

# A National Implementation Project to Prevent Catheter-Associated Urinary Tract Infection in Nursing Home Residents

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**IMPORTANCE** Catheter-associated urinary tract infection (UTI) in nursing home residents is a common cause of sepsis, hospital admission, and antimicrobial use leading to colonization with multidrug-resistant organisms.

**OBJECTIVE** To develop, implement, and evaluate an intervention to reduce catheter-associated UTI.

**DESIGN, SETTING, AND PARTICIPANTS** A large-scale prospective implementation project was conducted in community-based nursing homes participating in the Agency for Healthcare Research and Quality Safety Program for Long-Term Care. Nursing homes across 48 states, Washington, DC, and Puerto Rico participated. Implementation of the project was conducted between March 1, 2014, and August 31, 2016.

**INTERVENTIONS** The project was implemented over 12-month cohorts and included a technical bundle: catheter removal, aseptic insertion, using regular assessments, training for catheter care, and incontinence care planning, as well as a socioadaptive bundle emphasizing leadership, resident and family engagement, and effective communication.

**MAIN OUTCOMES AND MEASURES** Urinary catheter use and catheter-associated UTI rates using National Healthcare Safety Network definitions were collected. Facility-level urine culture order rates were also obtained. Random-effects negative binomial regression models were used to examine changes in catheter-associated UTI, catheter utilization, and urine cultures and adjusted for covariates including ownership, bed size, provision of subacute care, 5-star rating, presence of an infection control committee, and an infection preventionist.

**RESULTS** In 4 cohorts over 30 months, 568 community-based nursing homes were recruited; 404 met inclusion criteria for analysis. The unadjusted catheter-associated UTI rates decreased from 6.78 to 2.63 infections per 1000 catheter-days. With use of the regression model and adjustment for facility characteristics, the rates decreased from 6.42 to 3.33 (incidence rate ratio [IRR], 0.46; 95% CI, 0.36-0.58;  $P < .001$ ). Catheter utilization was 4.5% at baseline and 4.9% at the end of the project. Catheter utilization remained unchanged (4.50 at baseline, 4.45 at conclusion of project; IRR, 0.95; 95% CI, 0.88-1.03;  $P = .26$ ) in adjusted analyses. The number of urine cultures ordered for all residents decreased from 3.49 per 1000 resident-days to 3.08 per 1000 resident-days. Similarly, after adjustment, the rates were shown to decrease from 3.52 to 3.09 (IRR, 0.85; 95% CI, 0.77-0.94;  $P = .001$ ).

**CONCLUSIONS AND RELEVANCE** In a large-scale, national implementation project involving community-based nursing homes, combined technical and socioadaptive catheter-associated UTI prevention interventions successfully reduced the incidence of catheter-associated UTIs.

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More than 1.4 million people currently reside in nursing homes across the United States.<sup>1</sup> One-third of Americans aged 65 years or older will receive nursing home care in their lifetime, with nearly 20% residing in a nursing home for at least 1 year.<sup>1,2</sup> Nursing homes are crucial for meeting short- and long-term care needs of older adults. Unfortunately, preventable complications, such as infection, are commonly seen in nursing home residents, with approximately 2 million infections occurring each year.<sup>3,4</sup> Nearly 25% of the short-stay population returns to a hospital for treatment of an infection, accounting for 325 000 hospital transfers and over \$4 billion in additional annual health care costs.<sup>5</sup> Robust programs are therefore critical to prevent infections, reduce antimicrobial use and multidrug-resistant organisms, and enhance resident safety.

Up to 13% of men and 12% of women have an indwelling urinary catheter on admission to the nursing home,<sup>6-8</sup> and urinary tract infection (UTI) is one of the leading causes of infection among nursing home residents.<sup>3,8-10</sup> Although progress has been made in reducing catheter utilization with long-term use at 5% to 8% nationally,<sup>6-8</sup> catheters still remain in place for long periods, leading to higher risk of infections, especially antimicrobial-resistant infections.<sup>10-13</sup> Furthermore, knowledge of evidence-based practices to care for these devices among health care personnel in the long-term setting is suboptimal.<sup>14,15</sup> Small-scale studies have shown that catheter-associated UTIs can be successfully reduced within nursing homes,<sup>16</sup> but there is a paucity of studies about how to implement effective prevention efforts in a broad group of nursing homes nationally. The Agency for Healthcare Research and Quality (AHRQ) funded a large-scale infection prevention project in the nursing home setting, with the goal of developing and implementing interventions to reduce catheter-associated UTIs.<sup>17</sup>

## Methods

### Overview of the Implementation Project

The AHRQ Safety Program for Long-Term Care: Healthcare-Associated Infections/Catheter-Associated UTI aimed to reduce catheter-associated UTIs in nursing homes. The goal of this national project was to modify the elements of the Comprehensive Unit-Based Safety Program utilized for the AHRQ Safety Program for Reducing Catheter-Associated UTI in Hospitals<sup>18</sup> to launch an initiative to enhance adoption of infection prevention practices in nursing homes. The intervention was developed considering a variety of additional sources, including the Targeted Infection Prevention study.<sup>16</sup> It used a combination of technical and socioadaptive interventions. Technical interventions underscored professional development in urinary catheter utilization, catheter care and maintenance, and antimicrobial stewardship. Socioadaptive interventions focused on empowering facility teams, addressing implementation challenges, offering solutions to overcome barriers, and promoting resident safety culture, team building, and leadership, as well as resident and family engagement.<sup>17,19</sup> Socioadaptive interventions promote

### Key Points

**Question** Can a multicomponent initiative focusing on technical and socioadaptive interventions reduce catheter-associated urinary tract infection in nursing homes?

**Findings** In this large-scale national implementation project that included 404 community-based nursing homes, longitudinal analysis indicated that catheter-associated urinary tract infection rates decreased by 54% and urine culture orders decreased by 15% over the course of the project. Catheter utilization was largely unchanged.

**Meaning** A combined technical and socioadaptive catheter-associated urinary tract infection prevention intervention successfully reduced the incidence of catheter-associated urinary tract infection in community-based nursing homes.

understanding of the technical components to the end-users, allow translation of these components into practice, and permit modifications to fit local culture, population, and work flow.<sup>20,21</sup>

The Health Research and Educational Trust (HRET), a non-profit research affiliate of the American Hospital Association, provided project oversight with support from the national project team, an interdisciplinary group of experts composed of faculty members from geriatrics and aging research, general internal medicine, nursing, infectious diseases, infection prevention, epidemiology, and health services research. National project team partners included the University of Michigan, Abt Associates, the Association for Professionals in Infection Control and Epidemiology, Baylor College of Medicine, Contrast Creative, Qualidigm, and the Society of Hospital Medicine; the Centers for Disease Control and Prevention (CDC) and other federal agencies were interagency partners.

In addition to the national project team, central partners (ie, lead organizations) supported implementation of the project. Lead organizations included state hospital associations, state-based and professional organizations, state and regional organizations with expertise in quality improvement, National Consumer Voice, and other corporations and health care organizations. These lead organizations recruited nursing homes within their constituency (state/region or corporation), ensured that facilities were actively participating in the project (eg, attending educational sessions, submitting data), and disseminated any project-related information, materials, and resources. Each group of recruited facilities was led by the local organizational lead, a coach from HRET, and a clinical content expert from the national team. Guidance was also provided by a panel of experts on resident safety, catheter-associated UTI, teamwork, quality improvement, and implementation.

Health Research and Educational Trust, in coordination with the lead organizations, recruited nursing homes in 48 states, Washington, DC, and Puerto Rico in 5 cohorts. The results from the first 4 cohorts, which conducted the implementation project between March 1, 2014, and August 31, 2016, are described here. The fourth cohort had a compressed data collection schedule of 10 months. The fifth cohort served as a pilot with a compressed implementation and data collection

schedule with HRET serving as the organization lead; it is not included in this analysis. Data from this cohort will be available on the AHRQ website.

The University of Michigan and HRET institutional review boards reviewed the project and determined it to be quality improvement activities that did not meet the regulatory definition of research involving human subjects. Authors with access to data signed a data confidentiality agreement with HRET. The data analysis was conducted independent of the federal sponsor by 3 authors at the University of Michigan (M.T.G., D.R., and L.M.).

### Multicomponent Interventions

The project emphasized evidenced-based technical factors (eg, reducing indwelling catheter utilization, improving catheter care and maintenance, and antimicrobial stewardship) as well as socioadaptive factors (eg, promoting resident safety culture, team building, and leadership engagement) to prevent catheter-associated UTIs. The technical bundle highlighted key interventions: catheter removal, aseptic insertion, using regular assessments and feedback, training for catheter care, and incontinence care planning and hydration practices (eFigure 1 in the [Supplement](#)).<sup>17,22</sup> The project focused on residents with indwelling urinary catheters. This bundle included foundational infection prevention strategies (eg, hand hygiene, barrier precautions, and education for infection preventionists, frontline staff, residents, and families), as well as catheter-associated UTI prevention-specific strategies (eg, prompt removal of unnecessary catheters on admission, adopting evidence-based practices for catheter maintenance and insertion, reducing inappropriate catheter use, and considering alternatives to indwelling urinary catheters) (**Box**).<sup>23</sup> Antimicrobial stewardship and appropriate use of diagnostic tests, such as urinalysis and urine culture, were also emphasized. The technical bundle was used as a framework for educational materials, toolkits, and interactive activities (eFigure 1 in the [Supplement](#)). This technical bundle was complemented by the socioadaptive bundle that focused on enhancing attitudes and behaviors related to infection prevention practices and overall resident safety in nursing homes. Emphasis was placed on creating safety teams; engaging leadership, frontline staff, residents, and family members; enhancing communication strategies pertinent to resident safety; and sustained progress toward goals.

Education on the technical and socioadaptive bundles was provided through in-person or virtual learning sessions, interactive activities,<sup>24</sup> coaching calls, and webinars (eFigure 2 in the [Supplement](#)).<sup>17</sup> Three learning sessions—1 each at the project start, midpoint, and end—were provided for each cohort. Monthly coaching calls led by the local organizational lead and national project team faculty provided facility teams an opportunity to review data, discuss project implementation, and learn from each other by sharing successes and barriers. Onboarding and training webinars at the start of the project prepared facility teams to implement technical and socioadaptive interventions. These initial sessions were followed by monthly content webinars presented by faculty experts on the technical and socioadaptive principles of catheter-

#### Box. Technical Bundle: Remember C.A.U.T.I. to prevent CAUTI

Infections are the leading cause of illness and death in nursing homes.

These infections include catheter-associated urinary tract infections (CAUTIs).

Remember: No catheter means no CAUTI!

##### C: Catheter Removal

Think about catheters in any of your residents. Are the catheters really necessary?

Remove the catheter if there is no good indication for it. (See below.)

Every resident deserves a chance to be catheter free and infection free.

##### A: Aseptic Insertion

Only trained personnel should insert catheters.

Use hand hygiene, and insert using aseptic technique.

Use the smallest catheter size that will allow good drainage for the resident.

Use catheter securement devices.

##### U: Use Regular Assessments

Implement a process to assess at regular intervals whether a resident needs a catheter.

Insert new urinary catheters only where there is a good indication. Incontinence is NOT an appropriate indication for an indwelling urinary catheter.

Routinely consider alternatives to using a urinary catheter.

Use a bladder ultrasound to guide management.

##### T: Training for Catheter Care

Train staff, resident, and family.

Maintain a closed drainage system, and maintain unobstructed urine flow.

Use routine hygiene. Do not clean the periurethral area with antiseptics.

Routine catheter changes, urinalysis, and cultures are not required.

##### I: Incontinence Care Planning

Develop an incontinence care plan for each resident, including behavioral interventions.

##### Appropriate Indications for an Indwelling Urinary Catheter

To assist in healing of open sacral or perineal wounds in incontinent residents

For acute urinary retention or bladder outlet obstruction

To improve comfort for end-of-life care if needed

Agency for Healthcare Research and Quality. Prevent Catheter-Associated Urinary Tract Infection. C.A.U.T.I. Infographic. <https://www.ahrq.gov/sites/default/files/wysiwyg/professionals/quality-patient-safety/quality-resources/tools/cauti-ltc/modules/resources/tools/prevent/infographic.pdf>. Published March 2017. Accessed April 28, 2017.

associated UTI prevention. A list of educational presentation topics used for the onboarding, training, and monthly content webinars is given in eAppendix 1 in the [Supplement](#). Organizational leads and coaches across the cohorts also participated in a separate monthly call to review data trends, learn by sharing, identify barriers, and provide feedback to the

national project team on needed resources to facilitate implementation. An implementation guide, as well as multiple tools, train-the-trainer educational materials, and other resources, were developed to support facility teams at the start and throughout the project (<http://www.ahrq.gov/cautiLTCtools>). Further information is provided in eAppendix 2 in the Supplement. These materials were available on the project's website hosted by HRET as well as disseminated by organizational leads.

### Project Outcomes and Data Collection

The primary outcome was the catheter-associated UTI incidence rate defined as in the CDC's National Healthcare Safety Network (NHSN) as the number of catheter-associated UTIs meeting long-term care surveillance criteria divided by the number of catheter-days and multiplied by 1000 (CDC's NHSN protocol for tracking infections in long-term care facilities; January 2015).<sup>25</sup> Unlike clinical definitions that rely on physician diagnosis and antibiotic prescribing, NHSN surveillance criteria incorporate objective systemic and localizing clinical findings with laboratory-based criteria to define catheter-associated UTI.<sup>25</sup> The urinary catheter utilization ratio was a secondary outcome, defined as the number of catheter-days divided by the number of resident-days multiplied by 100 and reported as a percentage. Facility teams were coached on data collection at the start of the project and provided with practical hands-on tools to facilitate outcome measurement (<https://www.ahrq.gov/professionals/quality-patient-safety/quality-resources/tools/cauti-ltc/infection-surveillance.html>). These included surveillance pocket cards (<https://www.ahrq.gov/professionals/quality-patient-safety/quality-resources/tools/cauti-ltc/modules/resources/tools/cauti-surveillance/pocket-card.html>), simplified instructions to gather monthly data (<https://www.ahrq.gov/sites/default/files/wysiwyg/professionals/quality-patient-safety/quality-resources/tools/cauti-ltc/modules/resources/tools/cauti-surveillance/data-definitions.pdf>), and surveillance check lists (<https://www.ahrq.gov/professionals/quality-patient-safety/quality-resources/tools/cauti-ltc/modules/resources/tools/cauti-surveillance/assessment.html> and <https://www.ahrq.gov/professionals/quality-patient-safety/quality-resources/tools/cauti-ltc/modules/resources/tools/cauti-surveillance/review-form.html>). Completeness of surveillance data collection was actively monitored by the organizational leads and the project management teams. Beginning with the second cohort, facility-level data on urine culture orders were collected as an objective process measure and potential proxy for appropriate urine testing, given research suggesting that reducing overuse of urine cultures can decrease potential overdiagnosis and antimicrobial prescribing.<sup>26</sup> This is a finite and measurable outcome that can be accessed readily from administrative databases and thus reduce data collection burden on facilities.<sup>26</sup> The number of urine culture orders for all residents (both catheterized and noncatheterized) while in the facility (excluding, eg, emergency department, hospital inpatient, and outpatient visits) was standardized by dividing by the number of resident-days and multiplying by 1000.

Participating nursing homes collected data on the daily number of catheter-associated UTIs, catheter days, resident days, and urine cultures for each month of the project period (eFigure 2 in the Supplement). The expectation for data collection of the above metrics was that nursing homes share their data with the national project team each month throughout the project, using HRET's Comprehensive Data System.

### Statistical Analysis

To examine the changes in catheter-associated UTI rates and catheter utilization during the project, we used multilevel mixed-effects negative binomial regression. Random intercepts and slopes for time at the facility level were included to accommodate the nested-data structure. The log of the number of catheter-days was used as an offset for models examining changes in the NHSN catheter-associated UTI rate. The log of the number of resident-days was used as an offset for the catheter utilization models. Data were collected in aggregate every month for 12 months. The data were then analyzed by setting the first month's reported data to time zero, with each subsequent month being the number of days from the first reporting period. The 12th reporting period is 335 days from the first period; therefore, the time variable was divided by 335 to give an incidence rate ratio (IRR) representing change over the course of the project. All models were adjusted for the following facility characteristics: ownership, chain affiliation, bed size (calculated as the total number of beds divided by 10 so that the IRR represents a 10-bed increase, allowing easier interpretation of the IRR and 95% CI), provision of subacute care (yes/no), 5-star rating, having an infection preventionist with 3 or more years of experience, and presence of an infection prevention committee. We also assessed cohort effects over time in additional sensitivity analysis models.

All participating community-based nursing homes were included in the analysis if they remained active through the end of their cohort period and reported 2 months or more of outcome data and device-days. This analytic sample included 404 units from 38 states. Nursing homes reporting improbable data (eg, large fluctuations in reported device-days or resident-days from month to month within a given nursing home) were identified and excluded from the analytic data set. In addition, nursing homes missing one or more demographic characteristics were excluded from the multivariable analysis.

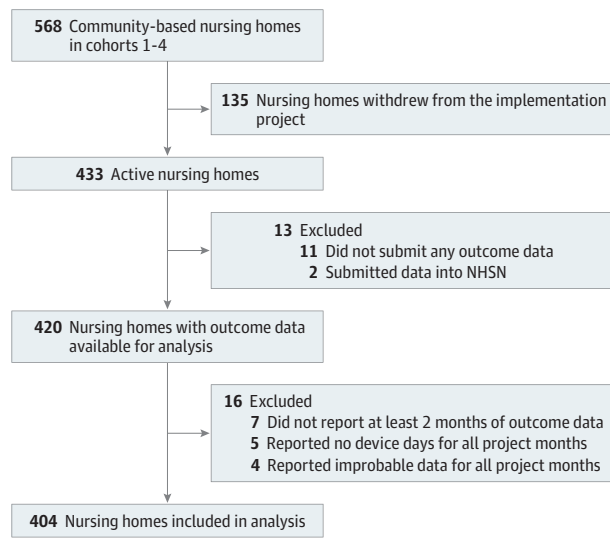
Nursing home characteristics and broader measures of quality of care (ie, unrelated to catheter-associated UTI rates) were assessed using descriptive statistics from data from the Centers for Medicare & Medicaid Services (CMS) Certification and Survey Provider Enhanced Reporting database,<sup>27</sup> the Minimum Data Set,<sup>28</sup> and the Nursing Home Compare 5-Star Quality Rating System. The Centers for Medicare & Medicaid Services (CMS) 5-star Quality Rating System gives each nursing home a rating of between 1 and 5 stars.<sup>29,30</sup> Nursing homes with 5 stars are considered to have much above average quality and nursing homes with 1 star are considered to have quality much below average.<sup>29,30</sup> To ensure generalizability of the results, the participating nursing homes' baseline characteristics and 5-star ratings were compared with those of the rest of the na-



tion using 1-way analysis of variance. In addition, as a test for unintended consequences of participation in the project on overall quality of care, we compared changes in 5-star ratings over time (2016 compared with 2013), using linear regression with adjustment for clustering by the project cohorts. For these national comparisons, nursing homes missing a federal iden-

tifier or quality measures were excluded from the analysis. Given attrition in the number of nursing homes submitting data over the course of the project, we also conducted a sensitivity analysis to examine whether changes in catheter-associated UTI rates differed between nursing homes that did and those that did not complete data submission. All reported *P* values are 2-sided, and *P* < .05 was regarded as statistically significant. Statistical analyses were performed using Stata/MP software, version 13.1 (StataCorp).

Figure 1. Nursing Homes Included in the Data Analysis



## Results

### Characteristics of the Nursing Homes

A total of 568 community-based nursing homes were recruited in cohorts 1 through 4. However, 164 nursing homes were excluded from the analyses for one or more of the following reasons: withdrew from the project, did not report outcome data for at least 2 months, reported no device days, or reported improbable data (Figure 1). The most frequently cited reasons for withdrawal from the project included time constraints and other competing priorities (n = 65) as well as staff turnover and shortages (n = 54). Therefore, we present data from 404 nursing homes that completed the project.

Participating nursing homes had a mean (SD) bed size of 120.7 (67.6) beds, 260 (67.2%) were for-profit, and 218 (56.3%) were part of a chain (Table 1). Compared with non-

Table 1. Facility Characteristics by Participation

Characteristic	Participating Nursing Homes (n = 387) <sup>a</sup>	Nonparticipating Nursing Homes (n = 14 652)	<i>P</i> Value
Facility size, No. of beds, mean (SD)	120.7 (67.6)	107.5 (60.1)	<.001
Ownership, No. (%)			
For-profit	260 (67.2)	10 287 (70.2)	.14
Nonprofit	108 (27.9)	3516 (24.0)	
Government	19 (4.9)	848 (5.8)	
Part of a chain, No. (%)	218 (56.3)	8143 (55.6)	.94
Composition by payer, % <sup>b</sup>			
Medicaid	15.4	15.1	.87
Medicare	58.7	60.4	.19
Medical complexity			
Case-Mix Index, mean (SD) <sup>c</sup>	1.30 (0.15)	1.28 (0.17)	.05
Residents receiving antibiotics, % <sup>b</sup>	10.0	9.7	.33
5-Star rating, mean (SD) <sup>d</sup>			
Overall rating	3.51 (1.17)	3.24 (1.24)	<.001
Quality rating	3.70 (0.98)	3.74 (1.02)	.39
Health inspection rating	3.01 (1.22)	2.81 (1.22)	<.001
Staffing rating	3.51 (1.03)	3.20 (1.12)	<.001

<sup>a</sup> Seventeen nursing homes were excluded from this analysis: 5 were missing a federal identification number and 12 were missing data from one or more sources.

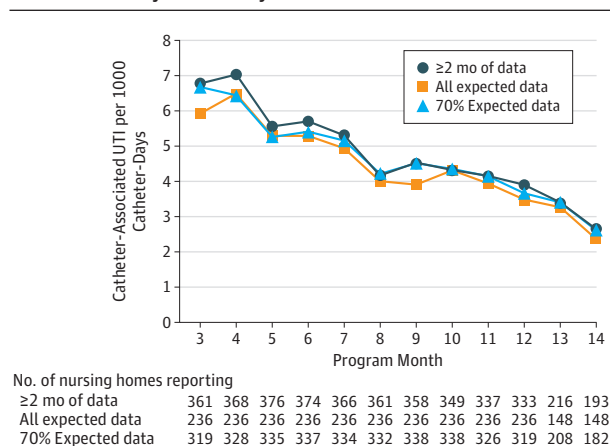
<sup>b</sup> Facility-reported percentages of patients covered by Medicare, Medicaid, or receiving any antibiotics in the past 7 days as reported quarterly to the Centers for Medicare and Medicaid Services (CMS). Numbers of patients not reported.

<sup>c</sup> The Case-Mix Index is each facility's aggregate Resource Utilization Group-III (RUG-III) scores of patients admitted in 2011. The RUG-III is determined by

Minimum Data Set information collected on all patients on admission and every quarter, with higher scores reflecting greater functional impairment, rehabilitation, and nursing needs.

<sup>d</sup> The Centers for Medicare and Medicaid Services (CMS) 5-star Quality Rating System gives each nursing home a rating of between 1 and 5 stars.<sup>29,30</sup> Nursing homes with 5 stars are considered to have quality much above average and nursing homes with 1 star are considered to have quality much below average.

**Figure 2. Catheter-Associated Urinary Tract Infection (UTI) Rates, as Defined by the National Healthcare Safety Network, During the 12-Month Project Period by Data Submission**



Catheter-associated UTI rates reported by nursing homes. Monthly Outcomes Data collection start: Cohort 1, May 2014; Cohort 2, November 2014; Cohort 3, June 2015; and Cohort 4, September 2015. Cohort 4 had compressed data collection schedule of 10 months.

participating nursing homes nationally,<sup>27-30</sup> participating nursing homes were slightly larger and had a higher mean overall quality-of-care 5-star rating. There were no significant differences in ownership, percentage of CMS-certified beds, resident complexity as measured by the case-mix index, or percentage of residents receiving antibiotics. Seventy-two percent of nursing homes reported having an infection preventionist with 3 or more years of experience and spent a mean (SD) of 11.0 (9.9) hours per week on infection prevention activities.<sup>31</sup>

### Changes in Catheter-Associated UTI Rates, Catheter Use, and Urine Culture Orders

Catheter-associated UTI rates steadily decreased from 6.78 per 1000 catheter-days (333 catheter-associated UTIs/49 140 catheter-days) at the beginning of the project to 4.17 per 1000 catheter days (211/50 618 catheter-days) at the midpoint and 2.63 per 1000 catheter-days (70 catheter-associated UTIs/26 610 catheter-days) at the end of the project period (Figure 2). The total number of catheter-associated UTIs and catheter-days by project month are displayed in eTable 1 in the Supplement. A total of 368 nursing homes had data available for our covariates of interest. After adjustment for facility characteristics, the incidence of catheter-associated UTIs was reduced from 6.42 to 3.33 per 1000 catheter-days (IRR, 0.46; 95% CI, 0.36-0.58;  $P < .001$ ) (Table 2). Furthermore, 276 of 368 (75.0%) of the nursing homes reported at least 40% reduction in catheter-associated UTI rates. Although nonprofit nursing homes had lower catheter-associated UTI rates at baseline compared to for-profit nursing homes (4.33 vs 8.15 catheter-associated UTIs per 1000 catheter-days, respectively), rate reductions from baseline were similar for both groups over the course of the project. Changes in catheter-associated UTI rates over the project did not differ significantly by cohort. Catheter

**Table 2. Multivariable Regression Estimates of Changes in Catheter-Associated UTI Rates**

Characteristic	IRR (95% CI) <sup>a</sup>	P Value
Time <sup>b</sup>	0.46 (0.36-0.58)	<.001
Ownership		
For-profit	1 [Reference]	.004
Nonprofit	0.68 (0.53-0.89)	
Part of a chain	0.98 (0.77-1.25)	.87
Bed size <sup>c</sup>	0.99 (0.97-1.01)	.16
Provides subacute care	1.06 (0.62-1.80)	.83
Overall 5-star rating	0.95 (0.86-1.05)	.33
Infection preventionist has ≥3 y experience	1.07 (0.83-1.39)	.59
Presence of committee to review HAIs, including CAUTI	1.01 (0.75-1.35)	.96

Abbreviations: CAUTI, catheter removal, aseptic insertion, using regular assessments, training for catheter care, and incontinence; HAIs, health care-associated infections; IRR, incidence rate ratio.

<sup>a</sup> Thirty-six nursing homes missing one or more demographic characteristics were excluded from the analysis.

<sup>b</sup> Time was defined as the number of days from the end of the first reporting month to the end of the 12th and final reporting month (335 days). Thus, the time variable was divided by 335 to give an IRR representing change over the course of the project.

<sup>c</sup> Bed size was calculated as the total number of beds divided by 10 so that the IRR represents a 10-bed increase to make the respective IRR and 95% CI more interpretable.

utilization did not change substantially during the project period, with 4.5% catheter use at the start of the project and 4.9% use at the end of the project period. After adjustment, catheter utilization remained steady, with rates of 4.50 at baseline and 4.45 at the end of the project (IRR, 0.95; 95% CI, 0.88-1.03;  $P = .26$ ) (eTable 2 in the Supplement). Urine culture order rates, after adjusting for facility characteristics, decreased from 3.49 urine cultures per 1000 resident-days at the beginning of the project to 3.08 urine cultures per 1000 resident-days at the end of the project. The results were similar in our adjusted model, with urine culture rates decreasing from 3.52 to 3.09 (IRR, 0.85; 95% CI, 0.77-0.94;  $P = .001$ ).

### Sensitivity Analyses

Of the 368 nursing homes in the primary analysis with data for all covariates included in adjusted models, 228 (62.0%) submitted all requested data for each assessment period. Among these 228 nursing homes, the catheter-associated UTI rate decreased by 50% (IRR, 0.50; 95% CI, 0.38 to 0.66;  $P < .001$ ) by the end of the project period. At least 70% of the expected data were submitted by 318 nursing homes (86.4%) and, among these facilities, there was a decrease of 55% in the catheter-associated UTI rate (IRR, 0.45; 95% CI, 0.35 to 0.58;  $P < .001$ ). The overall 5-star rating among participating facilities ( $n = 404$ ) improved by 0.02 points from before the project (2013) to after the project (2016), and the overall rating for nonparticipating facilities ( $n = 14 308$ ) declined by 0.09 points during the same time period. However, the change in overall 5-star rating over time (2016 vs 2013) did not differ between participating and nonparticipating nursing homes ( $\beta = 0.12$  points; 95% CI, -0.36 to

0.59). Change over time in other 5-star measures (quality, health inspection, and staffing ratios) were also not significantly different.

## Discussion

In this large-scale implementation project conducted in nationwide cohorts of nursing homes, we report a reduction in catheter-associated UTI rates by 54% over the 12-month period. With 75.0% of the facilities showing a reduction of 40% or more, we demonstrate that these reductions can be achieved by most of the facilities. Furthermore, we noted a reduction in the frequency of orders for urine cultures, highlighting that stewardship can be applied to the use of laboratory diagnostics that often lead to inappropriate use of antibiotics.<sup>26,32</sup> With a well-designed implementation framework tailored toward a frail, aging population with longer stays in the nursing home, this implementation project exemplifies that reducing infections and enhancing the safety of older adults in nursing homes is attainable.

Our findings add new information about how to effectively promote reduction in health care-associated infections in a geographically diverse and broad group of nursing homes. A successful cluster-randomized study in 12 nursing homes conducted by Mody and colleagues<sup>16</sup> involved active surveillance for device-associated infections and multidrug-resistant organisms with simple feedback, an interactive educational program emphasizing both overall infection prevention and device care,<sup>24</sup> and preemptive barrier precautions during high-risk activities. Furthermore, cost-effectiveness analysis showed that this intervention is expected to save \$39 000 per year with most savings due to a reduction in hospitalization related to catheter-associated UTIs.<sup>33</sup> The findings of overall reductions in clinically defined antibiotic-treated catheter-associated UTI rates by 31% and time to first catheter-associated UTI by 45%<sup>16</sup> based on patient-level data closely mirror findings from the larger implementation project reported herein, which used the more conservative standardized nursing home-specific NHSN surveillance criteria to define outcomes. Our findings also align with a recent report by Saint and colleagues<sup>18</sup> that showed a 32% reduction in catheter-associated UTI rates in non-intensive care units participating in the AHRQ Safety Program for Reducing Catheter-Associated UTIs in Hospitals.

Catheter utilization did not decrease during the project period perhaps, in part, because utilization rates were low in the nursing homes at the start of this project. With catheter use being a CMS publicly reported measure since 1990,<sup>29,30</sup> nursing homes have already developed a culture of prompt removal of catheters once clinical need is resolved.<sup>34</sup> An assessment of catheter-associated UTI prevention practices at the start of this project showed that a high percentage of nursing homes required documentation of indications as well as a physician order for catheter use.<sup>31</sup> As a result, unnecessary urinary catheters were generally removed within 48 hours of nursing home admission. Moreover, catheters are seen by nursing

caregivers as an impediment to functional independence of older nursing home residents.<sup>35</sup>

The catheter-associated UTI reductions seen within our project are likely to be the result of several factors. First, the technical bundle emphasized foundational infection prevention strategies as well as strategies specific to catheter use.<sup>36</sup> In particular, with low rates of catheter utilization, our intervention focused primarily on evidence-based strategies for catheter insertion and maintenance,<sup>37</sup> hydration practices, and appropriate use of diagnostic testing as shown by reductions in urine culture order rates.<sup>38</sup> Evidence suggests that interventions targeting overuse of urine cultures can lead to reduced urine culture orders, potential overdiagnosis, and subsequent antimicrobial use.<sup>26</sup> Our project further confirms that such interventions can be effective in nursing homes where urinary catheters, when used, are in place for prolonged periods of time. Second, our educational sessions were informed by knowledge and practice gaps identified by prior literature and a needs assessment conducted at the start of the project.<sup>24,32</sup> The educational sessions were interactive and included streamlined versions of each session to be used by the facility teams for their front-line personnel, including infographics, simplified train-the-trainer materials, and pocket cards.<sup>16,24</sup> Third, attention to socioadaptive elements modified from successful large-scale studies in acute care<sup>18,39,40</sup> was an explicit and unique part of the intervention to facilitate adoption of the technical bundle. Fourth, facility teams received sustained external support from the project's network of local organizational leads and coaches through monthly coaching calls with the national project team, learning from peer teams at other facilities, and being part of this national implementation project. For example, monthly support provided by the local organizational leads and coaches that discussed monthly surveillance data, implementation challenges, and strategies to overcome barriers helped facilities to understand their infection data in relation to local and national benchmarks and with targeted feedback to enhance evidence-based practices, hence making their surveillance data actionable. These external partners helped to identify opportunities for improvement that then empowered facility teams to lead and sustain local efforts.

## Limitations

Our implementation project needs to be considered in the context of the following limitations. We engaged nursing homes that voluntarily agreed to participate. Although this is one of the largest infection prevention projects, these interventions may not be successful in all US nursing homes, particularly those without support from external partners. Moreover, with the use of multiple strategies and tools simultaneously, identifying a single component that would explain our results is not possible. Since this was not a randomized controlled trial, our results could be confounded by unmeasured variables. We did not collect data on antimicrobial use, and catheter-associated UTIs reported by nursing homes were not independently verified as meeting NHSN criteria. However, we are encouraged that the reductions in catheter-associated UTI rates mirror rate reductions achieved by a patient-oriented cluster-

randomized study.<sup>16</sup> Furthermore, we could not compare our results with the catheter-associated UTI rates of nonparticipating facilities. Unlike hospitals, very few nursing homes (<1%) report catheter-associated UTI rates within the NHSN system, although UTI reporting has been identified as a priority within the Department of Health and Human Services National Action Plan to Prevent Healthcare-Associated Infections.<sup>41</sup> Finally, although a common limitation of large-scale studies,<sup>18</sup> it is possible that nursing homes that withdrew from the project or did not submit all expected data were not successful in implementing or sustaining this approach to catheter-associated UTI prevention.

## Conclusions

The interventions used in this large, national community-based nursing home implementation project, which relied on both technical and socioadaptive interventions, reduced catheter-associated UTI rates in settings where utilization is low but catheter use is prolonged. Although this project focused on reducing catheter-associated UTIs, a similar approach with an evidence-based implementation framework can be used to address other resident safety issues in community-based nursing homes.

### ARTICLE INFORMATION

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**Conflict of Interest Disclosures:** Dr Meddings has received honoraria for lectures and teaching related to prevention and value-based purchasing policies involving catheter-associated urinary tract infection (UTI) and hospital-acquired pressure ulcers. She has also received honoraria from RAND Corporation/ Agency for Healthcare Research and Quality (AHRQ) for preparation of an AHRQ chapter update on prevention of catheter-associated UTI. Dr Trautner has received honoraria for speaking from Baylor Scott & White, Texas A&M Health Sciences Center. She has provided consultation for Zambon Pharmaceuticals. Mr Schweon is a consultant for Crothall Healthcare, TouchPoint, APIC Consulting Services, and Fortis Management Group. He has a private consulting business. Mr Olmsted is a member of Ethicon, Inc, speakers' bureau, has served as external faculty for AHRQ's Long-term Care Safety and Intensive Care Unit collaboratives, as well as the Centers for Disease Control and Prevention States Targeting Reduction in Infections Via Engagement (STRIVE) collaborative, and is a member of the Premier's Safety Institute. Dr Saint has received fees for serving on advisory boards for Doximity and Jvion. No other conflicts of interest were reported.

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