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Concise Communication

Antimicrobial resistance in *Escherichia coli* and *Klebsiella pneumoniae* urine isolates from a national sample of home-based primary care patients with dementia

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Abstract

Annual prevalences of antimicrobial resistance among urine isolates (3,913 *Escherichia coli* isolates and 1,736 *Klebsiella pneumoniae* isolates) from home-based primary care patients with dementia were high between 2014 and 2018 (ciprofloxacin, 18%–23% and 5%–7%, respectively; multidrug resistance, 9%–11% and 5%–6%, respectively). Multidrug resistance varied by region. Additional studies of antimicrobial resistance in home-care settings are needed.

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Urinary tract infection (UTI) is one of the most commonly diagnosed and treated infections in older adults. The microbial etiology of UTIs has been well described; *Escherichia coli* and *Klebsiella pneumoniae* are the predominant organisms isolated.[1,2] Antimicrobial resistance is a major public health threat, and existing literature regarding antimicrobial resistance among UTIs in older adults has largely focused on nursing homes. Recent data from 243 nursing homes indicate that a substantial portion of UTIs due to *E. coli* and *K. pneumoniae* are multidrug-resistant.[2]

In the United States, the population of homebound older adults is >1.5 times larger than the nursing home population.[3] Similar to nursing home residents, homebound older adults often have dementia and are prone to UTI. Little is known regarding antimicrobial resistance among urine isolates from home care settings. Home-based primary care (HBPC) offers one method for homebound older adults to receive comprehensive care in their home.[4] In this study, we evaluated antimicrobial resistance among *E. coli* and *K. pneumoniae* urine isolates from a national sample of homebound older adults with dementia who were enrolled in HBPC.

Methods

This retrospective cohort study included persons aged ≥65 years with a diagnosis of dementia from whom an *E. coli* or *K. pneumoniae* isolate was collected in urine after enrollment in HBPC between January 1, 2014, and December 31, 2018, through the US Veterans Affairs (VA) healthcare system. Enrollment in HBPC occurred after receiving ≥2 in-person home visits by a physician or advanced practice provider within a calendar year. Additional inclusion criteria are described elsewhere.[5] In 2018, HBPC programs served >55,000 homebound patients across 130 VA medical centers. This study was deemed exempt from review by the institutional review boards at VA Connecticut Healthcare System and Yale University.

Data were obtained from the VA Corporate Data Warehouse. Patients with urine isolates with reported identification of *E. coli* or *K. pneumoniae* from inpatient (eg, hospital) or outpatient (eg, emergency department, home) locations and a susceptibility result were included. For both *E. coli* and *K. pneumoniae*, urine isolates collected after the initial in-person home visit by a physician or advance practice provider between 2014 and 2018 were evaluated.

Demographics and comorbidities were recorded at the time of the initial in-person home visit by a physician or advance practice provider. Data collected from urine isolates included the organism (*E. coli* or *K. pneumoniae*), collection date, and susceptibility to antimicrobials and antimicrobial groups that were prespecified based on clinical relevance and drug utilization in HBPC.[5] Antimicrobial resistance among urine isolates was defined as nonsusceptibility (resistant or intermediate susceptibility) to 1 or more of the following agents: ampicillin-sulbactam, third-generation cephalosporins, ciprofloxacin, gentamicin, piperacillin-tazobactam, meropenem, or trimethoprim-sulfamethoxazole. Multidrug-resistance was defined as isolates with nonsusceptibility to 3 or more of the prespecified antimicrobials or antimicrobial groups.[2]

For *E. coli* and *K. pneumoniae*, the annual proportions of urine isolates that were not susceptible to prespecified antimicrobials or

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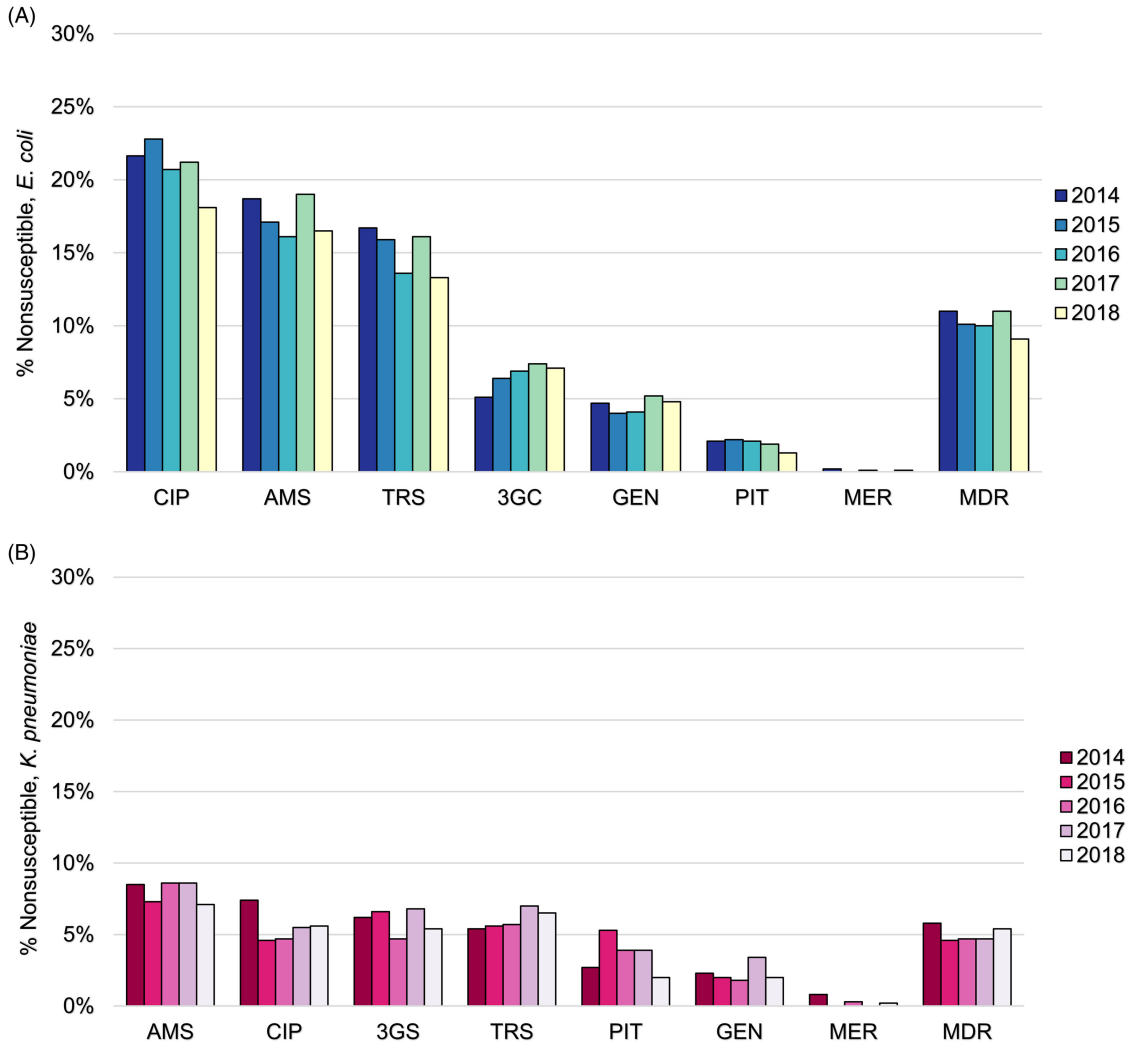

Fig. 1. Annual prevalence of antimicrobial nonsusceptibility when evaluating (A) the first *E. coli* urine isolate and (B) the first *K. pneumoniae* urine isolate collected per patient per year from homebound older adults with dementia who received home-based primary care through the Veterans Affairs Healthcare System in 2014–2018. The numbers of the first *E. coli* urine isolates and the first *K. pneumoniae* urine isolates collected per year are as follows: 2014 (n = 573 and n = 259), 2015 (n = 724 and n = 302), 2016 (n = 822 and n = 383), 2017 (n = 862 and n = 383), 2018 (n = 932 and n = 409). Note. CIP, ciprofloxacin; AMS, ampicillin-sulbactam, TRS, trimethoprim-sulfamethoxazole; 3GC, third-generation cephalosporins; GEN, gentamicin; PIT, piperacillin-tazobactam; MER, meropenem; MDR, multidrug.

antimicrobial groups were determined using the first urine isolate collected per patient per year between 2014 and 2018.[6] Characteristics of persons with and without multidrug-resistance detected from any urine isolate collected after the initial in-person home visit by a physician or advance practice provider were compared using the Fisher exact tests. Results were categorized by organism. Analyses were conducted using SAS version 9.4 software (SAS Institute, Cary, NC).

Results

When evaluating the first urine isolate collected per patient per year, 3,913 *E. coli* isolates and 1,736 *K. pneumoniae* isolates were examined. The mean annual prevalences of nonsusceptibility among *E. coli* and *K. pneumoniae* urine isolates were 21% and 6% for ciprofloxacin, 17% and 8% for ampicillin-sulbactam, 15% and 6% for trimethoprim-sulfamethoxazole, 7% and 6% for third-generation cephalosporins, 5% and 2% for gentamicin, and 2% and 4% for piperacillin-tazobactam, respectively (Fig. 1). Also, <1% of *E. coli* and *K. pneumoniae* urine isolates were nonsusceptible to meropenem. Overall, multidrug-resistance was detected in 9%–11% of urine *E. coli* isolates and 5%–6% of *K. pneumoniae* urine isolates (Supplementary Material online).

When evaluating all *E. coli* (n = 5,684) and *K. pneumoniae* (n = 2,337) isolates collected from urine after the initial in-person home visit by a physician or advance practice provider, 364 patients had a multidrug-resistant *E. coli* urine isolate, and 89 patients had a multidrug-resistant *K. pneumoniae* urine isolate (Table 1). Detection of multidrug-resistance from urine isolates was associated with region for *E. coli* ($P = .0003$) and *K. pneumoniae* ($P = .007$). Greater proportions of patients with versus without multidrug-resistant urine isolates were identified in the Northeast and South regions for *E. coli* (14.6% vs 8.9% and 36.3% vs 33.0%, respectively) and *K. pneumoniae* (18.0% vs 10.2% and 41.6% vs 35.2%, respectively).

Discussion

Using a national sample of homebound older adults with dementia who were enrolled in HBPC, we identified a high prevalence of

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Table 1. Patient-Level Characteristics of Homebound Older Adults With Dementia From Whom a Urine *Escherichia coli* or *Klebsiella pneumoniae* Isolate Was Collected After Enrollment in Home-Based Primary Care, 2014–2018

Characteristic[a]	Patients With *Escherichia coli* Urine Isolate			Patients With *Klebsiella pneumoniae* Urine Isolate		
	Non-MDR[b] (n = 2,791), No. (%)	MDR[c] (n = 364), No. (%)	*P* Value	Non-MDR (n = 1,396), No. (%)	MDR (n = 89), No. (%)	*P* Value
Age			.23			.44
65–74 y	545 (19.5)	83 (22.8)		327 (23.4)	26 (29.2)	
75–84 y	894 (32.0)	104 (28.6)		501 (35.9)	28 (31.5)	
≥85 y	1,352 (48.4)	177 (48.6)		568 (40.7)	35 (39.3)	
Sex			.07			.44
Male	2,579 (92.4)	346 (95.1)		1,327 (95.1)	87 (97.8)	
Female	212 (7.6)	18 (5.0)		69 (4.9)	2 (2.3)	
Race			.46			.06
White	1,944 (69.7)	255 (70.1)		953 (68.3)	52 (58.4)	
Black	612 (21.9)	87 (23.9)		338 (24.2)	33 (37.1)	
Other	62 (2.2)	6 (1.7)		24 (1.7)	1 (1.1)	
Unknown	173 (6.2)	16 (4.4)		81 (5.8)	3 (3.4)	
Ethnicity			.07			.20
Non-Hispanic	2,515 (90.1)	339 (93.1)		1,241 (88.9)	83 (93.3)	
Hispanic	247 (8.9)	22 (6.0)		142 (10.2)	5 (5.6)	
Unknown	29 (1.0)	3 (0.8)		13 (1.0)	1 (1.1)	
Comorbidities						
Diabetes	1,148 (41.1)	158 (43.4)	.43	662 (47.4)	41 (46.1)	.83
Lung disease	890 (31.9)	125 (34.3)	.37	434 (31.1)	25 (28.1)	.64
Vascular disease	590 (21.1)	85 (23.4)	.34	330 (23.6)	24 (27.0)	.52
Heart failure	530 (19.0)	78 (21.4)	.29	288 (20.6)	23 (25.8)	.28
BPH	524 (18.8)	77 (22.2)	.29	251 (18.0)	19 (21.4)	.40
Prostate cancer	370 (13.3)	44 (12.1)	.56	203 (14.5)	8 (9.0)	.16
Region			.0003			.007
Northeast	247 (8.9)	53 (14.6)		143 (10.2)	16 (18.0)	
Mid-Atlantic	725 (26.0)	80 (22.0)		371 (26.6)	25 (28.1)	
South	921 (33.0)	132 (36.3)		492 (35.2)	37 (41.6)	
Midwest	496 (17.8)	67 (18.4)		238 (17.1)	8 (9.0)	
West	402 (14.4)	32 (8.8)		152 (10.9)	3 (3.8)	

Note. MDR, multidrug-resistant; BPH, benign prostatic hypertrophy.
[a]Patient-level characteristics at the time of their first in-person home visit by a physician or advance practice provider.
[b]Patients with a non-MDR isolate detected from any urine sample when evaluating all urine isolates collected after the date of the first in-person home visit by a physician or advance practice provider.
[c]Patients with an MDR isolate detected from at least 1 urine sample when evaluating all urine isolates collected after the date of the first in-person home visit by a physician or advance practice provider.

antimicrobial nonsusceptibility among *E. coli* and *K. pneumoniae* urine isolates between 2014 and 2018. Among 3,913 *E. coli* urine isolates, the annual prevalence of nonsusceptibility was greatest for ciprofloxacin, ranging from 18% to 23%, and multidrug-resistance was detected in 9%–11% of isolates. In contrast, the annual prevalence of nonsusceptibility among 1,736 *K. pneumoniae* urine isolates was greatest for ampicillin-sulbactam, ranging from 7% to 9%, and multidrug-resistance was detected in 5%–6% of isolates. For both organisms, carbapenem-resistance, as measured by meropenem nonsusceptibility, was rare (0%–1%), and detection of multidrug-resistance varied by region.

These results suggest that the prevalence of multidrug-resistance among *E. coli* and *K. pneumoniae* urine isolates in HBPC programs is comparable to estimates from nursing homes. Among 2,539 *E. coli* UTIs and 776 *K. pneumoniae* or *K. oxytoca* UTIs reported from US nursing homes between 2013 and 2017, 9.4% and 5.9%, respectively, were multidrug resistant.[2] Notably, patients from these nursing homes had signs and symptoms suggestive of UTI, whereas clinical features of UTI among patients in the current study were not assessed. Patterns of antimicrobial resistance from the current work are also similar to those reported from other nursing home studies.[7,8]

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Notably, guidelines for the evaluation and management of UTI in home care settings are lacking. Existing recommendations do not address the unique challenges that clinicians face in diagnosing and treating infection among homebound patients who receive home care.[9] In the current study, we identified regional differences in the detection of multidrug-resistance among urine isolates. Many factors likely contributed to this finding, such as geographic variation in healthcare utilization, host factors, and antimicrobial use in HBPC.[5] Collectively, these data support the role for local urine antibiograms that include aggregate nonsusceptibility data among programs to inform empiric antibiotic use in home care settings like HBPC.[10]

Study limitations include a lack of data regarding the indication for urine specimen collection, potential contamination of urine specimens, and susceptibility to other commonly prescribed antibiotics. Urine specimens collected in non-VA locations and differences between VA microbiology laboratories were not evaluated. Finally, the current work was limited to Veterans, who are predominantly male, and involved homebound patients who received interdisciplinary, longitudinal HBPC.[4,5] These results may lack generalizability to non-Veterans or to homebound patients in other home-care settings who receive problem-focused, episodic care.[4] Nevertheless, this research has shown a high prevalence of antimicrobial resistance among *E. coli* and *K. pneumoniae* urine isolates, which limits the effectiveness of empiric treatment options for UTI in HBPC. This study addresses a gap in the scientific literature, which lacks surveillance data for antimicrobial resistance among uropathogens in home care and supports the rationale for further investigation of multidrug-resistant organisms in home care settings.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/ice.2023.98

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Conflicts of interest. All authors report no conflicts of interest relevant to this article.

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