
Valerie M. Vaughn, MD, MSc; Sanjay Saint, MD, MPH; M. Todd Greene, PhD, MPH; David Ratz, MS; Karen E. Fowler, MPH; Payal K. Patel, MD, MPH; Sarah L. Krein, PhD, RN

Abstract

IMPORTANCE Health care–associated infection (HAI) is associated with substantial harm. To reduce HAI, the largest integrated health care system in the United States—the Veterans Health Administration—was an early adopter of infection prevention policies and initiatives. Whether these efforts translated into increased use of practices to prevent HAI in Veterans Affairs (VA) hospitals is unknown.

OBJECTIVE To evaluate changes over time in infection prevention practices and the perception of the importance of infection prevention to hospital leadership.

DESIGN, SETTINGS, AND PARTICIPANTS For this survey study, every 4 years between 2005 and 2017, infection preventionists were surveyed at all VA hospitals on use of practices associated with common HAIs, including central line–associated bloodstream infection (CLABSI), catheter-associated urinary tract infection (CAUTI), ventilator-associated pneumonia (VAP), and (beginning in 2013) Clostridioides difficile infection. Data analysis was performed from February 1, 2019, to July 1, 2019.

MAIN OUTCOMES AND MEASURES Reported regular use of key infection prevention practices and perceived importance of infection prevention to hospital leadership.

RESULTS Between 2005 and 2017, 320 total surveys were completed with response rates ranging from 59% (73 of 124) in 2017 to 80% (95 of 119) in 2005. Use of 12 different infection prevention practices increased. Since 2013, 92% (69 of 75) to 100% of VA hospitals reported regular use of key infection prevention practices for Clostridioides difficile infection and CLABSI. In contrast, adoption of many practices to prevent CAUTI, although increasing, have lagged. Despite reported increases in the use of some practices for VAP such as semirecumbent positioning (89% [79 of 89] in 2005 vs 97% [61 of 63] in 2017, P = .007 for trend) and subglottic secretion drainage (23% [19 of 84] in 2005 vs 65% [40 of 62] in 2017, P < .001), use of other key practices such as daily interruptions of sedation (85% [55 of 65] in 2009 vs 87% [54 of 62] in 2017, P = .66) and early mobilization (81% [52 of 64] in 2013 vs 82% [51 of 62] in 2017, P = .88) has not increased. Antibiotic stewardship programs are now reported in nearly every VA hospital (97% [71 of 73]); however, some hospitals report practices for microbiologic testing for HAIs (eg, 22% [16 of 72] report routine urine culture testing in 2017) that could also contribute to antibiotic overuse.

CONCLUSIONS AND RELEVANCE From 2005 to 2017, reported use of 12 different infection prevention practices increased in VA hospitals. Areas for continued improvement of infection prevention practices appear to include CAUTI, certain VAP practices, and diagnostic stewardship for HAI. The reported adoption of many infection prevention practices in VA hospitals was higher than in non-VA hospitals. As hospitals continue to merge and health systems become increasingly integrated, these successes could help inform patient safety broadly.
Introduction

Health care–associated infections (HAIs) are harmful but often preventable. More than 600,000 patients are hospitalized with an HAI in the United States annually, among whom nearly 100,000 die. The Department of Veterans Affairs (VA) includes the largest integrated health care system in the United States, caring for more than 9 million veterans and including more than 120 inpatient facilities. The VA was also an early adopter of initiatives and directives aimed at reducing HAI, including infection prevention and, later, antibiotic stewardship. However, the extent to which VA hospitals have continued to adopt and use evidence-based practices targeting HAIs over time has not been evaluated.

Between 2005 and 2009, the use of key practices to prevent central line–associated bloodstream infection (CLABSI), ventilator-associated pneumonia (VAP), and catheter-associated urinary tract infection (CAUTI) increased in VA hospitals. Whether use of those key practices has continued to increase over time, however, is unknown. In addition, since initial surveys were performed, novel infection prevention practices have been developed and additional HAIs, such as *Clostridioides difficile* infection, have been recognized as important targets to improve patient safety. Successes and struggles in VA hospitals could inform infection prevention and patient safety broadly especially because hospitals continue to merge and health systems are becoming increasingly integrated.

To understand national trends in infection prevention, all VA hospitals were surveyed every 4 years between 2005 and 2017 to evaluate changes in infection prevention practices and the perception of the importance of infection prevention to hospital leadership.

Methods

Data Collection

This survey study used an ongoing survey in which, every 4 years, infection preventionists at VA hospitals across the United States are asked what practices their hospitals are using to prevent common HAIs. Survey methods have been previously described. In brief, for every 4-year period of the study (2005, 2009, 2013, and 2017), we surveyed all VA hospitals in the United States excluding those that had merged or closed since the previous survey. The survey process followed a modified Dillman approach that included an initial mailed invitational letter and survey, a reminder postcard after approximately 2 weeks, and additional survey mailings to those preventionists who had not yet responded. Hospitals that employed more than 1 infection preventionist were asked to have the lead infection preventionist serve as the primary respondent, although consulting with others as needed to complete the questionnaire was encouraged. Institutional review board approval with a waiver of signed informed consent was obtained from the VA Ann Arbor Healthcare System, Ann Arbor, Michigan. This study followed the American Association for Public Opinion Research (AAPOR) reporting guideline.

Survey Measures

In all surveys, participants were queried on hospital characteristics, details of their hospitals’ infection control programs, and use of prevention practices specifically related to CAUTI, CLABSI, and VAP. Questions related to *C difficile* infection prevention were added in 2013. As new evidence for infection prevention strategies emerged, additional questions for each HAI were incorporated, including questions related to routine testing for *C difficile* infection and urinary tract infection. For each infection prevention practice, participants were asked: “Using a scale from 1 to 5 (1 being never and 5 being always), please indicate how frequently the practice is used in your hospital.” We defined regular use as a rating of 4 or 5. Rather than using a Likert scale, 3 questions required a yes or no response to assess practices including (1) encouraging early mobilization, (2) screening routinely for urinary tract infection at hospital admission, and (3) having a written policy to routinely test for *C difficile* infection in patients with diarrhea who are taking antibiotics. The survey question related to
antibiotic stewardship changed over time. In 2009 and 2013, we asked hospitals how frequently antibiotic stewardship was used in their facility (1 [never] to 5 [always]). In 2017, we asked hospitals whether they had an antibiotic stewardship program (yes or no). Beginning in 2009, we also surveyed infection preventionists about their perception of how important prevention of each type of HAI was to their hospital leadership, assessed on a scale of 1 to 4 (1 being minimally important and 4 being extremely important).

**Statistical Analysis**
Analyses were performed from February 1, 2019, to July 1, 2019. We determined response rate based on response rate 2 as defined by AAPOR in which partial responses are considered respondents11; all sent surveys were included in the denominator of the response rate. Survey responses that were continuous variables (eg, bed size) were analyzed by linear regression with time as a continuous or ordinal covariate. Changes in the percentage of responding VA hospitals reporting regular use or leadership that viewed HAI prevention as very or extremely important over time were compared using a Cochran-Armitage test for trend (exact version when necessary). The sample size may vary owing to missing data. A 2-sided P < .05 was considered statistically significant, and SAS, version 9.4 (SAS Institute Inc) was used for all analyses.

**Results**
Between 2005 and 2017, a total of 320 surveys were completed, with survey response rates ranging from 59% (73 of 124) in 2017 to 80% (95 of 119) in 2005 (Table). Across years, the mean (SD) self-reported hospital size was 98 (83) beds. Although hospital size did not change over time, the mean reported percentage of rooms that were private increased between 2013 (48%) and 2017 (60%) (P = .02). Reported staffing for infection prevention also increased (mean [SD] full-time equivalents, 1.6 [0.9] in 2005 to 2.3 [1.4] in 2017, P < .001 for trend), although the number of hospitals with a hospital epidemiologist has remained stable (Table).

**Infection Prevention Practices**
Reported regular use of infection prevention practices for CAUTI, CLABSI, VAP, and *C difficile* infection are described for each year in eTable 1 in the Supplement. Use of 12 different infection prevention practices increased. For CAUTI, reported regular use of alternatives to urinary catheters increased over time, including portable bladder ultrasonography to determine postvoid residual (50% [42 of 84] in 2005 vs 88% [63 of 72] in 2017, P < .001 for trend) and condom catheters in men (46% [41 of 90] in 2005 vs 64% [46 of 72] in 2017, P = .02). Reported change in the use of procedures to promote removal of urinary catheters already in place (eg, reminder or stop orders, nurse-initiated discontinuation) was mixed, with increased use over time followed by decreased or plateaued use between 2013 and 2017 (Figure 1A).

### Table. Characteristics of Hospitals by Survey Year

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>2005 (n = 95)</th>
<th>2009 (n = 72)</th>
<th>2013 (n = 80)</th>
<th>2017 (n = 73)</th>
<th>P Value for Trend*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response rate, No./total No. (%)</td>
<td>95/119 (80)</td>
<td>72/117 (62)</td>
<td>80/126 (64)</td>
<td>73/124 (59)</td>
<td>NA</td>
</tr>
<tr>
<td>Adult acute care beds, mean (SD), No.</td>
<td>NT</td>
<td>93 (74)</td>
<td>98 (78)</td>
<td>103 (96)</td>
<td>.49</td>
</tr>
<tr>
<td>Adult intensive care unit beds, mean (SD), No.</td>
<td>17 (11)</td>
<td>15 (10)</td>
<td>14 (10)</td>
<td>13 (10)</td>
<td>.01</td>
</tr>
<tr>
<td>Private rooms, mean (SD), %</td>
<td>NT</td>
<td>NT</td>
<td>48 (28)</td>
<td>60 (31)</td>
<td>.02</td>
</tr>
<tr>
<td>Hospital affiliated with a medical school, %</td>
<td>80</td>
<td>74</td>
<td>76</td>
<td>71</td>
<td>.25</td>
</tr>
<tr>
<td>Full-time equivalents for infection preventionists, mean (SD)</td>
<td>1.6 (0.9)</td>
<td>1.9 (1.2)</td>
<td>2.2 (1.4)</td>
<td>2.3 (1.4)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Hospital has an epidemiologist, %</td>
<td>51</td>
<td>54</td>
<td>51</td>
<td>52</td>
<td>.91</td>
</tr>
</tbody>
</table>

Abbreviations: NA, not applicable; NT, not asked.
* Change in hospital characteristics over time was analyzed by linear regression with time as a continuous or ordinal covariate. P < .05 was considered to be statistically significant.
Figure 1. Reported Regular Use of Infection Prevention Practices by Year

A. Catheter-associated urinary tract infection

B. Central line–associated bloodstream infection

C. Ventilator–associated pneumonia

D. C. difficile infection

Survey questions assessing antibiotic stewardship differed between surveys. During 2009 and 2013, hospitals were asked (in a listing of infection prevention practices) how frequently antibiotic stewardship was used in their facility. In 2017, hospitals were asked “Does your hospital have an antimicrobial stewardship program?”

* Statistically significant increase in use assessed using the Cochran-Armitage test and considering \( P < .05 \) as significant. See eTable 1 in the Supplement for exact numbers.
For CLABSI, reported use of 2 infection prevention practices statistically significantly increased over time: maximal sterile barrier precautions during insertion (84% [76 of 90] in 2005 vs 97% [65 of 67] in 2017, \( P < .001 \)) and antimicrobial dressing with chlorhexidine (29% [26 of 90] in 2005 vs 96% [65 of 68] in 2017, \( P < .001 \)) (Figure 1B).

For VAP, reported use of 5 infection prevention practices increased over time, including use of semirecumbent positioning (89% [79 of 89] in 2005 vs 97% [61 of 63] in 2017, \( P = .007 \)), antimicrobial mouth rinse (33% [28 of 85] in 2005 vs 92% [58 of 63] in 2017, \( P < .001 \)), subglottic secretion drainage (23% [19 of 84] in 2005 vs 65% [40 of 62] in 2017; \( P < .001 \)), selective digestive tract decontamination (9% [8 of 86] in 2005 vs 32% [20 of 62] in 2017; \( P < .001 \)), and silver-coated endotracheal tubes (8% [5 of 66] in 2009 vs 20% [12 of 61] in 2017, \( P = .03 \)). Reported use of early mobilization (81% [52 of 64] in 2013 to 82% [51 of 62] in 2017, \( P = .88 \)) and daily interruptions of sedation (85% [55 of 62] in 2013 to 87% [54 of 62] in 2017, \( P = .66 \)) did not increase over time (Figure 1C).

Since 2013, regular use of 4 \( C \) \( \text{difficile} \) infection prevention practices has been reported in at least 90% of VA hospitals: (1) contact precautions (97% [74 of 76] in 2013 vs 97% [71 of 73] in 2017), (2) private rooms or cohorting (99% [75 of 76] in 2013 vs 100% [73 of 73] in 2017), (3) soap and water hand hygiene (92% [70 of 76] in 2013 vs 99% [72 of 73] in 2017), and (4) terminal disinfection (97% [74 of 76] in 2013 vs 97% [71 of 73] in 2017). In 2009 and 2013, approximately half of VA hospitals (56% [40 of 71] in 2009 vs 55% [41 of 75] in 2013) reported regular use of antibiotic stewardship. By 2017, nearly all VA hospitals (97% [71 of 73]) reported having an antibiotic stewardship program (Figure 1D).

The percentage of hospitals reporting a written policy to routinely test for \( C \) \( \text{difficile} \) infection when patients have diarrhea while receiving antibiotics did not significantly change over time (30% [23 of 76] in 2013 vs 40% [29 of 73] in 2017, \( P = .23 \) for trend). Between 2009 and 2017, infection preventionists reported increased use of routine urine tests to screen for urinary tract infection at hospital admission (8% [6 of 71] in 2009, 15% [11 of 73] in 2013, and 22% [16 of 72] in 2017, \( P = .02 \) for trend).

**Importance of HAI Prevention**

By 2017, 85% (61 of 72) to 88% (63 of 72) of infection preventionists believed hospital leaders considered prevention of CAUTI, CLABSI, VAP, and \( C \) \( \text{difficile} \) infection as very or extremely important. The percentage of hospitals reporting CLABSI and VAP prevention as very or extremely important to hospital leadership was consistently high (CLABSI: 89% [63 of 71] in 2009 vs 88% [63 of 72] in 2017; VAP: 88% [58 of 66] in 2009 vs 87% [55 of 63] in 2017), whereas the percentage of hospitals identifying CAUTI and \( C \) \( \text{difficile} \) infection prevention as very or extremely important began lower and increased over time (CAUTI: 37% [26 of 71] in 2009 vs 85% [62 of 73] in 2017; CDI: 68% [52 of 76] in 2013 vs 85% [61 of 72] in 2017) (Figure 2) (eTable 2 in the Supplement).
Discussion

Between 2005 and 2017, a national survey of VA hospitals was conducted every 4 years to ascertain hospital practices to prevent certain device-associated HAIs, with \textit{C difficile} infection prevention added in 2013. During the 12-year period examined, we observed statistically significant increases in reported use of 12 infection prevention practices across infection domains. As of 2013, at least 90% of responding VA hospitals reported use of key infection prevention practices for \textit{C difficile} infection and CLABSI. In contrast, although increases were observed, the number of hospitals reporting specific practices to prevent CAUTI, especially those associated with catheter discontinuation, was suboptimal, and reported practices associated with VAP remained mixed. Although antibiotic stewardship programs are now reported in nearly every VA hospital, some hospitals also report routine microbiologic testing that could contribute to antibiotic overuse.

In VA hospitals, the reported regular use of infection prevention practices for \textit{C difficile} infection and CLABSI increased and is now nearly universal. The reasons for high uptake of practices to prevent these infections potentially differ. For example, \textit{C difficile} infection is characterized by diarrhea, and thus, the recommended cleaning and hand hygiene practices may be easier to implement. Furthermore, synergy with antibiotic stewardship may promote greater use of practices to prevent \textit{C difficile} infection.\textsuperscript{12} On the other hand, CLABSI was the first disease to be publicly reported, potentially increasing its visibility as a patient safety target.\textsuperscript{13} Furthermore, CLABSI was the first HAI shown to be preventable through use of multiple infection prevention practices combined in a bundle,\textsuperscript{14} potentially explaining why maximum sterile barrier precautions and antimicrobial dressing with chlorhexidine—2 common bundle elements—were reported to be used nearly universally. There likely continues to be room for improvement for both diseases. Despite the high reported use of practices to prevent \textit{C difficile} infection and CLABSI, actual compliance with many practices (eg, hand washing) was likely lower.\textsuperscript{15}

Although increases over time were observed for most CAUTI prevention practices, the proportion of hospitals reporting regular use of CAUTI prevention practices was lower compared with the reported use of other HAI prevention practices. This lag may be associated with the relative lack of importance placed on CAUTI by hospital leadership. Of note, in both 2009 and 2013, a lower percentage of hospitals identified CAUTI as very or extremely important to hospital leaders compared with other HAIs. Although reported use of alternatives to catheters has increased over time, it is concerning that procedures to prompt catheter removal plateaued or decreased in 2017. The VA system cares for a predominantly male patient population; thus, patient demand could be encouraging the use of noncatheter alternatives without affecting initiatives to quickly remove unnecessary catheters.\textsuperscript{16} Furthermore, rigid structural hierarchies and barriers to communication between nurses and physicians may impede efforts to remove unnecessary catheters.\textsuperscript{17} Because nurse-prompted discontinuation and automatic stop orders are effective ways to decrease catheter use and CAUTI,\textsuperscript{18,19} it is imperative that hospitals work to implement and sustain these practices.

The reported use of most infection prevention practices for VAP have increased over time, including the use of silver-coated endotracheal tubes, which are expensive and have mixed evidence of efficacy.\textsuperscript{20} The reported use of daily interruptions of sedation and early mobility have not increased and remain used regularly in fewer than 90% of VA hospitals despite strong evidence that these practices not only prevent VAP but also prevent other adverse outcomes, such as delirium, duration of mechanical ventilation, poor mobility at discharge, and death.\textsuperscript{21-23} Variable inclusion of these additional practices in VAP prevention bundles could explain some variation.\textsuperscript{24}

Many VA hospitals reported having policies or routinely screening for certain HAIs. Paradoxically, these policies may be associated with patient harm. For example, the observed increase in the number of hospitals that reported routinely screening for urinary tract infection at hospital admission is particularly concerning, because higher rates of urine cultures are associated with higher inappropriate antibiotic use and \textit{C difficile} infection.\textsuperscript{25,26} Previous US studies of non-VA hospitals found even higher rates of routine urine cultures at admission, especially for patients with
urinary catheters. Inappropriate antibiotic use often results from routine testing because the urine of many elderly patients, especially those who are hospitalized and those with chronic urinary catheters, is colonized with bacteria. Asymptomatic bacteriuria does not require antibiotic treatment, even in patients with indwelling urinary catheters but is inappropriately treated with antibiotics in up to 80% of hospitalized patients. Similarly, the percentage of hospitals reporting a written policy to routinely test for *C difficile* infection when patients have diarrhea while receiving antibiotics has not decreased over time despite evidence that up to 15% of hospitalized patients may be asymptomatically colonized with *C difficile*. Thus, inappropriate testing (such as testing in patients who have received laxatives) can falsely elevate a hospital’s rate of *C difficile* infection and increase unnecessary and costly treatment. Policies promoting testing for urinary tract infection and *C difficile* infection may originally have been designed to reduce HAIs (or increase detection of HAIs that were present on admission) but may instead increase detection of asymptomatic colonization and promote unnecessary antibiotic use. Instead of indiscriminate testing, hospitals should promote diagnostic stewardship or practices to reduce unnecessary use of microbiologic testing to reduce costs associated with diagnostic testing and to improve antibiotic use within hospitals.

Our study has implications beyond the VA. In particular, our findings showed the strength of integrated health care systems to improve care nationally. Compared with results from a simultaneous study of a nationwide sample of non-VA hospitals, VA hospitals reported greater use of many infection prevention practices, such as the use of alternatives to indwelling urinary catheters, antimicrobial dressings with chlorhexidine for central lines, and soap and water hand hygiene for patients with *C difficile* infection. Although studies evaluating longitudinal trends in HAI prevention practices are limited, we generally found greater reported use of CAUTI, CLABSI, and VAP prevention practices than other national studies of non-VA hospitals, intensive care units, or nursing homes. The VA has been a leader in infection prevention and, more recently, in antibiotic stewardship. For example, the VA introduced a systemwide infection prevention initiative in 2007. Although initially targeting methicillin-resistant *Staphylococcus aureus*, this initiative included infection prevention practices applicable to all HAIs (eg, hand hygiene, contact precautions, and a hospital culture focused on infection prevention). The result was a sustained decline in hospital-onset, gram-negative bacteremia in VA hospitals through at least 2013.

Similarly, antibiotic stewardship programs were reported in 97% of VA hospitals, up from 92% of VA hospitals that reported having a written hospital policy that included an antibiotic stewardship program in 2015. In contrast, by 2015, only 48% of US hospitals nationally met all core elements of antibiotic stewardship (as defined by the Centers for Disease Control and Prevention). Though we did not assess implementation of antibiotic stewardship, previous studies have shown widespread use of multiple stewardship initiatives in VA hospitals, likely owing to Veterans Health Administration Directive 1031, which in 2013, established a policy for implementation and maintenance of Antimicrobial Stewardship Programs at all VA medical facilities. Similar programs did not become mandatory in non-VA hospitals until 2017. These successes within the VA may help inform infection prevention more broadly as hospitals continue to merge and health systems become increasingly integrated.

**Limitations**

This study has limitations. First, use was self-reported and may not reflect actual practices within hospitals. Second, response rates varied across years. Although response rates were high compared with other national multiyear surveys, this result could affect interpretation of longitudinal changes in practices. Third, we included only VA hospitals in this analysis, which may limit the applicability of our findings to non-VA hospitals. However, as more hospitals join integrated health care systems, these findings may offer insight into infection prevention across large systems. Fourth, not all questions were asked in all years, and some questions changed across years, limiting our ability to evaluate some longitudinal trends. Fifth, because of the inherent limitations of survey methods, we...
may have missed nuanced changes in infection prevention over time, such as whether increased use
reflected spread of practices in particular units or adoption of practices within bundles.

Conclusions

From 2005 to 2017, reported use of 12 different infection prevention practices increased in VA
hospitals. Areas for continued improvement of infection prevention practices appear to include
CAUTI, certain VAP practices, and diagnostic stewardship for HAI. The reported adoption of many
infection prevention practices in VA hospitals was higher than in non-VA hospitals. As hospitals
continue to merge and health systems become increasingly integrated, these successes could help
inform patient safety broadly.
REFERENCES


SUPPLEMENT.

eTable 1. Reported Regular Use of Infection Prevention Practices, by Year

eTable 2. Importance of Infection Prevention to Hospital Leadership, by Year