ORIGINAL ARTICLE

Reducing Inappropriate Urinary Catheter Use in the Emergency Department: Comparing Two Collaborative Structures

M. Todd Greene, PhD, MPH;[1,2,3] Mohamad G. Fakih, MD, MPH;[4] Sam R. Watson, MSA, CPPS;[5] David Ratz, MS;[1,3] Sanjay Saint, MD, MPH[1,2,3]

BACKGROUND. Urinary catheters, many of which are placed in the emergency department (ED) setting, are often inappropriate, and they are associated with infectious and noninfectious complications. Although several studies evaluating the effect of interventions have focused on reducing catheter use in the ED setting, the organizational contexts within which these interventions were implemented have not been compared.

METHODS. A total of 18 hospitals in the Ascension health system (ie, system-based hospitals) and 16 hospitals in the state of Michigan (ie, state-based hospitals led by the Michigan Health and Hospital Association) implemented ED interventions focused on reducing urinary catheter use. Data on urinary catheter placement in the ED, indications for catheter use, and presence of physician order for catheter placement were collected for interventions in both hospital types. Multilevel negative binomial regression was used to compare the system-based versus state-based interventions.

RESULTS. A total of 13,215 patients (889 with catheters) from the system-based intervention were compared to 12,104 patients (718 with catheters) from the state-based intervention. Statistically significant and sustainable reductions in urinary catheter placement (incidence rate ratio, 0.79; $P = .02$) and improvements in appropriate use of urinary catheters (odds ratio [OR], 1.86; $P = .004$) in the ED were observed in the system-based intervention, compared to the state-based intervention. Differences by collaborative structure in changes in presence of physician order for urinary catheter placement (OR, 1.14; $P = .60$) were not observed.

CONCLUSIONS. An ED intervention consisting of establishing institutional guidelines for appropriate catheter placement and identifying clinical champions to promote adherence was associated with reducing unnecessary urinary catheter use under a system-based collaborative structure.

Infect Control Hosp Epidemiol 2018;39:77–84

As many as 25% of inpatients have indwelling urinary catheters placed at some point during their hospitalization;[1] many of these are placed in the emergency department (ED) setting. An estimated 3 million urinary catheters are placed during an ED encounter in the United States each year.[2] Unfortunately, up to 65% of catheters placed in the ED may not be appropriate.[1,3–6] Catheter-associated urinary tract infection (CAUTI) is one of the most common healthcare-associated infections in the United States,[7] leading to excess morbidity, mortality, and costs.[8,9] Urinary catheters also cause other patient safety problems such as increased patient discomfort,[10] patient immobility,[11] and accidental removal.[12] Among the most effective approaches for reducing both infectious and noninfectious complications of urinary catheters is limiting indwelling urinary catheter use to cases in which an appropriate indication is present.[13] Considering that 18 million patients are admitted through the ED annually in the United States, appropriate catheter utilization in the ED is needed to reduce the clinical and economic burdens of urinary catheter-related harm.[2]

Collaborative approaches to infection prevention, which facilitate the sharing of best practices between participants, permit networking, provide content expertise, and allow for quantitative quality improvement comparisons, have become more common in recent years. Recent national surveys of acute-care hospitals in the United States have shown that the percentage of hospitals participating in a collaborative effort to reduce healthcare-associated infection increased from 42% to 83% between 2005 and 2013.[14,15] Specific to CAUTI prevention, national survey data from 2013 indicated that urinary catheter reminders and stop orders were used more regularly in hospitals participating in healthcare-associated infection collaboratives.[15] Successful collaborative approaches to reducing urinary catheter use and preventing CAUTI have been organized

Affiliations: 1. Center for Clinical Management Research, Veterans Affairs Ann Arbor Healthcare System, Ann Arbor, Michigan; 2. Department of Internal Medicine, University of Michigan Medical School, Ann Arbor, Michigan; 3. Veterans Affairs/University of Michigan Patient Safety Enhancement Program, Ann Arbor, Michigan; 4. Care Excellence, Ascension, St Louis, Missouri; 5. Michigan Health and Hospital Association, Okemos, Michigan.

Received August 3, 2017; accepted October 26, 2017; electronically published December 18, 2017

 0899-823X/2018/3901-0011. DOI: 10.1017/ice.2017.256

and implemented at the health system,[16,17] state,[18,19] and national[20,21] levels.

Starting in 2012, interventions focused on improving urinary catheter appropriateness in EDs were implemented as part of 2 distinct collaboratives. The first collaborative involved multiple hospitals within Ascension, a large non-for-profit health system with hospitals in 22 states and the District of Columbia. The second collaborative was led by the Michigan Health and Hospital Association (MHA), the organizing center for several previous successful collaborative efforts focused on device-related infections[19,22]; it consists of multiple hospitals in Michigan. To date, comparisons between collaborative approaches to urinary catheter reduction that have been implemented under different collaborative frameworks have not been conducted. Therefore, we compared the effectiveness of 2 distinct multisite, collaborative interventions, 1 system-based and 1 state-based. Both focused on reducing urinary catheter use in the ED.

METHODS

In 2012, a total of 18 Ascension hospitals participated in a system-based, collaborative ED intervention to reduce the use of urinary catheters, while 16 hospitals in the state of Michigan participated in a state-based ED collaborative with the same goal. Participation in both intervention settings was voluntary. Details of the interventions have been described previously.[16] Briefly, hospitals in both collaborative efforts were required to obtain leadership support, to identify both nurse and physician champions, and to establish institutional guidelines for appropriately indicated catheter placement based on Centers for Disease Control and Prevention (CDC) guidelines.[13] Both efforts implemented interventions to avoid inappropriate urinary catheter use, and one of the authors (M.G.F.) presented identical webinars on the technical aspects from indications to methods that help avoid catheter exposure. Table 1 illustrates the setting and the 3 study phases that occurred for both collaboratives.

Data Collection

Data were collected at the individual facilities and were then reported to the lead organizations (Ascension or MHA). Trained nurses at each facility collected the number of patients admitted through the ED, the number of patients admitted from the ED with a urinary catheter present, the indication for placement of catheters in the ED, and the number of catheters placed in the ED with a physician order. The primary outcome measure was rate of the newly placed urinary catheters in the ED (defined as the number of new catheters placed in the ED divided by the number of patients admitted during the same period and multiplied by 100). Appropriateness of urinary catheters placed in the ED (defined as the number of newly placed urinary catheters with an appropriate indication divided by the number of newly placed urinary catheters during the same period and multiplied by 100) and presence of physician order for the placement of a urinary catheter in the ED (defined as the number of physician orders for newly placed urinary catheters divided by the number of newly placed urinary catheters during the same period and multiplied by 100) were also tracked and compared as secondary outcomes.

Hospital EDs participating in the system-based intervention collected baseline data for 7 days (from June 4 to June 10, 2012), implementation data for 14 days (from June 18 to July 1, 2012), and sustainability data 1 day per month for 6 months (from July 2 to December 31, 2012). Among hospital EDs participating in the state-based intervention, baseline data were collected for 14 days (during April 2012), implementation data were collected for 12 days (in May 2012), and sustainability data were collected 1 day per month for 12 months (from June 2012 to May 2013). To be comparable to the Ascension cohort, we used the first 6 months of sustainability data reported for the MHA cohort in our analyses. For our analyses, all data from participating EDs were aggregated at the collaborative framework level (ie, system-based vs state-based) and at 3 distinct study phase levels: baseline, implementation, and sustainability.

Statistical Analysis

Descriptive statistics are given for comparisons of raw data by collaborative framework. Multilevel negative binomial regression with a random facility-level intercept was utilized to compare system-based versus state-based facilities regarding their performance in minimizing catheter use during the interventions. An interaction of group and time was used to test the hypothesis that system-based hospitals would perform better than state-based hospitals. Similarly, multilevel logistic regression models with random facility-level intercepts were used to compare system-based versus state-based facilities regarding the appropriateness of urinary catheter use and presence of a physician order accompanying urinary catheter placement. The interaction of group and time was again the coefficient of interest. Stata/MP software version 13.1 (StataCorp, College Station, TX) was used for all analyses.

RESULTS

The system-based cohort consisted of 13,215 patients with 889 urinary catheters placed in the ED. The state-based cohort consisted of 12,104 patients with 718 urinary catheters placed in the ED. Changes in urinary catheter placement, appropriateness, and presence of physician orders for both interventions can be found in Table 2. Multilevel regression results showed that the participating system-based EDs had higher catheter placement rates at baseline (incidence rate ratio [IRR], 1.34; 95% confidence interval [CI], 0.96–1.88; $P = .09$), but experienced greater declines over the course of the intervention (IRR, 0.79; 95% CI, 0.64–0.97; $P = .02$), compared to the EDs

https://doi.org/10.1017/ice.2017.256 Published online by Cambridge University Press

TABLE 1. Setting and Study Phases of Emergency Department Intervention to Reduce Inappropriate Use of Urinary Catheters

Setting	
System-Based (Ascension)	State-Based (Michigan Health & Hospital Association)
• All hospitals contacted • Voluntary enrollment based on hospital interest • Recruitment webinar attended by chief medical, nursing, and quality officers	• Emergency departments identified based on previous engagement in other initiatives • Participation in the intervention was voluntary
• Commitment from the site clinical leader for intervention enrollment	• Commitment from hospital president for intervention enrollment
• Educational webinars addressing the value of improving urinary catheter use • How to implement the improvements • Engaging emergency physicians and nurses • Tools to facilitate the work • Data collection and submission	• Educational webinars addressing the value of improving urinary catheter use • How to implement the improvements • Engaging emergency physicians and nurses • Tools to facilitate the work • Data collection and submission
Implementation tool kit • Description of the project • Different phases • Appropriate indications for catheter use • Proper insertion techniques • Educational tools	**Implementation tool kit** • Description of the project • Different phases • Appropriate indications for catheter use • Proper insertion techniques • Educational tools
Phases of the Study	
System-Based (Ascension)	State-Based (Michigan Health & Hospital Association)
Baseline (7 consecutive days) • Urinary catheter initial placement prevalence with evaluations for indications	**Baseline (14 consecutive days)** • Urinary catheter initial placement prevalence with evaluations for indications
Preimplementation (7 days) • Prepare the teams with sharing the institutional guidelines • Education without any data collection	**Preimplementation** (not applicable)
Implementation (14 consecutive days) • Nursing and physician staff education • Avoiding inappropriate urinary catheter placement • Education on proper insertion technique • Urinary catheter initial placement prevalence • Evaluation for indications • Feedback on performance	**Implementation (12 of 14 days)** • Nursing and physician staff education • Avoiding inappropriate urinary catheter placement • Education on proper insertion technique • Urinary catheter initial placement prevalence • Evaluation for indications • Feedback on performance
Sustainability (1 day per month, 6 days over 6 months) • Urinary catheter initial placement prevalence • Evaluation for indications • Feedback on performance	**Sustainability (12 days over 12 months)** • Urinary catheter initial placement prevalence • Evaluation for indications • Feedback on performance

participating in the state-based intervention. We detected no differences in the appropriateness of catheters placed between the system-based and state-based cohorts at baseline (odds ratio [OR], 1.04; 95% CI, 0.47–2.32; $P = .93$). However, there was an overall increase in appropriateness (all EDs combined regardless of collaborative framework) throughout the interventions (OR, 1.42; 95% CI, 1.08–1.87; $P = .01$) and system-based EDs made greater improvements in appropriateness over the course of the intervention (OR, 1.86; 95% CI, 1.22–2.84; $P = .004$). We detected no statistically significant overall changes over time (OR, 1.06; 95% CI, 0.74–1.53; $P = .74$) or differences between the system-based and state-based cohorts over time (OR, 1.14; 95% CI, 0.71–1.83; $P = .60$) in terms of catheter placement with accompanying physician orders.

The appropriateness of urinary catheter use increased from baseline to implementation for both the system-based and state-based cohorts from baseline to implementation, and appropriateness continued to increase for the state-based cohort during the sustainability phase. Changes in the indications noted for catheter placement for both interventions are illustrated in Table 3. Notable reductions for inappropriate indications among the system-based EDs were observed for the indications "other" (9.7% baseline; 1.3% sustainability) and "monitoring fluids in non-critically ill patients" (5.8% baseline;

https://doi.org/10.1017/ice.2017.256 Published online by Cambridge University Press

TABLE 2. Urinary Catheter Utilization, Appropriateness, and Presence of Physician Orders in Emergency Department (ED) by Collaborative Structure and Intervention Period

Cohort	Intervention Phase	Urinary Catheters Placed in the ED	No. of Patients	Appropriate Indication Noted	Physician Order for Catheter Placement Noted	Urinary Catheter Utilization, %	*P* Value[a]	Appropriate Urinary Catheter Use, %	*P* Value[a]	Urinary Catheters Placed With Physician Order Present, %	*P* Value[a]
System-based hospitals[b]	Baseline	309	3,381	226	268	9.1	Ref	73.1	Ref	86.7	Ref
	Intervention	423	6,896	385	378	6.1	< .001	91.0	< .001	89.4	.21
	Sustainability	157	2,938	145	139	5.3	< .001	92.4	< .001	88.5	.32
State-based hospitals[c]	Baseline	340	5,121	241	304	6.6	Ref	70.9	Ref	89.4	Ref
	Intervention	228	4,628	187	210	4.9	.03	82.0	.05	92.1	.38
	Sustainability	150	2,355	131	138	6.4	.97	87.3	.05	92.0	.99

[a]*P* values from stratified multilevel regression model with baseline as reference group.
[b]Ascension.
[c]Michigan Health & Hospital Association.

TABLE 3. Reasons Noted for Urinary Catheter Placement by Collaborative Structure and Intervention Period

	System-Based Hospitals (Ascension)			State-Based Hospitals (Michigan Health & Hospital Association)		
	Baseline (n = 309), No. (%)	Implementation (n = 423), No. (%)	Sustainability (n = 157), No. (%)	Baseline (n = 340), No. (%)	Implementation (n = 228), No. (%)	Sustainability (n = 150), No. (%)
Appropriate						
Accurate fluid measurements in critically ill patients	124 (40.3)	218 (51.9)	79 (50.3)	162 (47.6)	120 (52.6)	79 (52.7)
Need for prolonged immobilization	60 (19.5)	82 (19.5)	29 (18.5)	29 (8.5)	24 (10.5)	26 (17.3)
Urinary flow obstruction or urinary retention	28 (9.1)	54 (12.9)	24 (15.3)	22 (6.5)	27 (11.8)	16 (10.7)
Perioperative use in select surgical procedures	10 (3.2)	10 (2.4)	8 (5.1)	5 (1.5)	3 (1.3)	4 (2.7)
Sacral and perineal wound healing in incontinent patients	2 (0.6)	3 (0.7)	...	13 (3.8)	5 (2.2)	3 (2.0)
To improve comfort for end-of-life care	2 (0.6)	7 (1.7)	...	7 (2.1)	6 (2.6)	3 (2.0)
Acceptable institutional indication	...	10 (2.4)	4 (2.5)	3 (0.9)	2 (0.9)	...
Inappropriate						
Other	30 (9.7)	14 (3.3)	2 (1.3)	60 (17.6)	25 (11.0)	8 (5.3)
Monitoring fluids in non-critically ill patients	18 (5.8)	10 (2.4)	2 (1.3)	21 (6.2)	11 (4.8)	9 (6.0)
Immobility not related to trauma or surgery	11 (3.6)	1 (0.2)	2 (1.3)	...	...	...
Urine specimen collection	4 (1.3)	...	5 (3.2)	...	...	...
Dementia or chronic confusion	5 (1.6)	4 (1.0)	...	...	...	...
Debility	4 (1.3)	6 (1.4)	1 (0.6)	...	...	...
Incontinence without perineal or sacral wound	5 (1.6)	1 (0.2)	1 (0.6)	18 (5.3)	4 (1.8)	1 (0.7)
Patient request	3 (1.0)	...	...	...	...	...
Morbid obesity	2 (0.6)	...	...	...	...	...
Prolonged postoperative use	...	...	...	...	1 (0.4)	1 (0.7)

1.3% sustainability). In the state-based cohort, reductions in inappropriate indications were observed for the "incontinence without sacral or perineal wounds" (5.3% baseline; 0.7% sustainability) and "other" (17.6% baseline; 5.3% sustainability).

DISCUSSION

We present the results of a large multisite evaluation of interventions aimed at reducing inappropriate urinary catheter use in the ED under 2 different collaborative frameworks. Several important findings emerged from our study of urinary catheter use and appropriateness in the ED. First, we observed statistically significant greater reductions in urinary catheter placement among EDs in the system-based intervention compared to the EDs participating in the state-based intervention. Second, although we observed reductions in urinary catheter placement between baseline and implementation phases under both collaborative frameworks, decreases in urinary catheter placement rates were sustainable only under the system-based framework. Third, we detected statistically significant overall improvements in placing urinary catheters based on an appropriate indication, regardless of the collaborative framework that the intervention was implemented in. This finding is encouraging because education around and institutional support for appropriateness criteria for urinary catheter use were central to both interventions.

Several prior studies demonstrated successful reductions in urinary catheter placement in the ED and concurrent improvements in appropriateness of urinary catheters placed. Based on the findings from the 18 hospitals participating in the system-based ED intervention, Fakih et al[16] showed that establishing institutional guidelines for urinary catheter placement and identifying physician and nurse champions led to a 4% absolute reduction in newly placed catheters and a 24% increase in the appropriateness of newly placed catheters in the ED. Gokula et al[23] demonstrated increases in both appropriateness of urinary catheter use and presence of a physician order for catheter placement, as well as sustained decreases in the total number of catheters placed in the ED, following an intervention involving staff education and attaching an indication sheet to each catheter kit for staff to complete prior to placement. We did not detect overall improvements or differences by collaborative framework with respect to the presence of physician order for urinary catheter placement. The majority of urinary catheters placed in all participating EDs had a physician order present at baseline and this rate remained high throughout the interventions, in contrast to some earlier studies reporting that close to half of catheter placements did not have an accompanying physician order.[23,24] Prior studies have shown the impact of nurse-driven initiatives in reducing the number of patients leaving the ED with newly placed urinary catheters[25] and the number of CAUTIs associated with catheter insertion in the ED.[26]

The presentation of the technical components of the interventions were virtually identical in both collaborative frameworks. Which factors may have contributed to the greater reductions in urinary catheter placement in the EDs participating in the system-based intervention? First, the presence of ED physician and nurse champions were very well established at Ascension (the system-based cohort). Champions for the intervention at the Ascension EDs were actively engaged in establishing institutional guidelines promoting appropriate urinary catheter indications and ensuring completeness of data reporting throughout the intervention. Second, the organizational structure of Ascension may have contributed to greater accountability by directly engaging the teams and their local leaders through calls to discuss any barriers to implementation. Third, general CAUTI prevention has been a key focus area for Ascension hospitals since 2010. A survey of infection prevention practices at Ascension hospitals in 2012 showed that 79% of their hospitals had policies that include appropriate indications for catheterization, and 76% of their hospitals used bladder scanners to avoid inappropriate placement.[17] A repeat survey in 2014 revealed that up to 90% of their facilities have policies including the CDC appropriate indications and 90% use annual competency assessments for nurses regarding placement and care of urinary catheters.[27] On one hand, Ascension's ongoing organizational commitment to CAUTI prevention efforts, which include reducing catheter use, may have facilitated the uptake and sustainability of efforts to reduce inappropriate catheter use within the ED environment specifically. On the other hand, the state-based cohort started with a lower baseline, which may reflect more engaged staff in best practices and, thus, a narrower opportunity for improvement.

In this study, roughly 80% of urinary catheters placed in the ED were accompanied by an appropriate indication. It is encouraging that we observed significant improvements in the appropriate use of urinary catheters among all 34 EDs participating in this study. These facilities implemented interventions that focused on establishing institutional guidelines for urinary catheter appropriateness, on providing staff education on appropriateness criteria, and on identifying physicians and nurses to champion and promote the adoption of and adherence to the developed guidelines. While the present and previous studies demonstrate that focused interventions can successfully reduce inappropriate urinary catheter use in the ED, room for further improvement remains. A recent study of 129 ED providers found that despite self-reported knowledge of appropriate urinary catheter indications, when presented with clinical vignettes, the appropriate approach for urinary catheter placement was only correctly identified in 40% of cases among nurses and in 37% of cases among mid-level providers and physicians.[28] Additionally, this same study also found that ED providers very infrequently reassessed their patients for urinary catheter necessity during shift changes or at admission.[28]

Our findings need to be considered in the context of the following limitations. Participation in both the system-based and state-based interventions was voluntary, and our findings may not be generalizable to other EDs. Additionally, although we compared the effectiveness of similar ED interventions

https://doi.org/10.1017/ice.2017.256 Published online by Cambridge University Press

across multiple hospitals by different collaborative frameworks, we did not have external control groups to evaluate secular trends in EDs generally. Although similar, the data collection schedules differed modestly between EDs in the system-based and state-based hospitals, which may have impacted overall comparisons between the groups. Still, the data collected from multiple hospitals in each group provided robust aggregate numbers of patient and device days with which to compare each intervention phase.

Additionally, EDs in the system-based intervention had a 1-week preimplementation period, which may have provided better preparedness and additional opportunities for education. However, no data were collected during this period, so we were unable to quantitatively examine its impact on our metrics of interest. Emergency departments participating in the state-based intervention had, on average, lower catheter placement rates at baseline, which may have impacted their ability to achieve and sustain further significant reductions in urinary catheter placement rates. However, we did not observe statistically significant changes in catheter placement by collaborative framework over time, when stratifying baseline catheter placement rates by a cutoff point of 8% (results not shown).

Although the overall increase in documentation of appropriate indications across the interventions is a positive finding, we cannot rule out the possibility of biased documentation given the intervention focus on appropriate urinary catheter use (ie, limiting selection of indications to those appropriate). Notably, there was a systematic decrease in the overall use of the "other" inappropriate indication across the interventions, potentially suggesting that the interventions were successful in drawing increased attention and scrutiny toward indication selection. Finally, we were unable to evaluate the impact of the intervention on CAUTI rates or other noninfectious complications directly.

Limitations notwithstanding, our study shows that focused interventions can effectively reduce inappropriate urinary catheter use in the ED setting. Emergency departments participating in the intervention in the system-based hospitals demonstrated statistically significant greater reductions in urinary catheter placement over the course of the intervention than those in the state-based hospitals, and system-based hospitals were able to sustain reductions, suggesting that sustained improvements may be partially dependent upon the collaborative framework under which the interventions are implemented. Given the paucity of studies on urinary catheter placement in the ED, an achievable target number for urinary catheter utilization in this clinical setting is unclear. Fakih et al[16] previously demonstrated that EDs with baseline placement rates of <5% were unable to achieve further reductions in catheter placement, despite participating in focused interventions. Given this finding, coupled with our findings that EDs in the state-based intervention were able to achieve placement rates <5% during implementation and those in the system-based intervention approached 5% during the sustainability phase, interventions focused on reducing urinary catheter utilization in the ED setting may best benefit EDs with utilization rates >5%. Regardless, we continue to encourage all EDs to establish and adhere to institutional guidelines regarding appropriate catheter placement, to identify clinical champions[29] to encourage and reinforce appropriate catheter use, and to monitor device utilization ratios[30] in the ED setting as a means of tracking performance related to potential overall urinary catheter harm. Because the ED is usually a patient's first point of entry into the hospital, reducing inappropriate urinary catheter use in this setting is crucial for improving patient safety by reducing both infectious and noninfectious complications associated with urinary catheter use.

ACKNOWLEDGMENTS

Financial support: This work was supported by a grant from the National Institute of Diabetes and Digestive and Kidney Diseases (grant no. 1R21DK101654-01A1). The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Department of Veterans Affairs.

Potential conflicts of interest: Dr Saint reports receiving fees for serving on advisory boards from Doximity and Jvion. All authors report no conflicts of interest relevant to this article.

Address correspondence to M. Todd Greene, PhD, MPH, Center for Clinical Management Research, VA Ann Arbor Healthcare System, Department of Internal Medicine, Michigan Medicine, 2800 Plymouth Rd, NCRC Bldg 16, Room 470C, Ann Arbor, MI 48109 (mtgreene@med.umich.edu).

REFERENCES

1. Gokula RR, Hickner JA, Smith MA. Inappropriate use of urinary catheters in elderly patients at a midwestern community teaching hospital. *Am J Infect Control* 2004;32:196–199.
2. National Hospital Ambulatory Medical Care Survey: 2010 Emergency Department Summary Tables. Centers for Disease Control and Prevention website. http://www.cdc.gov/nchs/data/ahcd/nhamcs_emergency/2010_ed_web_tables.pdf. Published 2011. Accessed November 15, 2017.
3. Gardam MA, Amihod B, Orenstein P, Consolacion N, Miller MA. Overutilization of indwelling urinary catheters and the development of nosocomial urinary tract infections. *Clin Perform Qual Health Care* 1998;6:99–102.
4. Jain P, Parada JP, David A, Smith LG. Overuse of the indwelling urinary tract catheter in hospitalized medical patients. *Arch Intern Med* 1995;155:1425–1429.
5. Munasinghe RL, Yazdani H, Siddique M, Hafeez W. Appropriateness of use of indwelling urinary catheters in patients admitted to the medical service. *Infect Control Hosp Epidemiol* 2001;22:647–649.
6. Schuur JD, Chambers JG, Hou PC. Urinary catheter use and appropriateness in US emergency departments, 1995–2010. *Acad Emerg Med* 2014;21:292–300.
7. Klevens RM, Edwards JR, Richards CL Jr, et al. Estimating health care-associated infections and deaths in US hospitals, 2002. *Public Health Rep* 2007;122:160–166.
8. Foxman B. Epidemiology of urinary tract infections: incidence, morbidity, and economic costs. *Am J Med* 2002;113(Suppl 1A): 5S–13S.

https://doi.org/10.1017/ice.2017.256 Published online by Cambridge University Press

9. Saint S. Clinical and economic consequences of nosocomial catheter-related bacteriuria. *Am J Infect Control* 2000; 28:68–75.
10. Saint S, Lipsky BA, Baker PD, McDonald LL, Ossenkop K. Urinary catheters: what type do men and their nurses prefer? *J Am Geriatr Soc* 1999;47:1453–1457.
11. Saint S, Lipsky BA, Goold SD. Indwelling urinary catheters: a one-point restraint? *Ann Intern Med* 2002;137:125–127.
12. Hollingsworth JM, Rogers MA, Krein SL, et al. Determining the noninfectious complications of indwelling urethral catheters: a systematic review and meta-analysis. *Ann Intern Med* 2013;159:401–410.
13. Gould CV, Umscheid CA, Agarwal RK, Kuntz G, Pegues DA. Guideline for prevention of catheter-associated urinary tract infections 2009. *Infect Control Hosp Epidemiol* 2010;31:319–326.
14. Krein SL, Kowalski CP, Hofer TP, Saint S. Preventing hospital-acquired infections: a national survey of practices reported by US hospitals in 2005 and 2009. *J Gen Intern Med* 2012;27:773–779.
15. Krein SL, Greene MT, Apisarnthanarak A, et al. Infection prevention practices in Japan, Thailand, and the United States: results from national surveys. *Clin Infect Dis* 2017;64(Suppl 2): S105–S111.
16. Fakih MG, Heavens M, Grotemeyer J, Szpunar SM, Groves C, Hendrich A. Avoiding potential harm by improving appropriateness of urinary catheter use in 18 emergency departments. *Ann Emerg Med* 2014;63:761–768.
17. Fakih MG, Heavens M, Ratcliffe CJ, Hendrich A. First step to reducing infection risk as a system: evaluation of infection prevention processes for 71 hospitals. *Am J Infect Control* 2013;41:950–954.
18. Fakih MG, Watson SR, Greene MT, et al. Reducing inappropriate urinary catheter use: a statewide effort. *Arch Intern Med* 2012;172:255–260.
19. Saint S, Greene MT, Kowalski CP, Watson SR, Hofer TP, Krein SL. Preventing catheter-associated urinary tract infection in the United States: a national comparative study. *JAMA Intern Med* 2013;173:874–879.
20. Fakih MG, George C, Edson BS, Goeschel CA, Saint S. Implementing a national program to reduce catheter-associated urinary tract infection: a quality improvement collaboration of state hospital associations, academic medical centers, professional societies, and governmental agencies. *Infect Control Hosp Epidemiol* 2013;34:1048–1054.
21. Saint S, Greene MT, Krein SL, et al. A program to prevent catheter-associated urinary tract infection in acute care. *N Engl J Med* 2016;374:2111–2119.
22. Pronovost P, Needham D, Berenholtz S, et al. An intervention to decrease catheter-related bloodstream infections in the ICU. *N Engl J Med* 2006;355:2725–2732.
23. Gokula RM, Smith MA, Hickner J. Emergency room staff education and use of a urinary catheter indication sheet improves appropriate use of Foley catheters. *AmJ Infect Control* 2007;35:589–593.
24. Fakih MG, Pena ME, Shemes S, et al. Effect of establishing guidelines on appropriate urinary catheter placement. *Acad Emerg Med* 2010;17:337–340.
25. Patrizzi K, Fasnacht A, Manno M. A collaborative, nurse-driven initiative to reduce hospital-acquired urinary tract infections. *J Emerg Nurs* 2009;35:536–539.
26. Burnett KP, Erickson D, Hunt A, Beaulieu L, Bobo P, Shute P. Strategies to prevent urinary tract infection from urinary catheter insertion in the emergency department. *J Emerg Nurs* 2010;36:546–550.
27. Fakih MG HM, Grotemeyer J, Hendrich A. The power of a system: addressing catheter-associated urinary tract infections (CAUTI) in intensive care units. ID Week 2015; October 7–11, 2015; San Diego, CA.
28. Viswanathan K, Rosen T, Mulcare MR, et al. Emergency department placement and management of indwelling urinary catheters in older adults: knowledge, attitudes, and practice. *J Emerg Nurs* 2015;41:414–422.
29. Damschroder LJ, Banaszak-Holl J, Kowalski CP, Forman J, Saint S, Krein SL. The role of the champion in infection prevention: results from a multisite qualitative study. *Qual Saf Health Care* 2009;18:434–440.
30. Fakih MG, Gould CV, Trautner BW, et al. Beyond infection: device utilization ratio as a performance measure for urinary catheter harm. *Infect Control Hosp Epidemiol* 2016; 37:327–333.

https://doi.org/10.1017/ice.2017.256 Published online by Cambridge University Press