

Reducing Catheter-Associated Urinary Tract Infections Across a Hospital System Through Urine Culture Stewardship

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Abstract

Objective: To evaluate the effectiveness and safety of an evidence-based urine culture stewardship program in reducing hospital catheter-associated urinary tract infections (CAUTIs) and the rate of CAUTIs across a 3-hospital system.

Patients and Methods: This is a prospective, 2-year quality improvement program conducted from October 1, 2018, to September 30, 2020. An evidence-based urine culture stewardship program was designed, which consisted of the following: criteria for allowing or restricting urine cultures from catheterized patients, a best practice advisory integrated into the ordering system of an electronic medical record, and a systematic provider education and feedback program to ensure compliance. The system-wide rates of CAUTIs (total CAUTIs/catheter days \times 1000), changes in intercepts, trends, mortality, length of stay, rates of device utilization, and rates of hospital-onset sepsis were compared for 3 years before and 2 years after the launch of the program.

Results: Catheter-associated urinary tract infections progressively decreased after the initiation of the program ($B=-0.21$, $P=.001$). When the trends before and after the initiation of the program were compared, there were no statistically significant increases in the ratio of actual to predicted hospital length of stay, intensive care unit length of stay, system-wide mortality, and intensive care unit mortality. Although the rates of hospital-acquired sepsis remained consistent after the implementation of the stewardship program through the first quarter of 2020, the rates showed an increase in the second and third quarters of 2020. However, hospital-onset sepsis events associated with the diagnosis of a urinary tract infection did not increase after the intervention.

Conclusion: Urine culture stewardship is a safe and effective way to reduce CAUTIs among patients in a large multihospital health care system. Patient safety indicators appeared unchanged after the implementation of the program, and ongoing follow-up will improve confidence in the long-term sustainability of this strategy.

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Emerging data have suggested that the criteria used to standardize the identification of catheter-associated urinary tract infections (CAUTIs) for the purpose of surveillance result in the inclusion of some events that may not be clinically significant urinary tract infections (UTIs) requiring treatment, particularly in critically ill patients.^{1,2} These studies have suggested that a subset of CAUTIs represent incidentally detected, asymptomatic, catheter-related bacteriuria, or

an alternate condition accounting for symptoms such as fever that leads to ordering of a urine culture. There is increasing recognition that inappropriate use of urine cultures may be driving the detection and inappropriate treatment of asymptomatic catheter-related bacteriuria instead of clinically meaningful UTIs associated with the use of indwelling urinary catheters.²

The current practice of the use of urine cultures, especially in critically ill patients, is

driven by the belief that failure to obtain cultures even with a minimal indication of infection might result in harm to the patient. However, this practice can result in the misattribution of asymptomatic bacteriuria as the cause of symptoms and prevent or delay further clinical evaluation of other potential sources of infection. Medical students and residents are still taught to “pan culture” at the first sign of fever and are compelled to react with treatment to any positive results even when those cultures may not be clinically meaningful.³ Small studies aiming to avoid the “knee jerk” reaction of sending urine cultures from catheterized patients have demonstrated both the safety and efficacy of urine culture stewardship.^{4,5}

The goal of our quality improvement (QI) program was to show that the use of an evidence-based urine culture stewardship program, in addition to existing CAUTI prevention strategies, would reduce the rate of CAUTIs across our health care system without causing harm to patients.

PATIENTS AND METHODS

Setting

WakeMed Health and Hospitals is a not-for-profit hospital system that includes a level 1 trauma center with an attached inpatient rehabilitation hospital, level 2 trauma center, and community hospital with a total of 920 beds across 3 campuses in the metropolitan Raleigh, North Carolina, area. The WakeMed Urine Culture Stewardship Program (WMUCSP) was implemented in October 2018 in the adult medical unit, surgical unit, and intensive care unit (ICU) as part of a system-wide QI initiative to augment existing efforts to reduce CAUTIs and the utilization of urinary catheters.

The previous CAUTI prevention activities implemented in the health care system included the following: periodic assessment of catheter insertion and maintenance practices coupled with required educational sessions for all nursing staff; creation of a urinary catheter maintenance bundle with regular auditing and feedback of compliance to nursing units; development of a multidisciplinary, system-wide CAUTI task force responsible for continuous data review; sharing of the rates of CAUTIs and conducting

a root-cause analysis of CAUTI events with nursing staff; addition of new incontinence management products such as female external urine collection devices and better-designed condom catheters; development of indwelling urinary catheter indications with provider education; and a best practice advisory (BPA) in the electronic medical record (EMR) to prompt early removal of urinary catheters that no longer meet approved indications. At the time of implementation, facility data on patient outcomes were collected solely to assess the impact and safety of this QI program and exempted from institutional review board submission and approval.

Program Implementation

The WMUCSP consists of 3 key elements: establishing approved criteria and indications for ordering a urine culture for patients with indwelling urinary catheters; deploying an electronic BPA in the EMR and order-entry system to ensure that culture orders meet the new urine culture stewardship criteria; and implementing a comprehensive clinician education and engagement activity to promote understanding of and compliance with new criteria for ordering urine cultures among providers. A review of published urine culture stewardship data was used to formulate criteria based on which sending a urine culture from a catheterized patient was allowed (Table 1).^{2,4-6} If none of the criteria were met, the order for urine culture was not approved.

The BPA was triggered any time a provider tried to order a urine culture from a patient with an indwelling urinary catheter, reminding the provider of urine culture stewardship and requiring them to choose a clinical indication for ordering the culture. If no approved clinical indication was chosen, the patient was deemed to be at a low risk and the order for urine culture could not proceed. Alternative options, such as changing the indwelling urinary catheter and evaluating other sources of symptoms, were provided. If any approved clinical indication was met and chosen, the order for urine culture could proceed.

To obtain clinician support for WMUCSP, a series of educational activities were implemented. The architect of this QI initiative was the director of the urology department

TABLE 1. Criteria for Approving a Urine Culture From An Inpatient With an Indwelling Urinary Catheter

Fever in a patient who has received a renal transplant
Recent urological surgery (within the past 7 d)
Fever in a pregnant patient
Fever in a leukopenic patient (WBC < 1.5)
Fever and known hydronephrosis
Septic shock (must-meet criteria): Hypotension requiring vasopressor therapy to maintain a mean BP of ≥ 65 mm Hg and having a serum lactate level of >2 mmol/L after adequate fluid resuscitation ⁶
Diabetes mellitus with flank pain and CT or ultrasound evidence of renal or perinephric inflammation, abscess, or air
A qSofa score of ≥ 2 and new flank or suprapubic pain that lacks another explanation after chest and abdominal imaging (qSofa: 1 point each for the following: AMS, SBP < 100 mm Hg, and RR ≥ 22 breaths/min)
AMS, altered mental status; BP, blood pressure; CT, computed tomography; qSofa, quick sequential organ failure assessment; RR, respiratory rate; SBP, systolic blood pressure; WBC, white blood cell.

and colead of the CAUTI Task Force, considered by the medical staff to be both a colleague and subject matter expert. As a champion for WMUCSP, this physician initiated a series of communications to the medical staff, starting 6 months before the deployment of the BPA, to explain the rationale behind the program and enlisting their engagement and support for the program. Within 3 months before the launch of the program, all nursing staff, medical staff, house staff, and medical students were required to complete a brief training

module, including protocol details and safety parameters regarding the program. The training content and embedded clinical reminders within the BPA incorporated humor to maintain attention to the importance of WMCUSP (Figure 1).

After the implementation of the BPA, the members of the CAUTI Task Force conducted regular audit and reviews of all urine culture ordering events triggered within the EMR. Clinical data on each associated order of urine culture were reviewed by the members of the CAUTI Task Force using a standard tool maintained in a database. Providers noted to follow the BPA received positive feedback through an email thanking them. If an ordering provider inappropriately picked one of the required criteria to force the culture to proceed, a rapid feedback email was provided. For physicians who serially disregard the BPA, a phone call was made to the ordering provider by one of the cochairpersons of the CAUTI Task Force. To reinforce the BPA and maintain attention on the program, additional follow-up communications were sent by the physician champion to all medical staff reporting improvements and encouraging everyone to keep supporting the program.

Safety Monitoring

In collaboration with colleagues from the Centers for Disease Control and Prevention, the QI team incorporated a safety monitoring plan into WMUCSP, which was reviewed and approved by our institution's Chief Quality Officer and the hospital system's board of directors. Because adherence to the BPA would

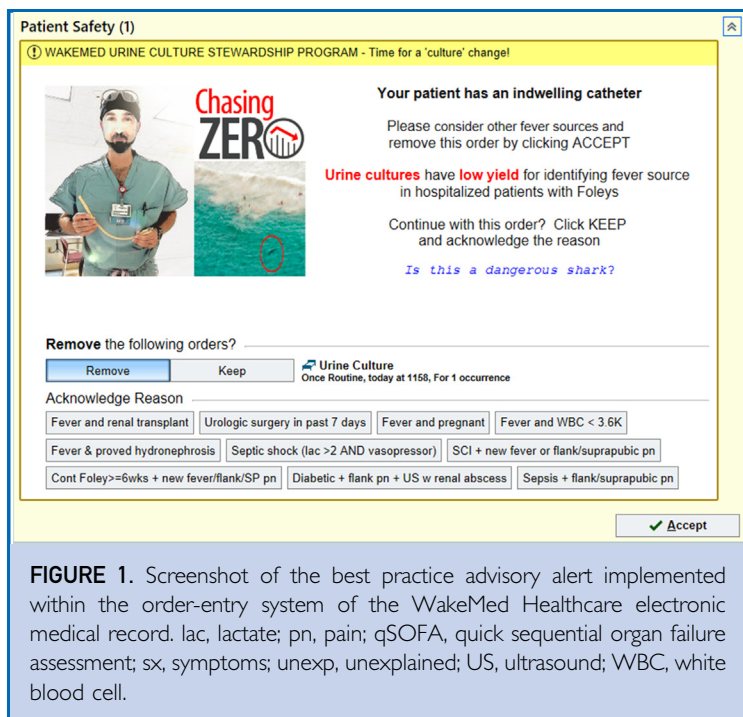


FIGURE 1. Screenshot of the best practice advisory alert implemented within the order-entry system of the WakeMed Healthcare electronic medical record. lac, lactate; pn, pain; qSOFA, quick sequential organ failure assessment; sx, symptoms; unexp, unexplained; US, ultrasound; WBC, white blood cell.

restrict some patients from having a urine culture submitted, the team wanted to ensure that clinically significant CAUTIs were not missed as a result of the program. As an additional safety measure, if a practitioner felt strongly that an order should be allowed to proceed outside of the WMUCSP criteria, a member of the CAUTI Task Force was available 24×7 to request an exception.

Statistical Analysis

The rates of CAUTIs, the rates of urinary catheter utilization as defined by National Healthcare Safety Network (NHSN), and all other secondary outcomes were analyzed using data from 3 years before and 2 years after the implementation of the program. The secondary outcomes included analysis of measures identified as surrogates for safety after the launch of the program, including overall hospital length of stay (LOS), ICU LOS, hospital mortality, ICU mortality, and rate of system-wide hospital-onset sepsis as determined by predefined International Classification of Diseases, 10th Revision, codes for sepsis, excluding events deemed to be present at admission (Premier Healthcare, Premier Inc). The LOS, hospital mortality, and ICU mortality were analyzed using the ratio of actual vs expected, where the expected values were calculated using Acute Physiology and

Chronic Health Evaluation IVb prediction models incorporated into the electronic ICU software (Cerner Corporation). Changes in the rates and expected ratios were compared using segmented interrupted time series. This included assessing differences in levels (intercept) and trends (slope) in quarterly infection rates before the implementation of the stewardship program with those in quarterly infection rates after the implementation of the stewardship program. Mid P exact tests were used for pairwise comparisons of pooled mean rates of CAUTIs and device utilization (DU) as well as expected vs observed LOS and mortality.

The serial autocorrelation between data points was assessed, and the Durbin-Watson statistic was used, when appropriate, for the final regression models. The Engle-Granger cointegration test was used to assess seasonality and stationarity. Statistical significance testing was conducted at $\alpha=0.05$. Statistical analyses were performed using SAS 9.4 (SAS Institute).

RESULTS

Before the implementation of the program, the rate of catheter utilization across the hospitals within the WakeMed Healthcare system decreased from 17.9% in 2016 to 14.4% in 2018. Despite this reduction in the use of

TABLE 2. Comparison of Outcomes Before and After the Implementation of the Stewardship Program Across the WakeMed Health Care System: 2016–2020

Outcomes	Before stewardship program	After stewardship program	P value	P value	
				Δ Level (P value)	Δ Trend (P value)
CAUTIs per 1000 catheter d	2.088	0.897	<.001	−0.393 (.167)	−0.205 (.001)
Device utilization rate	0.169	0.128	<.001	−0.014 (.278)	0.005 (.099)
Mortality ratio (observed vs expected)	1.064	1.019	.234	−0.161 (.096)	0.024 (0.181)
ICU mortality ratio (observed vs expected)	1.061	1.070	.839	−0.114 (.156)	−0.008 (.567)
Length of stay (observed vs expected)	1.127	1.114	<.001	−0.034 (.532)	0.017 (.100)
ICU length of stay (observed vs expected)	0.994	0.987	<.001	−0.009 (.809)	0.011 (.133)
Rate of hospital-onset sepsis per 1000 discharges	4.034	3.653	.178	−0.479 (.38)	0.536 (.003)

CAUTI, catheter-associated urinary tract infection; ICU, intensive care unit.

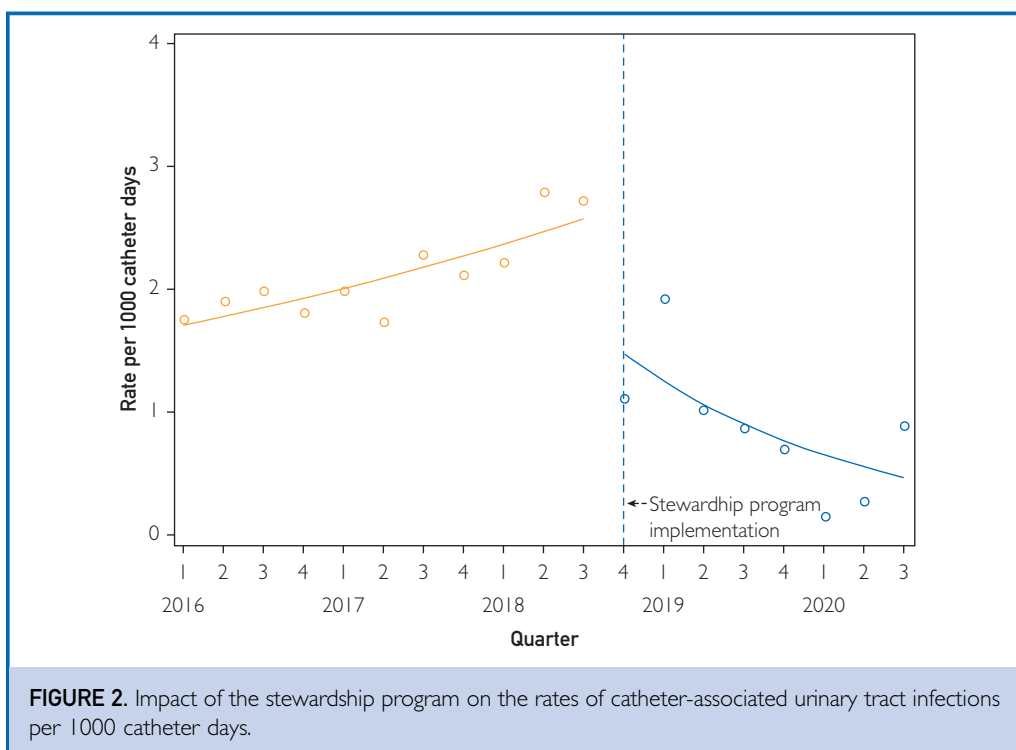


FIGURE 2. Impact of the stewardship program on the rates of catheter-associated urinary tract infections per 1000 catheter days.

catheters, the rate of CAUTIs paradoxically increased from 1.86 to 2.86 over the same time period. After the implementation of WMUCSP, the rate of CAUTIs before and after the implementation of the program decreased significantly from 2.09 to 0.90 ($P < .001$), and the rate of CAUTIs trended downward after the implementation of the program ($\beta = -0.205$, $P = .001$) (Figure 2). The DU rate, as calculated by NHSN, continued to decline over the 2-year program period.

There were no changes in the ratio of actual to predicted hospital LOS, ICU LOS, system mortality, or ICU mortality when the 3-year period before the launch of the program was compared with the 2-year period after the launch of the program (Table 2). Although there was no statistical difference in the rates of hospital-onset sepsis before and after the implementation of the program (4.03 vs 3.65, respectively; $P = .178$), the rates trended upward after implementation because of influential observations in the second and third quarters of 2020 (Figure 3). We conducted a postanalysis query to determine the number of hospital-onset sepsis

events using a concomitant International Classification of Diseases, 10th Revision, code for UTIs. This proportion was 19% during the preintervention period and 9% in the postintervention period (data not shown).

DISCUSSION

This urine culture stewardship QI program successfully reduced the rate of CAUTIs by 79% across our health care system while continuing to reduce the DU rate by an additional 20% after the implementation of the program. Although we included outcome data from 2020, which may have been impacted by the coronavirus disease 2019 pandemic, we did not observe an overall increase in hospital or ICU LOS or ICU mortality. During the postintervention evaluation period, we observed flattening of a previously decreasing rate of hospital-onset sepsis. However, the rate appeared to be increasing as a result of changes in the last 2 quarters (quarters 2 and 3 of 2020), which also coincided with a rise in admissions for coronavirus disease 2019 in our hospitals. Although not part of the safety evaluation initially, a posthoc analysis found that the proportion of hospital-

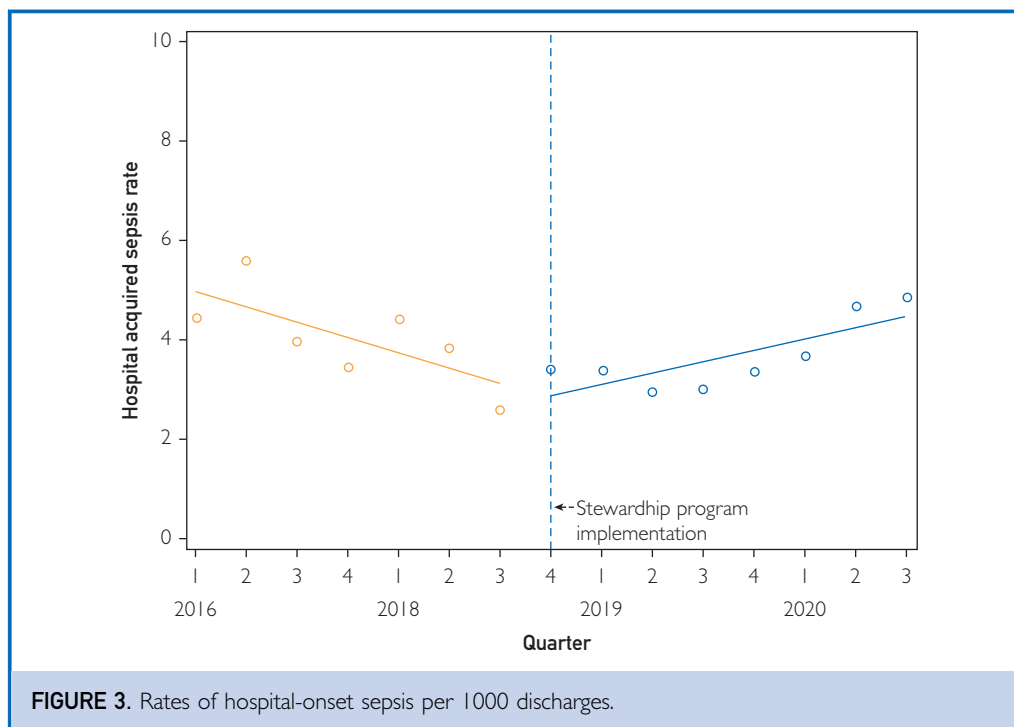


FIGURE 3. Rates of hospital-onset sepsis per 1000 discharges.

onset sepsis events associated with a diagnostic code for UTI did not increase during the postintervention period.

Because CAUTIs are incriminated as one of the top causes of nosocomial morbidity and mortality, the debate on the risk vs benefit of the use of urinary catheters is one held by clinicians every day throughout the world. It is frequently reported that CAUTIs are responsible for 449,334 events per year, each costing between \$750 and \$3800 and resulting in a total of over \$340 million yearly, attributable to the incidence of CAUTIs in the United States.⁷ Over the past decade, pay-for-performance programs, such as value-based purchasing and the hospital-acquired condition reduction programs, have resulted in severe financial penalties against hospitals with higher-than-expected rates of CAUTIs.⁸ In response, hospitals have scrambled to quickly reduce CAUTIs to improve patient safety and avoid financial damages.

Because a patient cannot have a CAUTI without an indwelling urinary catheter and unnecessary use of catheters puts patients at the risk of harm, reducing DU became the foundation of many CAUTI reduction programs. Reduced and limited use of indwelling

urinary catheters became, and still is, a standard practice in hospitals all over the country, resulting in clinicians avoiding their use and removing them as soon as possible. Public reporting of the rates of CAUTIs through Hospital Compare, Leapfrog Scores, and Healthgrades have even made the public wary of device-related UTIs during hospitalization.⁹ Thus, hospitals risk reputational damage if their publicly reported CAUTI metric is too high. Ironically, aggressive catheter removal programs have been shown to increase the rates of CAUTIs in some instances.^{3,10} Strategies to remove or never place catheters, particularly in patients at a lower risk of asymptomatic bacteriuria, could reduce the total number of catheter days while less significantly affecting the number of CAUTI events, resulting in overall higher rates of CAUTIs.³ Therefore, hospitals that are most successful at reducing the use of urinary catheters may appear to have less effective prevention programs.¹⁰

Before the initiation of WMUCSP, our hospital system experienced the paradox of having robust nursing catheter care programs and one of the lowest rates of catheter utilization in the entire state¹¹ while still seeing the

rate of CAUTIs increase every year. Data from this QI study support the fact that the safest and most effective way to reduce the rates of CAUTIs is to not only reduce exposure to indwelling urinary catheters but also address the detection and overtreatment of asymptomatic catheter-associated bacteriuria through urine culture stewardship. Several studies evaluating the efficacy of CAUTI reduction bundles have taken similar approaches to incorporate improvements in both DU and urine culture practices.^{3,4} The investigators noted that reducing catheter utilization in isolation may have had the undesirable effect of increasing the rates of CAUTIs by dramatically reducing the denominator while minimally affecting the numerator. Now, through the inclusion of urine culture stewardship, this paradox can be averted.

An increasing body of evidence has suggested that the surveillance definition of CAUTI includes a subset of events in which the source of symptoms may not be the urinary tract. In 2015, Tedja et al¹ demonstrated that 51% of critically ill patients diagnosed with CAUTIs actually had an alternative source of fever, 18% had noninfectious sources of fever, and 32% had no identifiable source. Urine culture results were not helpful in guiding any changes in antibiotic therapy. Furthermore, only 6% of patients with CAUTIs developed bacteremia, and the urinary tract could not be definitively established as the source of bloodstream infection. In a large veterans affairs study, Trautner et al⁵ demonstrated that restricting ordering of urine cultures resulted in significantly less treatment of asymptomatic catheter-associated bacteriuria, without increased reporting of adverse sequelae of the protocol. Not only can urine culture stewardship be implemented without harm to patients, a case can be made that detecting asymptomatic bacteriuria due to inappropriate use of urine cultures is a harmful driver of overutilization of antibiotics.^{1,5} Eliminating the detection of incidental catheter-associated bacteriuria will curb the perceived obligation to treat patients with a positive result and improve the in-hospital use of antibiotics.¹²

Although the findings of this QI initiative are encouraging, we acknowledge some limitations of the program's design and evaluation. The electronic BPA was activated

simultaneously in the physician order-entry system, preventing the opportunity to have control units and impacting our ability to account for unrecognized confounders. Because of resource constraints, data collection and the analysis of outcomes were conducted at the system level and could not be stratified by facility or unit. Thus, it is possible that the reduction in the rates of CAUTIs may not have been equal across the different hospitals or unique patient groups. Finally, although several clinically important patient safety outcomes, such as mortality and LOS, were monitored to detect unintended harm during the implementation of this diagnostic stewardship program, we recognize that these are indirect measures influenced by many other external factors unrelated to the intervention.

Despite these limitations, we believe that WMUCSP safely avoided the overdiagnosis and overtreatment of clinically insignificant catheter-associated bacteriuria. One of the keys to our success was medical provider support and adherence to the program. In his landmark paper on the psychological conditions of personal engagement and disengagement at work, Kahn¹³ described 3 conditions that are vital to successful workplace engagement, namely, meaningfulness, safety, and availability. Our frequent outreach leading up to and during the program met these conditions to effectively engage all ordering providers in our hospital system, thus promoting camaraderie and personal investment in the initiative. Engagement with 24×7 support from the CAUTI Task Force was expectedly robust during the first 3 months of the program, with emails or phone inquiries occurring approximately 5-7 times per week. However, after providers became more comfortable and familiar with the protocol, the task force was rarely contacted. Although this program was limited to a single health care system, our experience mirrors the findings of several other programs.^{4,5} In addition, as the total number of CAUTIs decreased, we observed a shift in the clinical patient population experiencing CAUTIs from patients with indwelling catheters presenting with fever and a positive urine culture result to patients developing urinary tract symptoms after catheter removal remaining in the infection window for CAUTI surveillance. Although

additional follow-up will be needed to verify this observation, recognizing this new catheter-associated complication will help target our prevention efforts to a group of patients with an increased risk of symptomatic infections. By removing the “noise” of incidental catheter-associated bacteriuria, providers can approach the detection and prevention of CAUTIs in a way that focuses on clinically significant events in patients who would truly benefit from improved management of urinary catheters.

POTENTIAL COMPETING INTERESTS

The authors report no competing interests.

Abbreviations and Acronyms: BPA, best practice advisory; CAUTI, catheter associated urinary tract infection; CDC, Centers for Disease Control and Prevention; EMR, electronic medical record; LOS, length of stay; WMUCSP, WakeMed Urine Culture Stewardship Program

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