JAMA Internal Medicine | Original Investigation

A Multifaceted Antimicrobial Stewardship Program for the Treatment of Uncomplicated Cystitis in Nursing Home Residents

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IMPORTANCE Urinary tract infections are the most common infections in nursing home residents. However, most antibiotic use is for unlikely cystitis (ie, nonspecific symptoms and positive culture results secondary to asymptomatic bacteriuria or a urine sample improperly collected for culture) that is unnecessary and inappropriate. This antibiotic use is associated with an increased risk of antimicrobial resistance, adverse drug events, and *Clostridioides difficile* (formerly *Clostridium difficile*) infections.

OBJECTIVE To determine the association of a multifaceted antimicrobial stewardship and quality improvement intervention with the reduction in unnecessary antimicrobial use for unlikely cystitis among noncatheterized nursing home residents.

DESIGN, SETTING, AND PARTICIPANTS A quality improvement intervention evaluation was conducted to target antimicrobial use among residents with unlikely cystitis in 25 nursing homes across the United States. Baseline data were collected between February 1, 2017, and April 30, 2017. The intervention was conducted from May 1, 2017, to April 30, 2018.

INTERVENTIONS Intervention nursing homes (n = 12) were randomized to receive a 1-hour introductory webinar, pocket-sized educational cards, tools for system change, and educational clinical vignettes addressing the diagnosis and treatment of suspected uncomplicated cystitis. Monthly web-based coaching calls were held for staff of intervention nursing homes. All facilities received quarterly feedback reports regarding the management of uncomplicated cystitis. Control group nursing homes (n = 13) received usual care.

MAIN OUTCOMES AND MEASURES The primary outcome was the incidence of antibiotic treatment for unlikely cystitis cases, defined using published criteria. Secondary outcomes included overall antibiotic use for any urinary tract infection and the safety outcomes of *C difficile* infections, as well as all-cause hospitalizations and death.

RESULTS Among the 25 nursing homes participating in this quality improvement study, including 512 408 intervention facility resident-days and 443 912 control facility resident-days, fewer unlikely cystitis cases were treated with antibiotics in intervention facilities compared with control facilities (adjusted incident rate ratio [AIRR], 0.73 [95% CI, 0.59-0.91]); *C difficile* infection rates were also lower in intervention nursing homes vs control nursing homes (AIRR, 0.35 [95% CI, 0.19-0.64]). Overall antibiotic use for any type of urinary tract infection was 17% lower in the intervention facilities than the control facilities (AIRR, 0.83 [95% CI, 0.70-0.99]; $P = .04$). There was no increase in all-cause hospitalizations or deaths due to the intervention (all-cause hospitalizations: AIRR, 0.95 [95% CI, 0.75-1.19]; all-cause death: AIRR, 0.92 [95% CI, 0.73-1.16]).

CONCLUSIONS AND RELEVANCE This study suggests that a low-intensity, multifaceted intervention was associated with improved antibiotic prescribing for uncomplicated cystitis in a cohort of nursing homes without an adverse association with other safety outcomes. Although promising, further study is needed to determine whether the intervention could be widely implemented to assist facilities in meeting new federal nursing home requirements for antimicrobial stewardship and quality assurance performance improvement programs.

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JAMA Intern Med. 2020;180(7):944-951. doi:10.1001/jamainternmed.2020.1256
Published online May 11, 2020.

Antimicrobial stewardship programs are a cornerstone in the national approach to combating antimicrobial resistance and improving patient safety in the United States.[1] There is a particular need to develop and disseminate effective antimicrobial stewardship programs in the nursing home setting. The rate of antimicrobial use in nursing homes is significant; between one-half and two-thirds of residents receive an antimicrobial drug during the course of 1 year.[2,3] Moreover, antimicrobial use varies substantially across facilities, differing by up to 10-fold.[3,4] This degree of variation is greater than that found in acute care settings[4] and appears to be associated with prescriber and facility practices rather than resident-level factors.[5] More important, high rates of antimicrobial use in nursing homes are associated with increased rates of adverse drug events among all facility residents, not just those receiving antibiotics.[3]

Focused antimicrobial stewardship programs targeting the management of urinary tract infections (UTIs) are ideal interventions for nursing homes. Urinary tract infection, the most common reason for antibiotic use in nursing homes,[6,7] may refer to complicated infections (eg, pyelonephritis, prostatitis, or catheter-associated infections), uncomplicated cystitis, and cases of unlikely cystitis (eg, a patient with nonspecific symptoms and a positive culture result stemming from asymptomatic bacteriuria or a urine sample poorly collected for culture). Much of the antibiotic use for UTI is unnecessary owing to diagnostic errors for uncomplicated cystitis (eg, a patient with questionable symptoms with negative culture results) and inappropriate treatment of unlikely cystitis (eg, a patient with asymptomatic bacteriuria).[8-10] To our knowledge, only 2 rigorously designed randomized interventions addressing UTI-associated antimicrobial stewardship have been conducted, and the degree of association between antimicrobial stewardship and antibiotic use in these studies was modest and not sustained over time.[11-14] No studies have focused solely on differentiating treatment between uncomplicated cystitis and asymptomatic bacteriuria, which has previously been identified as a major gap in care.[8]

Given this background, there is a need for practical antimicrobial stewardship programs focused on improving the approach to uncomplicated cystitis in nursing home residents. Therefore, the objective of this study is to determine the effectiveness and safety of a multifaceted antimicrobial stewardship and quality improvement initiative in reducing unnecessary antimicrobial use for unlikely cystitis cases in noncatheterized nursing home residents.

Key Points

Question Can a multifaceted antimicrobial stewardship and quality improvement intervention reduce unnecessary treatment of unlikely cystitis (ie, nonspecific symptoms and positive culture results secondary to asymptomatic bacteriuria or a urine sample improperly collected for culture) among noncatheterized nursing home residents?

Findings This quality improvement study of 25 nursing homes, including 512 408 intervention facility resident-days and 443 912 control facility resident-days, found that the intervention was associated with a reduction in the incidence of antibiotic use for unlikely cystitis cases by 27% and a reduction in overall antibiotic use for any type of urinary tract infection by 17% compared with the control group. There were no significant differences in all-cause hospitalizations or mortality.

Meaning If implemented, these intervention tools may help nursing homes improve clinical care while meeting recently revised federal requirements for antimicrobial stewardship and quality improvement.

Methods

Design, Setting, and Participants

This was a quality improvement initiative designed to optimize antimicrobial treatment for uncomplicated cystitis in nursing home residents. Participating nursing homes represent a convenience sample recruited with the help of the leadership of the American Medical Directors Association–The Society of Post-Acute and Long-Term Care Medicine. Inclusion criteria were administrative support confirmed by a signed participation letter, a completed facility demographics form, and willingness to submit deidentified baseline and follow-up case report forms for each suspected nursing home-acquired UTI as well as a monthly summary sheet identifying aggregate facility-level metrics. Suspected nursing home-acquired UTI was defined as any clinical suspicion of UTI as determined by the prescribing clinician.[15] Facilities were excluded if they were participating in another antibiotic stewardship project or another major quality improvement project. All residents residing in the participating nursing homes were included in this facility-level intervention because each resident contributed a number of resident-days of exposure, affording the opportunity for outcomes. Baseline data were collected between February 1, 2017, and April 30, 2017. The intervention was conducted from May 1, 2017, through April 30, 2018. The **Figure** shows the derivation of the study sample. The University of Pittsburgh institutional review board reviewed the study protocol and determined it not to be human participants research; no informed consent was required. The University of Pittsburgh Medical Center Quality Council approved the work as a quality improvement project.

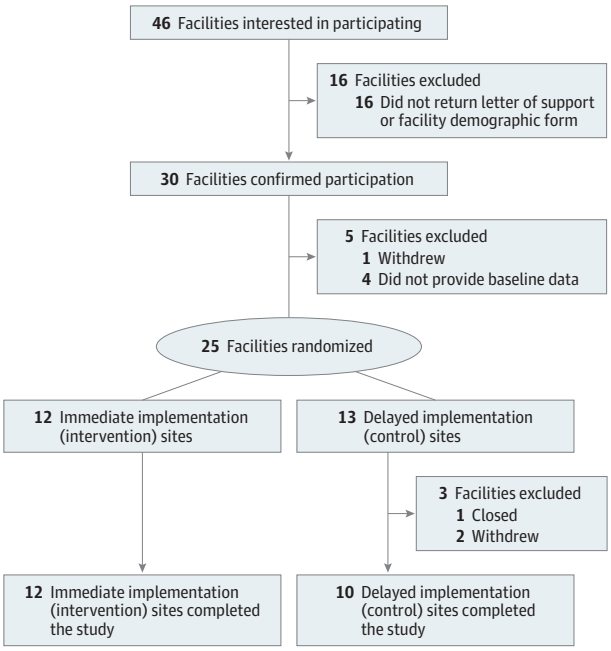
Randomization

After a 3-month baseline run-in period (from February 1 to April 30, 2017), facilities were randomized in equal proportions into 1 of 2 groups: an immediate implementation cohort (intervention) and a delayed implementation cohort (controls). To ensure a balance between groups, we stratified by nursing home state, urban or rural status, and number of beds, with attention to geographical separation to prevent cross-contamination.

Intervention

The multifaceted antimicrobial stewardship intervention focused on uncomplicated cystitis and included education of nursing, pharmacy, and prescribing staff; dissemination of guidelines for the diagnosis and treatment of uncomplicated

Figure. Facility Flow



cystitis; tools for system change; audit; and facility feedback. The previously published guidelines used in this intervention were developed via 2 separate, modified Delphi surveys of a panel of expert physicians and pharmacists.[16,17] The intervention was delivered during a 12-month period (from May 1, 2017, to April 30, 2018) after the baseline 3-month run-in period. Specific intervention components included (1) a 1-hour webinar presented by a physician, pharmacist, and infection preventionist that provided information about the project, introduced the diagnostic and treatment guidelines for uncomplicated cystitis, and highlighted the role of the program in promoting nursing home compliance with new federal requirements for antibiotic stewardship and quality assurance and performance improvement programs[18]; (2) provision of posters and pocket-sized educational cards with the diagnostic and treatment guidelines; (3) standardized physician order set forms for the diagnosis and treatment of suspected, uncomplicated cystitis; (4) an active monitoring sheet designed to improve identification and documentation of signs and symptoms associated with the diagnosis of UTIs; (5) 1-page educational clinical vignettes, directed to prescribers and nursing staff, that address common issues surrounding the diagnosis and treatment of UTIs; (6) routine facility-level audit and feedback regarding UTI rates, compliance with the guidelines, and associated outcomes using summative data; and (7) web-based coaching sessions, held every 6 weeks, for nursing, pharmacy, and prescribing staff of the intervention nursing homes. The tools used for this intervention have been packaged as a free resource available to all nursing homes.[19] During the last quarter of the intervention period, a single 1-on-1 coaching telephone call was held with the infection control nurse or director of nursing from each facility to review the facility feedback information, assess use of the stewardship tools (identify which tools were being used), and answer questions. These types of interventions have been shown to be effective in previous studies designed to improve the quality of prescribing in nursing homes.[11,12,20-22]

The control nursing homes received usual care. To encourage ongoing data submission and facility retention, intervention and control nursing homes each received certificates documenting their participation in a federally funded antimicrobial stewardship and quality assurance and performance improvement program. Certificates were provided for each month of complete data submission. At the conclusion of the 12-month study, control nursing homes received the same multifaceted antimicrobial stewardship intervention focused on uncomplicated cystitis that included staff education, dissemination of guidelines for the diagnosis and treatment of uncomplicated cystitis, tools for system change, audit, and facility feedback.

Main Outcomes and Measures

Because the goal of this intervention was to reduce unnecessary antibiotic use for uncomplicated cystitis, we used a diagnostic approach in which UTI cases were grouped into 1 of 3 categories: (1) complicated (eg, catheter associated, pyelonephritis, or prostatitis), (2) uncomplicated cystitis cases for which empirical antibiotics would be appropriate as per previously published guidelines (dysuria and at least 1 of gross hematuria, suprapubic pain, and urinary frequency/urgency; or both hematuria and suprapubic pain), and (3) unlikely cystitis cases for which empirical antibiotics would be unnecessary (main outcome). Unlikely cystitis cases may represent cases of asymptomatic bacteriuria, contaminated urinary specimens, or noninfectious conditions that can be confused with cystitis (eg, nonspecific symptoms in the absence of urinary-specific symptoms). Diagnostic criteria for these categories have been previously published.[16] Overall antibiotic use for any UTI was also measured. Patient safety variables included *Clostridioides difficile* (formerly *Clostridium difficile*) infections and all-cause hospitalizations and deaths. *C difficile* was defined according to each facility's established protocol. Outcome data were obtained from deidentified individual case report forms, paired urine culture results, and monthly summary reports provided by the study nursing homes. Data forms were limited to 1 page to facilitate data collection. The consistency and accuracy of data collection was addressed through monitoring by the study coordinator (G.A.) and recurring standardized data collection training sessions.

Statistical Analysis

For descriptive purposes, data on the number of urine cultures performed, complicated UTIs, catheter use, cases of uncomplicated cystitis, and cases of unlikely cystitis during the run-in period were tabulated. Descriptive statistics were used to summarize continuous (mean [SD] and median [range]) and categorical (frequencies and percentages) variables stratified by group, facility, and/or month. Outcomes are counts and thus reported per 1000 resident-days. Based on the run-in period incidence of antimicrobial prescribing for unlikely cystitis of 1.03 per 1000 resident-days, we had 80% statistical power to

detect statistical significance of a reduction as small as 15% in the intervention facilities compared with the controls with an active study period of 1 year and a 2-tailed test with $P < .05$ considered statistically significant.

For the main analysis, we fitted a series of generalized estimating equation models with a Poisson distribution for each of the monthly count outcomes as the dependent variable, a logarithmic link function, natural logarithm of facility resident-days within the month as an offset to account for exposure, intervention group as the independent variable of interest, run-in period rate of outcome as a covariate, and an exchangeable working correlation structure to account for correlation between data from the same facility across different months. All analyses were conducted using SAS, version 9.3 software (SAS Institute Inc).

Results

Of 46 facilities verbally agreeing to participate in the intervention, 30 confirmed interest by submission of a facility letter of support and completion of a facility demographics form. Of the 30 sites, 25 were randomized, and 22 completed the intervention. See the Figure for the flow of facilities through the study and the reasons for noncompletion. During the 12-month active period, there were 512 408 intervention facility resident-days and 443 912 control facility resident-days. During the same period, the data submission rate was 93% (134 of 144) of the facility-months in the intervention group, 74% (115 of 156) in the control group before excluding the sites that were closed or had withdrawn, and 96% (115 of 120) in the control group after excluding the sites that were closed or had withdrawn.

The characteristics of the intervention and control nursing homes are presented in **Table 1**. There were no statistically significant differences between groups in any of the baseline characteristics. The mean (SD) number of beds was 139.7 (110.1) in the intervention group and 127.6 (80.3) in the control group. There were more for-profit facilities in the intervention group than in the control group (8 of 12 [67%] vs 4 of 13 [31%]), although the difference was not statistically significant ($P = .07$). Most intervention telephone call participants were nurses.

A comparison of UTI and safety-related measures during the preintervention run-in period is shown in **Table 2.**[16] Intervention facilities had a higher rate of UTIs than did control facilities (1.91 per 1000 resident-days vs 1.77 per 1000 resident-days), as well as a higher rate of unlikely cystitis cases treated with antimicrobials (1.14 per 1000 resident-days vs 0.91 per 1000 resident-days) and all-cause death (1.14 per 1000 resident-days vs 0.94 per 1000 resident-days). Intervention facilities had a lower rate than control facilities of uncomplicated cystitis cases (0.11 per 1000 resident-days vs 0.27 per 1000 resident-days) and *C difficile* infections (0.04 per 1000 resident-days vs 0.06 per 1000 resident-days). However, as supported by the data reported in Table 2, none of these differences were statistically significant.

The association of the intervention with outcomes is shown in **Table 3**. For the primary outcome, the incidence of antimicrobial use for unlikely cystitis was 27% less in the intervention facilities (adjusted incident rate ratio [AIRR], 0.73 [95% CI, 0.59-0.91]; $P = .004$). In terms of safety outcomes, the rate of *C difficile* infection remained stable in the intervention group but increased in the control group, which was associated with a baseline-adjusted reduction in the intervention group of 65% (AIRR, 0.35 [95% CI, 0.19-0.64]; $P < .001$). Secondarily, overall antibiotic use for any type of UTI was 17% lower in the intervention facilities than in the control facilities (AIRR, 0.83 [95% CI, 0.70-0.99]; $P = .04$). There was no statistically significant difference in the incidence of urine cultures performed (AIRR, 0.84 [95% CI, 0.68-1.04]; $P = .10$), all-cause hospitalization (AIRR, 0.95 [95% CI, 0.75-1.19]; $P = .63$), or all-cause death (AIRR, 0.92 [95% CI, 0.73-1.16]; $P = .48$) between the 2 groups, although the intervention group descriptively had a fewer number of urine cultures performed than the control group (1.39 per 1000 resident-days vs 1.52 per 1000 resident-days).

Discussion

This multifaceted antimicrobial stewardship and quality improvement initiative, which focused on uncomplicated cystitis in noncatheterized nursing home residents, was associated with improved antibiotic use for UTIs. Specifically, the intervention was associated with a reduction in the incidence of antibiotic use for unlikely cystitis cases by 27% and overall antibiotic use for any type of UTI by 17%. Previous randomized[13,14] and unrandomized studies[23-28] of UTI-focused antimicrobial stewardship programs have not specifically targeted antibiotic use for uncomplicated cystitis, the most common type of UTI. The reduction in overall use of antibiotics for UTIs, our secondary outcome, was consistent with results of previous trials.[13,14,25,28] The reduction in antibiotic use proved safe, with no significant differences in the rate of all-cause hospitalization or death. The lack of differences in hospitalizations and deaths is consistent with prior work suggesting a low risk for undertreatment of this condition.[13,14,25,29] Although there was a statistically significant 65% reduction in *C difficile* infections, we interpret this finding with caution and reserve conclusions owing to the small number of events, the increased number of events in control facilities associated with the difference, and the lack of information about overall antimicrobial use. Whether the reductions in antibiotic use are associated with reduced antimicrobial resistance rates is not known and should be the subject of future work.

These findings are important because a UTI is the most common reason for antibiotic use in nursing homes, and most cases are unnecessary.[6,8] Nursing homes face many challenges in addressing antimicrobial stewardship, including limited staffing, limited staff expertise, high staff turnover rates, and difficulties with effectively engaging prescribers.[30] Pragmatic approaches to antimicrobial stewardship are thus important in such a setting. Our findings suggest that facilities can successfully improve antibiotic use and outcomes with such tools and an approach with a low level of onsite engagement. The state of Pennsylvania has contracted with our group

Table 1. Characteristics of Nursing Homes

Characteristic	Intervention group (n = 12)	Control group (n = 13)	*P* value
Facility size, No. of beds			
Mean (SD)	139.7 (110.1)	127.6 (80.3)	.81
Median (range)	91.5 (60-446)	120.0 (44-320)	
Occupancy, No. of beds			
Mean (SD)	126.1 (107.3)	116.6 (75.2)	.85
Median (range)	83.0 (57-435)	110.0 (35-297)	
No. of admitting physicians			
Mean (SD)	4.9 (6.2)	8.8 (13.4)	.22
Median (range)	2.0 (1-20)	5.0 (1-50)	
No. of physicians with ≥5 residents			
Mean (SD)	2.8 (2.3)	3.2 (2.4)	.40
Median (range)	2.0 (1-8)	3.0 (0-10)	
No. of RN staff hours/resident/d			
Mean (SD)	0.9 (0.3)	0.8 (0.2)	.29
Median (range)	0.9 (0.5-1.5)	0.7 (0.5-1.2)	
No. of LPN or LVN hours/resident/d			
Mean (SD)	0.9 (0.3)	0.8 (0.2)	.62
Median (range)	0.9 (0.3-1.2)	0.9 (0.6-1.2)	
No. of CNA hours/resident/d			
Mean (SD)	2.3 (0.7)	2.4 (0.5)	.62
Median (range)	2.3 (0.6-3.6)	2.4 (1.7-3.5)	
Medicaid residents, No. (%)			.62
≤25%	3 (25)	2 (15)	.82
26%-50%	2 (17)	1 (8)	
51%-75%	5 (42)	8 (62)	
76%-100%	2 (17)	2 (15)	
For-profit ownership, No. (%)	8 (67)	4 (31)	.07
Facility network, No. (%)			
Single	4 (33)	8 (62)	.16
Chain	8 (67)	5 (39)	
Medical director board certified in medical direction by ABPLM, No. (%)	5 (42)	6 (46)	.82
Uses advanced practitioners, No. (%)	10 (83)	11 (85)	>.99
1-y Staff turnover rate, No. (%)			
≤20%	1 (8)	5/12 (42)	.20
21%-40%	7 (58)	6/12 (50)	
41%-60%	2 (17)	1/12 (8)	
61%-80%	2 (17)	0	
Region, No. (%)			
Midwest and Northwest	3 (25)	4 (31)	>.99
Northeast	6 (50)	6 (46)	
Potomac or Southeast	2 (17)	2 (15)	
South Central or Southwest	1 (8)	1 (8)	
Facility location			
Micropolitan	1 (8)	1 (8)	>.99
Rural	6 (50)	6 (46)	
Metropolitan	5 (42)	6 (46)	

Abbreviations: ABPLM, American Board of Post-Acute and Long-Term Care Medicine; CNA, certified nursing assistant; LPN, licensed practical nurse; LVN, licensed vocational nurse; RN, registered nurse.

to implement this intervention program with volunteer nursing homes (nursing homes that were not part of this study that are receiving the intervention as part of an open dissemination project).

The tools developed and disseminated herein promote education and organizational change by targeting common work system components.[20,31] Use of web-based training and coaching calls to promote a "train-the-trainer" approach, as recommended by others, ensured the ability to reach a national sampling of sites.[31]

This project is unique given its focus on the diagnosis and management of uncomplicated cystitis as opposed to all types of UTIs. Individuals with uncomplicated cystitis are generally less ill, making it difficult to differentiate between uncompli-

Table 2. Baseline Values of UTIs and Safety Outcomes and Their Comparison During the Run-in Period (From February to April 2017)

Outcome	Intervention facilities		Control facilities		Incident rate ratio (95% CI)	*P* value
	Overall rate per 1000 resident-days	Rate across facilities, median (range)	Overall rate per 1000 resident-days	Rate across facilities, median (range)		
All UTIs	1.91	1.69 (0.82-5.52)	1.77	1.77 (0.39-4.20)	1.13 (0.64-1.99)	.67
UTIs with catheter use	0.28	0.31 (0.00-1.04)	0.33	0.23 (0.00-0.93)	0.83 (0.35-1.98)	.68
Urine cultures performed	1.69	1.29 (0.82-5.17)	1.72	1.77 (0.39-3.68)	1.03 (0.59-1.81)	.91
Complicated UTIs[16,a]	0.36	0.48 (0.00-1.19)	0.44	0.23 (0.00-1.08)	0.84 (0.35-2.00)	.69
Uncomplicated cystitis[16,a]	0.11	0.00 (0.00-0.51)	0.27	0.17 (0.00-2.36)	0.41 (0.12-1.37)	.15
Unlikely cystitis[16,a]	1.44	0.99 (0.67-4.99)	1.06	0.99 (0.00-1.60)	1.45 (0.79-2.64)	.23
Unlikely cystitis cases treated with antimicrobials[b]	1.14	0.97 (0.67-4.28)	0.91	0.96 (0.45-1.90)	1.30 (0.82-2.08)	.26
Clostridioides difficile infections	0.04	0.00 (0.00-0.18)	0.06	0.00 (0.00-0.63)	0.67 (0.24-1.88)	.45
All-cause hospitalizations	1.74	1.88 (0.62-4.13)	1.95	1.70 (0.67-4.50)	0.88 (0.50-1.55)	.66
All-cause deaths	1.14	1.38 (0.67-1.91)	0.94	1.30 (0.00-2.54)	1.20 (0.77-1.89)	.42
Antimicrobial use for any UTI[c]	1.56	1.46 (0.82-4.81)	1.48	1.57 (0.39-4.20)	1.08 (0.70-1.66)	.71

Abbreviation: UTI, urinary tract infection.

[a] Urinary tract infections are grouped into 1 of 3 categories: (1) complicated UTI (eg, catheter associated, pyelonephritis, or prostatitis), (2) uncomplicated cystitis for which antimicrobial therapy is indicated (eg, simple uncomplicated cystitis), and (3) unlikely cystitis for which antimicrobial therapy is generally not warranted (eg, asymptomatic bacteriuria, contaminated urinary specimens, or noninfectious conditions, such as atrophic vaginitis, that can be confused with simple cystitis). Suspected cystitis cases constitute uncomplicated cystitis and unlikely cystitis cases. Diagnostic criteria for these categories have been previously published.[16]

[b] Antimicrobial therapy for unlikely cystitis cases is generally not warranted.

[c] Antimicrobial therapy for any type of UTI (complicated cystitis, uncomplicated cystitis, or unlikely cystitis).

Table 3. Data on Unnecessary Antimicrobial Use and Health Outcomes During the Active Period (From May 2017 to April 2018)

Outcome and period	Intervention facilities		Control facilities		Unadjusted		Adjusted for run-in period rate	
	Overall rate per 1000 resident-days	Rate across facilities, median (range)	Overall rate per 1000 resident-days	Rate across facilities, median (range)	Incident rate ratio (95% CI)	*P* value	Incident rate ratio (95% CI)	*P* value
Unlikely cystitis cases treated with antimicrobials								
Follow-up year	0.75	0.75 (0.43-2.54)	0.83	0.95 (0.25-1.67)	0.94 (0.61-1.46)	.79	0.73 (0.59-0.91)	.004
Post hoc analysis for follow-up quarter								
1 (May-July 2017)	0.97	0.79 (0.36-4.32)	0.98	1.14 (0.64-2.59)	1.05 (0.62-1.80)	.85	0.82 (0.60-1.10)	.19
2 (August-October 2017)	0.66	0.84 (0.00-2.21)	0.78	0.85 (0.25-2.41)	0.85 (0.56-1.29)	.43	0.65 (0.50-0.85)	.002
3 (November 2017-January 2018)	0.66	0.66 (0.37-1.95)	0.73	0.76 (0.00-1.01)	0.99 (0.65-1.49)	.95	0.74 (0.56-0.98)	.04
4 (February-April 2018)	0.71	0.86 (0.37-1.89)	0.83	0.86 (0.25-1.69)	0.87 (0.52-1.46)	.61	0.68 (0.48-0.96)	.03
Clostridioides difficile infections								
Follow-up year	0.04	0.04 (0.00-0.16)	0.13	0.09 (0.00-0.29)	0.33 (0.17-0.62)	<.001	0.35 (0.19-0.64)	<.001
All-cause hospitalizations								
Follow-up year	1.75	2.04 (0.57-4.41)	2.02	1.77 (0.47-2.66)	0.88 (0.58-1.33)	.55	0.95 (0.75-1.19)	.63
All-cause deaths								
Follow-up year	1.13	1.32 (0.43-1.78)	1.12	1.23 (0.58-2.07)	1.03 (0.74-1.43)	.87	0.92 (0.73-1.16)	.48
Antimicrobial use for any UTI								
Follow-up year	1.20	1.12 (0.62-2.95)	1.32	1.46 (0.56-2.32)	0.91 (0.66-1.27)	.59	0.83 (0.70-0.99)	.04
Urine cultures performed								
Follow-up year	1.39	1.32 (0.59-3.84)	1.52	1.29 (0.51-2.41)	0.94 (0.57-1.55)	.81	0.84 (0.68-1.04)	.10

Abbreviation: UTI, urinary tract infection.

cated cystitis and unlikely cystitis cases. Clinicians often support their decision to treat unlikely cystitis cases by citing concerns about the risk of undertreatment of uncomplicated cystitis. Unlike most prior studies,[13,14,25] the facilities in our study were able to sustain progress over the project period. Post hoc analyses showed that the gains occurred primarily in the last 3 quarters of the intervention. Because the tools were introduced sequentially over time and there was ongoing opportunity for

reeducation, it likely took some time for the benefits of the intervention to fully materialize. Despite the high turnover rates among nursing facility staff, we were encouraged by the continued participation of the nursing homes in our initiative.

Limitations and Strengths

Our quality improvement project has several limitations. We did not stratify randomization by differences in baseline antibiotic use. Although not statistically significant, differences in antibiotic use during the run-in period may have been associated with the observed differences, as seen by the less pronounced differences in unadjusted comparisons and the significant differences in adjusted comparisons. However, the magnitudes of the rates suggest that the intervention facilities were associated with a greater reduction in antimicrobial use. We believed that considering geographical location was of greater importance to study integrity because cross-contamination would have threatened internal validity without recourse, whereas the baseline imbalance could be statistically controlled. Although not statistically significant, intervention facilities had a greater number of admitting physicians and more staff turnover. We had not collected information to identify whether control facilities had more part-time physicians. We speculate that the greater staff turnover would have had an adverse association with our intervention, and thus our results may potentially underestimate the true intervention effect. Facilities were not blinded, presenting the risk of performance bias. In addition, because of limited resources, we were unable to directly collect data from sites and thus had to rely on self-report. We attempted to mitigate the risk of bias through the use of objectively defined outcome measures. To ensure consistent data collection processes and accurate reporting of data, we used simplified data collection forms and provided recurring standardized training sessions on data collection. Analysis of our data shows similar rates of data completeness across sites. Although it is possible that the recurring training sessions for data collection may be associated with the results obtained by the control group, we do not think this possibility is likely. If any effect was present, our results would be biased toward the null hypothesis and represent a conservative finding despite such an effect. Use of simplified data collection forms also meant that we were not able to collect information on other potential outcomes of interest, such as overall antibiotic use, which should be a focus of future study. Participating facilities may not be representative of the larger population of facilities in the country to the same extent afforded by a complex sampling design. However, facilities participated from numerous regions across the country and had baseline characteristics similar to other US nursing homes.[32] Although physicians, nurse practitioners, and physician assistants were invited to participate in the coaching calls, nearly all of the call participants were nurses, which limited our ability to directly reach prescribers, again potentially limiting the effect of this intervention. Future studies would benefit by qualitatively examining avenues for improving engagement of prescribers and other health care professionals (eg, consultant pharmacists) as well as exploring the most effective aspects of the multifactorial intervention and the extent of sustaining outcomes after the end of the intervention.

Despite the limitations, our study has a number of strengths, including the use of practical tools designed specifically for common work system components, the participation of facilities from across the country, and the incorporation of a control group. By considering location and other factors, we were able to mitigate the risk of cross-contamination between intervention groups. Web-based conferencing and coaching calls enabled us to provide training at minimal cost, avoiding the need for onsite education and greatly expanding the number of facilities that could be involved.[33] Data completion rates were high and were likely boosted by the use of data submission certificates confirming participation in an antimicrobial stewardship and quality assurance and performance improvement program. Both of these programs are now required as part of the Centers for Medicare & Medicaid Services federal nursing home licensure regulations.[18]

Conclusions

This study found that a low-intensity, multifaceted quality improvement intervention was associated with a reduction in the risk of inappropriate treatment of unlikely cystitis cases and in overall antibiotic use for UTIs. Future efforts to improve adherence to the intervention and clinician engagement may further improve outcomes. The effect of this intervention on the rates of antimicrobial resistance still needs to be determined. Further study is needed to determine whether the intervention could assist facilities in meeting the new federal nursing home requirements for antimicrobial stewardship and quality assurance and performance improvement programs.

ARTICLE INFORMATION

Accepted for Publication: March 21, 2020.

Published Online: May 11, 2020. doi:10.1001/jamainternmed.2020.1256

Author Contributions: Drs Nace and Perera had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.
Concept and design: All authors.
Acquisition, analysis, or interpretation of data: Nace, Hanlon, Crnich, Drinka, Schweon, Perera.
Drafting of the manuscript: All authors.
Critical revision of the manuscript for important intellectual content: Nace, Hanlon, Crnich, Drinka, Schweon, Perera.
Statistical analysis: Nace, Crnich, Perera.
Obtained funding: Nace, Hanlon.
Administrative, technical, or material support: Nace, Drinka, Schweon.
Supervision: Nace, Drinka, Anderson.

Conflict of Interest Disclosures: Dr Nace reported receiving grants to the University of Pittsburgh from the National Institute on Aging, the Agency for Healthcare Research and Quality, the Centers for Disease Control and Prevention, the Centers for Medicare & Medicaid Services, the Pennsylvania Department of Health, and the Donoghue Foundation during the conduct of this study. Dr Hanlon reported receiving grants to the University of Pittsburgh from the National Institute on Aging, the Agency for Healthcare Research and Quality, Veterans Health Administration Health Services Research and Development Service, the Pennsylvania Department of Health, and the Donoghue Foundation during the conduct of this study. Dr Crnich reported receiving grants from the Agency for Healthcare Research and Quality, the Centers for Disease Control and Prevention, Veterans Administration Cooperative Studies Program, Wisconsin Partnership Program, and the Wisconsin Department of Health Services during the conduct of this study. Dr Drinka reported receiving grants from the Agency for Healthcare Research and Quality during the conduct of this

study. Mr Schweon reported serving as a consultant for APIC Consulting, Crothall Healthcare, and TouchPoint. Dr Anderson reported receiving grants from the Agency for Healthcare Research and Quality during the conduct of this study. Dr Perera reported receiving grants to the University of Pittsburgh from the National Institutes of Health, the Agency for Healthcare Research and Quality, National Institute for Occupational Safety and Health, Department of Veterans Affairs, Patient-Centered Outcomes Research Institute, US Department of Defense, the Pennsylvania Department of Health, and the Donoghue Foundation during the conduct of this study. No other disclosures were reported.

Funding/Support: Study funding was provided by grant R18-HS023779 from the Agency for Healthcare Research and Quality, grant P30-AG02482711 from the National Institute on Aging, and support from American Medical Directors Association (AMDA)–The Society of Post-Acute and Long-Term Care Medicine.

Role of the Funder/Sponsor: The funding sources had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Additional Contributions: The AMDA–The Society for Post-Acute and Long-Term Care Medicine provided assistance in recruiting nursing facilities for participation in this project and made the project tools freely available on their website.

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