A Targeted Infection Prevention Intervention in Nursing Home Residents With Indwelling Devices: A Randomized Clinical Trial

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**IMPORTANCE** Indwelling devices (e.g., urinary catheters and feeding tubes) are often used in nursing homes (NHs). Inadequate care of residents with these devices contributes to high rates of multidrug-resistant organisms (MDROs) and device-related infections in NHs.

**OBJECTIVE** To test whether a multimodal targeted infection program (TIP) reduces the prevalence of MDROs and incident device-related infections.

**DESIGN, SETTING, AND PARTICIPANTS** Randomized clinical trial at 12 community-based NHs from May 2010 to April 2013. Participants were high-risk NH residents with urinary catheters, feeding tubes, or both.

**INTERVENTIONS** Multimodal, including preemptive barrier precautions, active surveillance for MDROs and infections, and NH staff education.

**MAIN OUTCOMES AND MEASURES** The primary outcome was the prevalence density rate of MDROs, defined as the total number of MDROs isolated per visit averaged over the duration of a resident’s participation. Secondary outcomes included new MDRO acquisitions and new clinically defined device-associated infections. Data were analyzed using a mixed-effects multilevel Poisson regression model (primary outcome) and a Cox proportional hazards model (secondary outcome), adjusting for facility-level clustering and resident-level variables.

**RESULTS** In total, 418 NH residents with indwelling devices were enrolled, with 34,174 device-days and 6,557 anatomic sites sampled. Intervention NHs had a decrease in the overall MDRO prevalence density (rate ratio, 0.77; 95% CI, 0.62-0.94). The rate of new methicillin-resistant *Staphylococcus aureus* acquisitions was lower in the intervention group than in the control group (rate ratio, 0.78; 95% CI, 0.64-0.96). Hazard ratios for the first and all (including recurrent) clinically defined catheter-associated urinary tract infections were 0.54 (95% CI, 0.30-0.97) and 0.69 (95% CI, 0.49-0.99), respectively, in the intervention group and the control group. There were no reductions in new vancomycin-resistant enterococci or resistant gram-negative bacilli acquisitions or in new feeding tube-associated pneumonias or skin and soft-tissue infections.

**CONCLUSIONS AND RELEVANCE** Our multimodal TIP intervention reduced the overall MDRO prevalence density, new methicillin-resistant *S. aureus* acquisitions, and clinically defined catheter-associated urinary tract infection rates in high-risk NH residents with indwelling devices. Further studies are needed to evaluate the cost-effectiveness of this approach as well as its effects on the reduction of MDRO transmission to other residents, on the environment, and on referring hospitals.

**TRIAL REGISTRATION** clinicaltrials.gov Identifier: NCT01062841

Published online March 16, 2015.
Approximately 1.4 million Americans reside in 15,600 US nursing homes (NHs), and in 2010 there were 2.5 million short-stay admissions. More than 40% of all Medicare beneficiaries discharged from hospitals in 2011 required postacute care. Multidrug-resistant organisms (MDROs) are endemic in NHs, with prevalence rates exceeding 35% and surpassing those for hospitals. With increasing acuity of illness, the risk of acquiring new infections increases substantially, with approximately 2 million infections occurring in NHs each year.

Indwelling devices, such as urinary catheters and feeding tubes, are frequently used in NHs. National data for the United States show that approximately 5% to 7% of all NH residents have an indwelling urinary catheter and that 5% to 7% have feeding tubes, while 12% to 15% of new admissions to NHs have an indwelling urinary catheter. Compared with NH residents without indwelling devices, residents with indwelling devices have a higher prevalence of MDRO colonization at multiple anatomic sites. The NH residents with indwelling devices share many characteristics with hospitalized populations, and improper care of residents with these devices presents opportunities for pathogen acquisition. The hands of health care workers (HCWs) in these NHs are frequently colonized with gram-negative bacilli (66%), Candida (41%), Staphylococcus aureus (20%), and vancomycin-resistant enterococci (VRE) (9%), increasing the risk of pathogen transmission when providing assistance with various activities of daily living.

Despite the large number of NH residents who are colonized and subsequently infected, randomized trials evaluating interventions focused on the entire population or specific high-risk groups are infrequent. Studies conducted at single NHs have generally focused on 1 of the following 4 types of interventions: hand hygiene, decolonization regimens, infection prevention education, and nurse education. Although these studies show a trend toward reduced MDRO colonization and infections, the reduction in MDROs has not been statistically significant in most cases. Therefore, we conducted a multicenter randomized clinical trial to test whether a multimodal practical evidence-based targeted infection program (TIP) would reduce the prevalence density of MDRO colonization and the incidence of new device-related infections in high-risk NH residents.

Methods

Design Overview, Setting, and Participants
We approached 17 community-based NHs in southeast Michigan that had expressed a preliminary interest in participating in our research program (Figure). Thirteen agreed to have initial communications with us, of which 12 agreed to participate and remained in our study for 3 years from May 2010 to April 2013. This study was approved by the institutional review board at the University of Michigan. The full study protocol can be found in the trial protocol in Supplement 1. All Medicare-certified and Medicaid-certified NHs have an infection control program. Similar to most US NHs, all study sites had an on-site infection preventionist, most of whom served in this role part-time and had additional responsibilities (eTable 1 in Supplement 2). All NHs had access to laboratory and radiology services. The TIP intervention included the following: (1) preemptive barrier precautions; (2) active surveillance for MDROs and infections, with data feedback; and (3) NH staff education on key infection prevention practices and hand hygiene promotion (Table 1). The control group NHs continued to practice according to their own infection prevention policies.

Written informed consent to collect surveillance samples and resident-specific data was obtained from each resident or his or her durable power of attorney. Inclusion criteria were (1) any short-stay or long-stay resident with an indwelling urinary catheter, a feeding tube (nasogastric or percutaneous endoscopic gastrostomy tube), or both for more than 72 hours and (2) informed consent. Residents receiving end-of-life care were excluded. Study personnel (B.L., S.E.M., J.F., and E.K.) obtained data on participant characteristics, age, sex, functional status, comorbidity, and facility-level predictors, such as the quality ratings. The Centers for Medicare & Medicaid Services created the 5-star quality rating system to help consumers, their families, and caregivers compare NHs. This rating incorporates health inspections, staffing, and quality measures. While the field staff (B.L., S.E.M., J.F., and E.K.) were aware of the intervention assignment, one of us (K.S.) processing microbiology cultures was blinded.

Sample Size
Our sample included 12 NHs, with a mean of 137 beds each. The enrollment period for the study was 36 months. Based on preliminary data, we estimated that each NH would care for a mean of 22 residents with an indwelling device per year. Power calculations were based on anticipating a 30% reduction (rate ratio, 0.70) in MDRO prevalence as a result of our intervention. The desired statistical power was 80%, and the significance criterion was .05. Based on previous data, the expected MDRO prevalence density rates were 42 MDRO isolates, including new and repeat isolates from all anatomic sites, per 1000 device-days in the intervention group and 60 MDROs per 1000 device-days in the control group. Because this was a prospective study of NH residents, we also adjusted for intracluster correlation (using an intraclass correlation coefficient of 0.07). Therefore, 12 NHs were sufficient to reach 80% power to reject the null hypothesis of no difference in the overall MDRO prevalence density between the 2 groups. We anticipated conducting 1600 study visits over 3 years.

Randomization and Intervention
We chose to randomize NHs instead of participants using cluster randomization. Randomizing participants can lead to contamination by HCW experiences learned when caring for the intervention participants, thus underestimating the true effect of the intervention. Therefore, NHs served as the unit of allocation. The NHs were stratified by ownership (for profit vs not for profit) because prior studies have shown differences in quality of care by ownership status. Once stratified, NHs were assigned to intervention status using computer-generated randomization by our study statistician (A.G.). Six were randomized to the intervention group and 6 to the control group.
Precautions

Individuals in the intervention group with an indwelling device, irrespective of their MDRO colonization or infection status, were placed on preemptive barrier precautions for the duration of their participation. Specifically, barrier precaution signs were placed on the doors to their rooms, inside their closet, at the nurses’ station, and on their medical records. The HCWs were encouraged to perform hand hygiene before and after providing any care to the participants and were encouraged to wear gowns and gloves when performing morning and evening care, device care, and during any care activity where splashing may be expected to occur. Hand hygiene products, disposable gowns, and personal protective equipment caddies were placed strategically at each intervention site. Residents were not isolated. They were allowed to socialize and obtain rehabilitation outside their room. For nonenrolled residents, intervention NHs followed their existing policies for those infected or colonized with MDROs.

Surveillance

Microbiological samples from the nares, oropharynx, enteral feeding tube insertion site, suprapubic catheter site, groin, perianal area, and wounds were obtained from all participants to assess MDRO colonization at baseline, day 15, and then monthly for up to 1 year, regardless of prior colonization status. Because there is no established active surveillance strategy in this diverse population with varying lengths of stay and case mix and because residents with devices have multisite colonization, we cultured multiple anatomic sites to assess our primary outcome. Standard microbiological methods were used to identify methicillin-resistant Staphylococcus aureus (MRSA), Vancomycin-resistant enterococci (VRE), ceftazidime-resistant gram-negative bacilli, and ciprofloxacin-resistant gram-negative bacilli.
resistant gram-negative bacilli by trained research staff as previously described. Infections were identified using clinical definitions from participants’ medical records, abstracted by trained study coordinators (B.L., S.E.M., and J.F.). The MDRO colonization and infection rates were reported monthly to the intervention NHs by the study coordinators. Graphs, charts, and tables of the data were designed to be easily understood by HCWs and emphasized infection and MDRO risks posed by indwelling devices.

**Education**

Once a resident was enrolled in the study, the nurse’s aide, nurse, his or her physician of record, and the infection preventionist received informational pocket cards. The cards focused on infection recognition using NH-appropriate definitions, including the minimum criteria to initiate antibiotics for specific infections (eg, catheter-associated urinary tract infections (CAUTI)) as well as criteria by McGeer et al for surveillance of infections (eAppendix in Supplement 2). Infection preventionists at the intervention NHs were also invited to a half-day conference on surveillance methods for infections (Conference Agenda in eAppendix in Supplement 2). In addition, a structured, interactive infection control education program for HCWs was designed, implemented, and evaluated. Ten educational modules, executed every 2 to 3 months over 3 years, were conducted by the research team (L.M., B.L., S.E.M., E.K., R.A.R., R.N.O., and S.F.B.) at the intervention NHs.

The educational sessions were targeted to nurses and nurses’ aides, although all NH staff were encouraged to attend. Each session was 30 minutes long, was offered multiple times to include workers on all shifts, and was accompanied by a pretest and posttest consisting of 5 to 10 questions. Session topics included an overview of infection prevention practices, hand hygiene, appropriate indications for device use and device care, and recognition of infections, with content following evidence-based guidelines. Each didactic session was presented using pre-taped DVDs, followed by an interactive component that included game formats modeled after Jeopardy and Wheel of Fortune or device care skits on infection prevention themes. The HCWs at the control facilities were given a similar test on each session at the same time, but no education was provided.

Barrier precautions were promoted using posters, videos, and dance routines. The HCWs were educated on the indications, technique, and duration of effective hand hygiene as well as appropriate glove and gown use. To reduce the Hawthorne effect (also referred to as the observer effect), structured 30-minute observations to monitor HCW activities and their use of barrier precautions were conducted within participant rooms. The alternative of following an HCW in this setting would have changed his or her behavior.

**Main Outcomes and Measures**

The primary study outcome was the overall MDRO prevalence density rate, defined as each participant’s total number of MDRO-positive anatomic sites across all MDROs per visit averaged over the duration of his or her participation. While incidence rates describing new acquisitions are appropriate for acute care hospitals, prevalence measures are better suited to describe the prevalence of multianatomic site MDRO colonization in a long-stay NH population from a public health perspective. This measure captures both transient and persistent MDRO colonization over the duration of participation (ie, a participant with persistent MDRO colonization would have a higher prevalence than someone with intermittent or no colonization). In addition, participants with a greater involvement of MDRO across anatomic sites would have a higher prevalence. We also evaluated the effect of this intervention on an individual’s risk of new MDRO acquisition, defined as the
A Targeted Infection Prevention Intervention

Results

Study Group Characteristics

In total, 203 NH residents with indwelling devices were enrolled in the intervention group, with 17 490 device-days and 3283 active surveillance samples collected. In total, 215 NH residents were enrolled in the control group, with 16 684 device-days and 3274 samples collected. The exclusion of residents with baseline visits only and no follow-up resulted in an analytic population of 154 residents with 871 study visits in the intervention group (with 2116 samples collected) and 162 residents with 857 visits in the control group (with 3072 samples collected). There were no significant differences in baseline characteristics between these 2 groups (Table 2). The NH characteristics, assignments, and resident follow-up for both groups per Consolidated Standards of Reporting Trials guidelines are summarized in the Figure and in eTable 1 and eTable 2 in Supplement 2, respectively. The number of surveillance samples collected during the study and from specific anatomic sites did not differ between the 2 groups (eTable 3 and eTable 4 in Supplement 2).

MDRO Rates

The MDRO prevalence density rates based on cluster-level summaries are listed in eTable 5 in Supplement 2. Using data from the participants enrolled during the first 30 days, there was no statistically significant difference in the overall baseline MDRO colonization rates between the groups.

For the primary outcome, when adjusted for the cluster study design as well as for baseline colonization, age, sex, race, and NH quality rating, we found a 23% reduction in the prevalence density rate for all MDROs (rate ratio, 0.77; 95% CI, 0.62-0.94; P = .01) in the intervention group (Table 3). When analyzing data for individual MDROs, the intervention group had

number of residents with new acquisitions per 1000 device-days at risk as exploratory analyses. New acquisition was assessed at the resident level (eg, a resident culture negative for MRSA at baseline with a subsequent follow-up culture positive for MRSA at any anatomic site). The secondary outcome was the incidence of device-associated infections per 1000 device-days. We defined clinical infections objectively by the presence of both of the following: (1) a clinical note in the participant’s medical record documenting an infection and (2) prescription of a systemic antibiotic for at least 3 days to treat that infection. Each participant was followed from enrollment up to 1 year or through his or her discharge, death, or device removal, whichever occurred first.

Statistical Analysis

A mixed-effects multilevel Poisson regression model was used to predict MDRO prevalence density as a function of the intervention (primary outcome), including facility as a random effect and offset by the number of anatomic sites sampled. To obtain the geometric mean, the prevalence density rate for all MDROs (rate ratio, 0.77; 95% CI, 0.62-0.94; P = .01) in the intervention group (with 2116 samples collected) and 162 residents with 857 visits in the control group (with 3072 samples collected). There were no significant differences in baseline characteristics between these 2 groups (Table 2). The NH characteristics, assignments, and resident follow-up for both groups per Consolidated Standards of Reporting Trials guidelines are summarized in the Figure and in eTable 1 and eTable 2 in Supplement 2, respectively. The number of surveillance samples collected during the study and from specific anatomic sites did not differ between the 2 groups (eTable 3 and eTable 4 in Supplement 2).

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Table 2. Characteristics of Nursing Home Residents With Indwelling Devices

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>All Residents</th>
<th>Residents With &gt;1 Follow-up Visit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intervention Group (n = 203)</td>
<td>Control Group (n = 215)</td>
</tr>
<tr>
<td></td>
<td>Intervention Group (n = 154)</td>
<td>Control Group (n = 162)</td>
</tr>
<tr>
<td>No. of follow-up visits</td>
<td>920</td>
<td>910</td>
</tr>
<tr>
<td>Device-days, mean (SD)</td>
<td>116.1 (121.1)</td>
<td>104.2 (123.5)</td>
</tr>
<tr>
<td>Age, mean (SD), y</td>
<td>74.4 (12.4)</td>
<td>72.5 (13.2)</td>
</tr>
<tr>
<td>Male sex, No. (%)</td>
<td>95 (46.8)</td>
<td>123 (57.2)</td>
</tr>
<tr>
<td>White race, No. (%)</td>
<td>175 (86.2)</td>
<td>187 (87.0)</td>
</tr>
<tr>
<td>Comorbidity score, mean (SD)</td>
<td>2.8 (1.8)</td>
<td>3.0 (2.3)</td>
</tr>
<tr>
<td>Physical self-maintenance score, mean (SD)</td>
<td>22.0 (4.4)</td>
<td>21.6 (4.3)</td>
</tr>
<tr>
<td>Indwelling device use, No. (%)</td>
<td>.39</td>
<td>.58</td>
</tr>
<tr>
<td>Urinary catheter</td>
<td>120 (59.1)</td>
<td>112 (52.1)</td>
</tr>
<tr>
<td>Feeding tube</td>
<td>56 (27.6)</td>
<td>70 (32.6)</td>
</tr>
<tr>
<td>Both urinary catheter and feeding tube</td>
<td>27 (13.3)</td>
<td>33 (15.3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abbreviation: NA, not applicable.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Staphylococcus aureus

Abbreviations: GNB, gram-negative bacilli; MRSA, methicillin-resistant

A 22% reduction in the MRSA prevalence density rate (rate ratio, 0.78; 95% CI, 0.64-0.96; \( P = .01 \)). Participants with urinary catheters showed reduced colonization with MRSA and ceftazidime-resistant gram-negative bacilli, and participants with feeding tubes showed reduced colonization with MRSA. We also assessed the effectiveness of the TIP intervention in reducing MDRO colonization at different anatomic sites (eTable 6 in Supplement 2). When evaluating anatomic site–level differences for individual MDROs, the intervention group showed a lower mean MDRO prevalence (eTable 7 in Supplement 2).

New acquisitions of MRSA and resistant gram-negative bacilli were common. For example, after excluding residents with baseline MRSA colonization, the rates of new acquisition were 6.2 and 7.9 per 1000 device-days at risk at intervention and control sites, respectively (Table 4). New VRE acquisition occurred less frequently. After excluding residents with baseline VRE colonization, the rates of new acquisition were 1.7 and 2.3 per 1000 device-days at risk at intervention and control sites, respectively. After accounting for facility-level and resident-level covariates as well as facility-level clustering, the hazard

### Table 3. Prevalence Rate of MDROs in Nursing Home Residents With Indwelling Devices Following a Targeted Infection Prevention Intervention

<table>
<thead>
<tr>
<th>Variable</th>
<th>No. of MDROs Isolated (% of Positive Swabs)</th>
<th>Value (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intervention Group (n = 154)</td>
<td>Control Group (n = 162)</td>
</tr>
<tr>
<td>All Indwelling Devices</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All MDROs</td>
<td>1299 (26.6)</td>
<td>1732 (32.6)</td>
</tr>
<tr>
<td>MRSA</td>
<td>254 (8.2)</td>
<td>323 (10.5)</td>
</tr>
<tr>
<td>VRE</td>
<td>122 (3.9)</td>
<td>162 (5.3)</td>
</tr>
<tr>
<td>Cefazidime-resistant GNB</td>
<td>185 (5.4)</td>
<td>295 (8.4)</td>
</tr>
<tr>
<td>Ciprofloxacin-resistant GNB</td>
<td>738 (19.5)</td>
<td>952 (24.2)</td>
</tr>
<tr>
<td>Urinary Catheters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All MDROs</td>
<td>665 (27.0)</td>
<td>784 (32.8)</td>
</tr>
<tr>
<td>MRSA</td>
<td>141 (8.8)</td>
<td>158 (11.3)</td>
</tr>
<tr>
<td>VRE</td>
<td>53 (3.3)</td>
<td>92 (6.6)</td>
</tr>
<tr>
<td>Cefazidime-resistant GNB</td>
<td>89 (5.2)</td>
<td>112 (6.7)</td>
</tr>
<tr>
<td>Ciprofloxacin-resistant GNB</td>
<td>382 (19.8)</td>
<td>422 (23.4)</td>
</tr>
<tr>
<td>Feeding Tubes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All MDROs</td>
<td>312 (22.2)</td>
<td>429 (26.9)</td>
</tr>
<tr>
<td>MRSA</td>
<td>64 (6.4)</td>
<td>86 (8.7)</td>
</tr>
<tr>
<td>VRE</td>
<td>23 (2.3)</td>
<td>18 (1.8)</td>
</tr>
<tr>
<td>Cefazidime-resistant GNB</td>
<td>29 (2.4)</td>
<td>71 (6.1)</td>
</tr>
<tr>
<td>Ciprofloxacin-resistant GNB</td>
<td>196 (16.5)</td>
<td>254 (20.1)</td>
</tr>
</tbody>
</table>

Abbreviations: GNB, gram-negative bacilli; MDROs, multidrug-resistant organisms; MRSA, methicillin-resistant Staphylococcus aureus; VRE, vancomycin-resistant enterococci.

* \( P < .05 \).

### Table 4. New Multidrug-Resistant Organism (MDRO) Acquisition a

<table>
<thead>
<tr>
<th>Intervention Group</th>
<th>Rate of New Acquisition per 1000 Device-days</th>
<th>Rate of New Acquisition per 1000 Device-days</th>
<th>Cluster- and Covariate-Adjusted Hazard Ratio (95% CI)</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>New MRSA Acquisition (n = 248 Residents at Risk) a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>8722</td>
<td>56</td>
<td>7115</td>
<td>0.79 (0.65-0.95)</td>
</tr>
<tr>
<td>New VRE Acquisition (n = 258 Residents at Risk) a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>12756</td>
<td>26</td>
<td>11070</td>
<td>2.3</td>
</tr>
<tr>
<td>First New Ciprofloxacin-Resistant or Cefazidime-Resistant GNB Acquisition (n = 211 Residents at Risk) a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>7524</td>
<td>35</td>
<td>5685</td>
<td>6.2</td>
</tr>
</tbody>
</table>

Abbreviations: GNB, gram-negative bacilli; MRSA, methicillin-resistant Staphylococcus aureus; VRE, vancomycin-resistant enterococci.

a New acquisition was assessed at the resident level (eg, a resident being negative for MRSA at baseline with a subsequent follow-up culture positive for MRSA at any anatomic site).

b Once a participant was colonized with the MDRO, he or she did not contribute to at-risk days.

c Excluded are first new ceftazidime-resistant GNB or ciprofloxacin-resistant GNB acquisition.

c Excluded are participants with only 1 visit and those already colonized with the specific MDRO at baseline.

d Included are first new ciprofloxacin-resistant or ceftazidime-resistant GNB acquisition.
Abbreviation: CAUTI, catheter-associated urinary tract infection.

Our strategies demonstrated the utility of using a comprehensive yet technically simple strategy to produce these outcomes instead of time-consuming and resource-intensive measures. Our NH population with indwelling devices. We demonstrated the utility of using a comprehensive yet technically simple strategy to produce these outcomes instead of time-consuming and resource-intensive measures. Our strategies were aimed at enhancing the existing infection prevention program in NHs by making education interactive, multidimensional, and directly applicable to a high-risk population.

Several factors help explain the observed reduction in MDROs. First, preemptive barrier precautions likely led to reduced pathogen prevalence density and new MRSA acquisition. Instituting preemptive precautions has led to reduced MRSA, *Clostridium difficile*, and resistant gram-negative bacilli colonization in acute care, usually during MDRO outbreaks. Second, we complemented preemptive barrier precautions with interactive, engaging infection prevention education delivered through HCW in-service implementation. Informational slides were followed by creative interactive games that reinforced educational messages presented during the didactic sessions. Third, our intervention included interactive methods of enhancing hand hygiene, such as dance routines; demonstrations of hand washing technique (using Glo Germ gel; Glo Germ Company); and pre-post hand cultures, as well as environmental sampling to illustrate the transfer of organisms. These interactive strategies enhanced HCW knowledge and participation, facilitated conversations about infection prevention in NHs, and likely led to reduced transmission of pathogens when providing indwelling device care.

Our multimodal TIP intervention also led to a reduction in clinically defined CAUTIs, reflecting a reduction in antibiotic use as the intervention NHs adopted appropriate criteria for diagnosis of infections during the study period. Distribution of pocket cards that focused on infection recognition to all health care professionals involved in the resident care, including nurses’ aides, nurses, and physicians, may have also affected rates by improving diagnosis of CAUTIs and reducing antibiotic use, leading to decreased prevalence density rates of MDROs. Educational sessions on appropriate urinary catheter use and care (including emphasis on hand hygiene) may have reduced CAUTI rates by limiting contamination of catheter sites. In the Netherlands, Coolś and van der Meer established an overall infection control program in one NH, with emphasis on hand hygiene, restriction of long-term indwelling urethral catheters, treatment of only symptomatic infections, and weekly all-physician meetings to discuss residents with infections. That program reduced clinically defined urinary tract infections from 256 in 515 residents in year 1 to 66

### Table 5. Clinically Defined Indwelling Device-Associated Infections in Nursing Home Residents

<table>
<thead>
<tr>
<th>Intervention Group</th>
<th>Infections</th>
<th>Device-days</th>
<th>Control Group</th>
<th>Infections</th>
<th>Device-days</th>
<th>Cluster-Adjusted Hazard Ratio (95% CI)</th>
<th>P Value</th>
<th>Cluster- and Covariate-Adjusted Hazard Ratio (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>First New CAUTI, All (n = 166 Residents)</td>
<td>31</td>
<td>5982</td>
<td>43</td>
<td>4292</td>
<td>0.49 (0.27-0.90)</td>
<td>.02</td>
<td>0.54 (0.30-0.97)</td>
<td>.04</td>
<td></td>
</tr>
<tr>
<td>All New CAUTI, Includes Recurrent Infection (n = 166 Residents)</td>
<td>56</td>
<td>9413</td>
<td>75</td>
<td>8118</td>
<td>0.62 (0.43-0.88)</td>
<td>.008</td>
<td>0.69 (0.49-0.99)</td>
<td>.045</td>
<td></td>
</tr>
<tr>
<td>Feeding Tube-Associated Skin and Soft-Tissue Infection (n = 118 Residents)</td>
<td>4</td>
<td>5635</td>
<td>3</td>
<td>5062</td>
<td>1.21 (0.43-3.43)</td>
<td>.72</td>
<td>1.09 (0.22-5.45)</td>
<td>.92</td>
<td></td>
</tr>
<tr>
<td>Feeding Tube-Associated Pneumonia (n = 118 Residents)</td>
<td>10</td>
<td>5635</td>
<td>8</td>
<td>5062</td>
<td>1.09 (0.36-3.26)</td>
<td>.88</td>
<td>1.83 (0.53-6.31)</td>
<td>.34</td>
<td></td>
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</tbody>
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Abbreviation: CAUTI, catheter-associated urinary tract infection.

Discussion

We found that a multimodal evidence-based TIP intervention involving preemptive barrier precautions, active surveillance for infections and MDROs, hand hygiene promotion, and structured infection prevention education reduced colonization with MDROs and prevented clinically defined CAUTIs in our NH population with indwelling devices. We demonstrated the utility of using a comprehensive yet technically simple strategy to produce these outcomes instead of time-consuming and resource-intensive measures. Our strategies were aimed at enhancing the existing infection prevention program in NHs by making education interactive, multidimensional, and directly applicable to a high-risk population.

Several factors help explain the observed reduction in MDROs. First, preemptive barrier precautions likely led to reduced pathogen prevalence density and new MRSA acquisition. Instituting preemptive precautions has led to reduced MRSA, *Clostridium difficile*, and resistant gram-negative bacilli colonization in acute care, usually during MDRO outbreaks. Second, we complemented preemptive barrier precautions with interactive, engaging infection prevention education delivered through HCW in-service implementation. Informational slides were followed by creative interactive games that reinforced educational messages presented during the didactic sessions. Third, our intervention included interactive methods of enhancing hand hygiene, such as dance routines; demonstrations of hand washing technique (using Glo Germ gel; Glo Germ Company); and pre-post hand cultures, as well as environmental sampling to illustrate the transfer of organisms. These interactive strategies enhanced HCW knowledge and participation, facilitated conversations about infection prevention in NHs, and likely led to reduced transmission of pathogens when providing indwelling device care.

Our multimodal TIP intervention also led to a reduction in clinically defined CAUTIs, reflecting a reduction in antibiotic use as the intervention NHs adopted appropriate criteria for diagnosis of infections during the study period. Distribution of pocket cards that focused on infection recognition to all health care professionals involved in the resident care, including nurses’ aides, nurses, and physicians, may have also affected rates by improving diagnosis of CAUTIs and reducing antibiotic use, leading to decreased prevalence density rates of MDROs. Educational sessions on appropriate urinary catheter use and care (including emphasis on hand hygiene) may have reduced CAUTI rates by limiting contamination of catheter sites. In the Netherlands, Coolś and van der Meer established an overall infection control program in one NH, with emphasis on hand hygiene, restriction of long-term indwelling urethral catheters, treatment of only symptomatic infections, and weekly all-physician meetings to discuss residents with infections. That program reduced clinically defined urinary tract infections from 256 in 515 residents in year 1 to 66.
in 527 residents in year 6. In a more recent study, Evans et al. introduced an MRSA bundle of universal nasal surveillance on admission, transfer, or discharge, as well as contact precautions for MRSA infection or colonization, hand hygiene promotion, and institutional culture change. Their program resulted in a trend toward reducing MRSA CAUTIs in Veterans Affairs spinal cord injury units. Ours is one of the first studies involving multiple community-based NHi.s in the United States to show the effectiveness of a multimodal TIP intervention in reducing antibiotic-treated CAUTIs.

The key strengths of this study are the evaluation of a multimodal TIP intervention in NHi.s and the goal to reduce MDRO colonization and infections in a high-risk population with indwelling devices. The TIP components were designed to upgrade and integrate individual practices into routine NH care, with emphasis on appropriate use and harms related to the use of indwelling devices. We examined a high-risk population in which there is a lack of rigorous randomized clinical trials to guide clinical practice and policy. Ours is also one of the initial studies involving a community-based NH consortium showing that horizontal interventions to enhance routine infection prevention practices reduce MDRO colonization and antibiotic use related to CAUTIs in a high-risk population.

The study also has limitations. First, our study was conducted in NH facilities in southeast Michigan. While our study facilities resemble other US NHi.s with respect to their ownership status, the mean number of beds, availability of laboratory and radiology services, and the presence of a person responsible for infection prevention, our results may not be generalizable to other types of long-term care facilities, such as assisted-living facilities and hospice centers. Second, we did not assess the effect of the TIP intervention on other potentially at-risk residents at these NHi.s (e.g., residents with wounds). With the increasing complexity of resident populations being served at these NHi.s, future studies should target other at-risk groups. Our goal was to evaluate the effectiveness of our TIP intervention in reducing MDRO transmission from HCWs to a population at high risk of MDRO acquisition due to the presence of indwelling devices. Whether these interventions lead to reduced transmission from these high-risk residents to the rest of the population also needs to be evaluated in the future. Third, we defined CAUTIs using clinical definitions. A recent systematic review demonstrates that there are many different definitions for CAUTIs used in the long-term care setting. Ninety percent of all controlled interventional studies reported either symptomatic or physician-diagnosed urinary tract infections (n = 13) or CAUTI definition not specified (n = 5) as the outcome of interest. We chose to use clinically defined CAUTIs because this measure represents actual antibiotic-treated infections, and antibiotic use remains a significant risk factor for MDRO colonization. Fourth, we did not monitor hand hygiene that could have occurred outside a resident’s room; therefore, our estimates of in-room hand hygiene compliance may be conservative. To minimize the Hawthorne effect, research personnel conducted in-room observations instead of following HCWs as they conducted their duties. Fifth, we did not assess the cost-effectiveness of the interventions because it was beyond the scope of this study.

**Conclusions**

Limitations notwithstanding, we found that a comprehensive multimodal TIP intervention in NHi.s focused on reducing MDRO colonization and CAUTIs is feasible and effective. We designed the TIP intervention by engaging community-based NHi.s with little experience in conducting prospective research and with few infection prevention resources to demonstrate strategies that could be adopted in this traditionally resource-poor setting.
A Targeted Infection Prevention Intervention


effectively prevent the transmission of MDR organisms.24 The need to address transmission of multidrug-resistant organisms (MDROs) has never been more critical for nursing homes. Nursing home care is increasing in complexity as growing proportions of residents are entering homes directly from acute care hospitals. The post-acute care population experiences health care exposures such as invasive medical devices, wounds, and antibiotic use that are well-established risk factors for MDRO acquisition, colonization, and infection. In this issue of JAMA Internal Medicine, Mody and colleagues2 describe a new approach to reduce MDRO prevalence and incidence of infections in nursing homes through a multifaceted, targeted infection prevention (TIP) intervention. The TIP intervention incorporates an extensive educational curriculum for nursing staff, active surveillance for MDRO colonization and infections, and the preemptive use of gown and gloves during daily care of all residents with indwelling medical devices (eg, urinary catheters, feeding tubes). Using cluster randomization at the facility level, implementation of the TIP intervention resulted in a 23% reduction in MDRO prevalence among residents with indwelling devices in 6 intervention homes compared with 6 usual care homes. In addition, residents in the intervention homes had a significantly lower risk of methicillin-resistant Staphylococcus aureus acquisition (hazard ratio, 0.78; P = .01) and fewer clinically diagnosed catheter-associated urinary tract infections (hazard ratio, 0.54; P = .04).

While the comprehensive nature of the TIP intervention makes it difficult to determine the contribution of any individual component on the clinical outcomes seen in the study, the preemptive use of barrier precautions reflects an important shift in the use of gown and gloves away from a pathogen-driven model to a resident-centered model. The burden of MDRO colonization in nursing homes is high, and new acquisition of resistant organisms occurs frequently.2 Given the absence of active surveillance programs, limited use of laboratory diagnostics, and poor communication about MDRO history at care transitions, identification of MDRO colonization in nursing homes is difficult. However, the presence of indwelling devices has clearly been shown to increase risk of MDRO colonization and risk of infection in nursing home residents.3 The approach taken by Mody and colleagues4 to focus on certain resident risk factors for implementation of gown and gloves may help nursing homes ensure that appropriate practices are in place during care of the highest-risk individuals in the facility. In some ways, this strategy aligns more closely with the fundamental principle of standard precautions to consider risk of transmission during care activities for every person, regardless of known infection or colonization status.4

Although adherence to standard precautions entails the use of gown and gloves based on risk of exposure during any patient care task, health care facilities (including nursing homes) often emphasize the importance of gown and gloves use during care for individuals known to be colonized or infected with MDROs (ie, contact precautions). Infection control programs often focus more on monitoring health care personnel adherence to gown and gloves use when interacting with MDRO-colonized individuals, even low-risk individuals with limited risk of organism shedding. This is despite evidence that health care personnel are inconsistent in adherence to standard precautions even during patient care activities with high potential for exposure to body fluid or mucous membranes.5 The training and feedback to health care personnel on a pathogen-directed use of gown and gloves may inadvertently undermine the importance of risk-based use of gown and gloves during patient care.

In the nursing home setting, several implementation issues influence appropriate use of gown and gloves. Some facilities have frontline nursing staff wear gloves for all resident contacts, regardless of the patient care activity. However, when gloves are used inappropriately, hand hygiene adherence is reduced.6 Other facilities may be reluctant to use gown and gloves for fear that this equipment will undermine efforts to create a homelike environment for residents. Gown and gloves are perceived as a barrier between the resident and the caregiver, which could adversely affect the psychosocial well-being of the resident.7 However, if gown and gloves were no longer only associated with MDRO colonization or infection, perhaps the use of this equipment during care would not be considered as stigmatizing to residents.

Mody and colleagues8 have provided a strong argument for reconsidering the approach to MDRO management in nurs-
ing homes given the challenges to identifying colonized individuals and transmission events. However, more work needs to be done to fully understand the ramifications of this change in practice. The definition of “high risk” in this study was limited to the presence of devices, but other groups of residents (e.g., those with wounds) may also benefit from this risk factor-based implementation of precautions. The effect of this intervention at the facility level, including MDRO prevalence among residents without devices, should be explored. In addition, the cost-effectiveness of the TIP intervention and the feasibility of sustaining the intervention without the external support provided by the study team must be examined given the significant investment in infection prevention education and infrastructure required for successful implementation.

Despite these unanswered questions, this article demonstrates the feasibility of performing a well-designed, prospective multicenter, interventional study in a community nursing home setting. It addresses an important safety issue for a high-risk population and shows the efficacy of several practical infection prevention interventions. We need more high-quality, outcomes-driven infection prevention research studies in nursing homes to expand the evidence base for strategies to reduce MDROs and infections in this rapidly growing health care setting.

ARTICLE INFORMATION

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Conflict of Interest Disclosures: None reported.

Disclaimer: The findings and conclusions in this report are those of the author and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

REFERENCES


