials included in these surveys limit the ability to make clear intercountry comparisons, the information obtained is essential to inform priorities for stewardship interventions to improve antimicrobial use.[4,5,7,12]

Table 3. Antimicrobials Used by Site of Infection for Treatment of Active Infection or Medical Prophylaxis[a]

	Antimicrobials, No. (%)	
Site of infection	Treatment of active infection (n = 1120)[b]	Medical prophylaxis (n = 262)[b]
Urinary tract	315 (28.1)	107 (40.8)
Skin or wound	264 (23.6)	36 (13.7)
Respiratory tract	189 (16.9)	28 (10.7)
Bone or joint	133 (10.1)	27 (10.3)
Gastrointestinal tract	88 (7.9)	Not applicable

[a] More than 1 site of infection could be documented for an antimicrobial.

[b] For treatment of active infection, the value indicates 77.0% of the total, and for medical prophylaxis, 18.0%

Table 4. Antimicrobials by WHO ATC Classification and Rationale[a]

WHO ATC classification[b]	Rationale, No. of antimicrobials: Treatment of active infection (n = 1120)[c]	Medical prophylaxis (n = 262)[c]	Noninfectious or other (n = 72)[c,d]	Total, No. (%) (N = 1454)[c]
Fluoroquinolones[e]	174	12	2	188 (12.9)
First-generation cephalosporins	134	33	3	170 (11.7)
Combinations of sulfonamides and trimethoprim-including derivatives	78	41	0	119 (8.2)
Tetracyclines	73	29	12	114 (7.8)
Intestinal anti-infective antibiotics	63	13	28	104 (7.2)
Combinations of penicillins, including β-lactamase inhibitors[e]	94	3	2	99 (6.8)
Third-generation cephalosporins[e]	96	1	0	97 (6.7)
Nitrofuran derivatives	49	20	1	70 (4.8)
Glycopeptide antibacterials[f]	62	2	2	66 (4.5)
Nitroimidazole derivatives	54	1	1	56 (3.9)
Nucleosides and nucleotides excluding reverse transcriptase inhibitors	16	32	5	53 (3.6)
Penicillins with extended spectrum[e]	34	11	0	45 (3.1)
Antimycotics, triazole derivatives	37	5	0	42 (2.9)
Macrolides	20	11	4	35 (2.4)
Carbapenems[e]	33	0	0	33 (2.3)
Other antibacterials	14	19	0	33 (2.3)
Lincosamides	24	4	2	30 (2.1)
Second-generation cephalosporins	20	3	0	23 (1.6)

Abbreviations: WHO ATC, World Health Organization Anatomic Therapeutic Chemical.

[a] A list of the WHO ATC classification system classifications and codes is included online (eBox in the Supplement).

[b] WHO ATC classifications with less than 1% of total use are not shown, but they include the following: trimethoprim and derivatives (11), tuberculosis treatment/antibiotics (10) adamantane derivatives/dopaminergic agents (9 total); fourth-generation cephalosporins[e] (8 total), β-lactamase–sensitive penicillins[e] (7 total), hyrdrazides (7 total), other aminoglycosides (6 total); β-lactamase–resistant penicillins[e] (5 total), imidazole (3 total), lepra treatment (3 total); other cephalosporins and penems (3 total), stomatological preparations/anti-infectives and antiseptics for local oral treatment (2 total); antifungals for systemic use (1 total), other tuberculosis treatment (1 total), and monobactams (1 total).

[c] For treatment of active infection, the value indicates 77.0% of the total, medical prophylaxis, 18.0%, and for noninfectious or other, 5.0%.

[d] Includes 12 (0.8%) antimicrobials with missing rationale.

[e] Denotes WHO ATC classifications included in the definition of broad-spectrum antibiotics.

[f] All intravenous (parenteral) vancomycin.

Table 5. Most Frequently Used Antimicrobials by Site of Infection[a]

Rank	Site of infection: Urinary tract (n = 422)[b]	Skin, wound (n = 311)[b]	Respiratory tract (n = 217)[b]	Bone or joint (n = 163)[b]	Gastrointestinal (n = 110)[b]
Microbial used, No. (%)					
1	Nitrofurantoin 68 (16.1)	Cephalexin 64 (20.6)	Levofloxacin 61 (28.1)	Vancomycin intravenous 29 (17.8)	Vancomycin oral 47 (42.7)
2	Trimethoprim/sulfamethoxazole 66 (15.6)	Doxycycline 41 (13.2)	Azithromycin 26 (12.0)	Cefazolin 19 (11.7)	Metronidazole 32 (29.1)
3	Ciprofloxacin 56 (13.3)	Trimethoprim/sulfamethoxazole 27 (8.7)	Amoxicillin/clavulanic acid 23 (10.6)	Doxycycline 17 (10.4)	Ciprofloxacin 7 (6.4)
4	Cephalexin 53 (12.6)	Vancomycin intravenous 20 (6.4)	Doxycycline 19 (8.8)	Ceftriaxone 16 (9.8)	Rifaximin 6 (5.5)
5	Amoxicillin/clavulanic acid 25 (5.9)	Clindamycin 18 (5.8)	Trimethoprim/sulfamethoxazole 12 (5.5)	Piperacillin/tazobactam and metronidazole 8 (4.9)	Amoxicillin and erythromycin 3 (2.7)

[a] More than 1 site of infection could be documented for an antimicrobial.

[b] For the urinary tract, the value indicates 29.0% of the total, for skin wound, 21.4%, for respiratory tract, 14.9%, for bone or joint, 11.2%, and for gastrointestinal, 7.6%.

Stratification of antimicrobial use by various facility and resident characteristics helped to identify factors associated with variation in prevalence, and 2 main themes emerged: exposure to the hospital setting and the presence of medical devices, as has been reported elsewhere.[7,22] Higher antimicrobial use prevalence was observed among short-stay residents

admitted for postacute skilled nursing or rehabilitation care and residents most recently admitted to the nursing home (within 30 days). Residents receiving antimicrobials during day 1 and 2 of their stay were most likely initiated before nursing home admission, including residents admitted for treatment. Antimicrobial use was higher among residents with a medical device present, and urinary catheters and central venous catheters were significantly associated with antimicrobial use . While few residents had a central venous catheter, their antimicrobial use prevalence was highest. Because 86% of antimicrobials for residents with a central venous catheter were via the intravenous route, it is possible many were admitted to the nursing home to receive antimicrobial therapy via their catheter. Information on these characteristics can be used to focus interventions among residents among whom prevalence is highest, and there is the greatest opportunity to reduce antimicrobial exposure. This approach may be especially important if resources are insufficient to include all residents within a facility in stewardship initiatives.

These data confirm that prescribing for urinary tract infections is the leading indication for antimicrobial use in nursing home residents, accounting for 29% of overall use; a detailed description has been published elsewhere.[21] The other main indications for antimicrobial use were for skin and wound and respiratory tract infections. As reported elsewhere,[18,22] if the survey had been performed during winter months, antimicrobial use for respiratory tract infections would likely increase. These 3 leading indications, representing the majority of antimicrobial use, mirror results reported from other countries.[15,25-29] Monitoring and optimizing diagnostic and testing practices, in addition to antimicrobial use for these 3 indications, and specifically including urinary tract prophylaxis, which is mostly inappropriate,[15,21,25,30] should be a major focus of antimicrobial stewardship activities in nursing homes. Implementation of treatment guidelines for urinary tract infections that inform and standardize treatment decisions, like those from the Society of Post-Acute and Long-Term Care Medicine,[31] can help optimize antimicrobial use.

Substantial data exist to demonstrate that fluoroquinolones are frequently selected for use among nursing home residents[15,21] and older adults.[32,33] There are serious concerns about the multiple adverse events from fluoroquinolone use,[6,33-35] including the emergence of antibiotic resistance and *Clostridioides difficile* infection and the potential for increased risk of damage to tendons, muscles, joints, the central nervous system, glucose abnormalities, and abdominal aortic aneurysm rupture. Broad-spectrum antibiotics made up 33.2% of overall use, about the same as reported among hospitalized patients.[34] Use of broad-spectrum antibiotics may reflect the treatment of existing multidrug-resistant infections, which can be considerable in nursing homes,[7,8] although inappropriate use can increase the risk for resistant infections[6] and *C. difficile* infection.[35] While some clinicians have stated a preference for prescribing broad-spectrum antibiotics because of their ease of use, including broad coverage, infrequent dosing, and patient adherence,[36] some investigators have been able to reduce broad-spectrum antibiotic use in nursing homes through provision of education and access to alternative oral antibiotics for treatment of urinary tract infection.[37] Due to the array of adverse events and high frequency of use, broad-spectrum agents should be prioritized for antimicrobial use surveillance and stewardship activities in nursing homes.

Limitations

This study has several limitations. First, the 1-day cross-sectional design may be prone to daily fluctuations and overrepresent antimicrobials administered for longer durations. Second, because the survey was performed within selected counties of the 10 EIP states that are largely urban, it is uncertain if the data are generalizable to other US nursing homes. However, the participating nursing homes were not found to be substantially different than those in the United States[21] as a whole, and selected resident-level characteristics are comparable with published CMS data on nursing home residents.[11] Third, the survey was based on data from 2017 and may not represent nursing homes in 2021. Fourth, we did not collect data to determine whether an antimicrobial was initially prescribed and cannot identify residents who were admitted for antimicrobial therapy. Fifth, classifications for rationale and infectious sites were based on retrospective review of nursing home documentation in the nursing home, and missing or insufficient records may have resulted in misclassification. Additionally, this survey was not designed to evaluate the appropriateness of all antimicrobial use. Based on a pilot initiative,[30] a process to evaluate the appropriateness of initiating treatment for urinary tract infection from these nursing home prevalence survey data are being developed.

Conclusions

In this cross-sectional prevalence survey of a cohort of US nursing homes in 2017, the prevalence of antimicrobial use was 8.2 per 100 residents. This survey provides information on the pattern of antimicrobial use among these nursing home residents.

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