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MAJOR ARTICLE

Knowledge and Practices of Physicians and Nurses Related to Urine Cultures in Catheterized Patients: An Assessment of Adherence to IDSA Guidelines

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Background. A positive urine culture often drives initiation of antimicrobials even in the absence of symptoms. Our objectives were to evaluate the knowledge and practice patterns related to ordering urine cultures in patients with indwelling urinary catheters.

Methods. We performed chart reviews of catheter-associated urinary tract infections (CAUTIs) at our academic health care system between October 1, 2015, and September 30, 2017, to assess practice patterns related to the assessment of potential CAUTIs. Following this, we surveyed physicians and nurses about indications for ordering urine cultures in catheterized patients between January 11, 2018, and April 17, 2018. The accuracy of these indications was assessed based on Infectious Diseases Society of America CAUTI and asymptomatic bacteriuria guidelines.

Results. On chart review, we identified 184 CAUTIs in 2 years. In 159 episodes (86%), urine cultures were ordered inappropriately. In 114 episodes (62%), CAUTI criteria were met by "pan-culturing" rather than symptom-directed testing. Twenty cases (11%) experienced partial or delayed management of other infections, drug adverse events, and *Clostridioides difficile* infections (CDIs). On our survey, we received 405 responses, for a response rate of 45.3%. Mean scores varied by occupation and level of training. Nurses were more likely than physicians to consider change in appearance (61% vs 23%; $P < .05$) and odor (74% vs 42%; $P < .05$) of urine as indications to order urine cultures.

Conclusions. Our data reveal specific knowledge gaps among physicians and nurses related to ordering urine cultures in catheterized patients. The practice of pan-culturing and inappropriate urine culture orders may contribute to overdiagnosis of surveillance CAUTIs, delay in diagnosis of alternative infections, and excess CDIs.

Keywords. catheter-associated urinary tract infections; diagnostic stewardship; nurses; urinary catheter; urine cultures.

Positive urine cultures in catheterized patients invariably prompt antimicrobial therapy. Differentiating catheter-associated bacteriuria from catheter-associated urinary tract infection (CAUTI) is challenging as the diagnosis cannot be made based on laboratory markers alone. In the absence of genitourinary obstruction, trauma, or pyelonephritis, a CAUTI is a diagnosis of exclusion [1]. However, urine cultures are often ordered in catheterized patients for subjective findings (eg, color, odor) and nonspecific symptoms. Given the high incidence of colonization and contamination in catheterized urine samples, it is critical to focus on urine culture practices in catheterized patients. Recognizing this, the American College of Critical Care Medicine, Infectious Diseases Society of America (IDSA), and American Board of Internal Medicine Choosing Wisely Campaign provide guidance that positive cultures in catheterized patients are usually indicative of colonization and do not require treatment in most cases [2–4].

Nurses are the first point of communication and coordination of care for appropriate catheter care, urine collection, and antibiotic therapy. There is growing recognition of the need to include education about antimicrobial and diagnostic stewardship in nursing curricula to counter the problem of growing antimicrobial resistance [5–7]. Our objectives were to (1) review practice patterns related to assessment of potential CAUTIs and (2) assess the knowledge of physicians and nurses related to urine culture practices in catheterized patients.

METHODS

Study Design

We assessed (1) practice patterns by performing a retrospective chart review and (2) knowledge by administering a previously validated survey instrument.

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Setting

This project was conducted at 3 hospitals within the not-for-profit Yale New Haven Health System—Yale New Haven Hospital, a 1541-bed academic tertiary care center in New Haven, Connecticut; Bridgeport Hospital, a 383-bed private acute care hospital in Bridgeport, Connecticut; and Greenwich Hospital, a 206-bed regional hospital in Greenwich, Connecticut. Hospitals were classified into 2 types to compare practice patterns: tertiary care center (New Haven) and community medical centers (Greenwich and Bridgeport). This project was deemed a quality improvement study by the institutional review board at each individual site.

Chart Review of Practice Patterns

To assess clinical practice patterns related to the assessment of potential CAUTIs, we performed a retrospective review of all patients identified with National Healthcare Safety Network (NHSN) CAUTIs between October 1, 2015, and September 30, 2017. Only surveillance CAUTI cases were chosen, as NHSN criteria are more standardized than administrative or clinical criteria, and the NHSN CAUTI rate is a good reflection of the rate of culturing. CAUTIs, dates of catheter insertion and removal, and culture data were extracted from our hospital's infection prevention database. Chart reviews were performed by an infectious disease physician, a critical care fellow and an infection preventionist (S.A., L.S., C.S.). Before initiating chart reviews, the reviewers met to decide on a uniform protocol and criteria for review. The charts were equally divided among these primary reviewers chronologically. All reviewers utilized the definitions outlined below to collect data on indications for urine culture orders, pan-culturing, and adverse events in patients with CAUTIs. They also collected information on antimicrobial therapy for CAUTIs and repeat urine culture orders within 2 weeks of the CAUTI diagnosis. Validation was performed by a second reviewer on the entire data set. Disagreements between primary and secondary reviewers were adjudicated by a different primary reviewer. Kappa statistics for chart review of practice patterns were calculated to assess interrater reliability.

Definitions

For the purpose of chart reviews, we used the 2017 NHSN CAUTI surveillance definition [8]. Hence, all cultures included were performed after day 2 of admission. "Pan-culturing" was defined as ordering 2 or more of the following cultures for any indication (eg, fever, delirium, hypotension) within a time interval of 6 hours from the index urine culture in the absence of symptom-directed evaluation: (1) blood cultures, (2) urine cultures, (3) respiratory cultures, or (4) stool studies such as *Clostridioides difficile* testing [9]. In addition to pan-culturing, data on any imaging within the same time interval were also obtained. For example, if the index urine culture was ordered at 10 AM, followed by a blood culture at 1 PM on the same day, it was considered to be pan-culturing for the purpose of this study. However, if blood cultures were ordered at 5 PM that day, it would not be considered pan-culturing. Appropriateness of urine culture orders was based on the 2009 IDSA CAUTI and 2005 asymptomatic bacteriuria (ASB) guidelines [4, 10]. Appropriate indications included symptoms referable to the urinary tract (ie, dysuria, urgency, frequency after catheter removal), signs of genitourinary obstruction or trauma (hematuria, flank pain, stones, urinary retention after catheter removal), complications related to a urologic procedure, signs of pyelonephritis, or severe shock. Inappropriate indications included change in urine character, fever, and other nonspecific indications (eg, generalized abdominal pain, diarrhea, hypotension) without ruling out other causes, change in mental status, leukocytosis, positive urinalysis, or lack of documentation of specific indication for culturing. All references to urinalysis and urine culture were reviewed in physician and nursing notes. If an appropriate indication was found by chart review, the concurrent inappropriate indications were not included (eg, in a patient with flank pain and foul-smelling urine, only flank pain was included). However, if 1 inappropriate indication was found, then additional indications were included (eg, in a patient with foul-smelling urine and pyuria, both were included). Complications assessed included partial or delayed management of other infections, drug adverse effects, and new or concurrent diagnosis of *C. difficile* infection (CDI) within 3 weeks of the date of CAUTI diagnosis. CDI cases were identified by a rapid glutamate dehydrogenase antigen/toxin enzyme immunoassay test, followed by a cytotoxin test when needed to confirm CDI.

Survey Instrument and Distribution

We modified a previously validated survey instrument used to assess physician and nurse knowledge about indications for obtaining urine cultures in a catheterized patient [11]. Participation was voluntary, anonymous, and without compensation. The survey (Supplementary Data) was distributed electronically to hospitalist and nursing staff. The same survey in paper form was distributed in person to physician trainees (medical residents, medical students, as well as medicine, pediatrics, neurology, surgery residents, and fellows) before conferences and clinics. Survey responses were received between January 11, 2018, and April 17, 2018, from tertiary and community medical centers. The response rate was assessed using the American Association for Public Opinion Research's type 1 method [12]. The survey instrument included 13 questions related to indications for ordering urine cultures in catheterized patients. The accuracy of the responses was assessed based on the 2009 IDSA CAUTI and 2005 ASB guidelines [4, 10]. We excluded 1 question related to new-onset confusion in an elderly patient, as the updated ASB guidelines were not published at the time of this

project [13, 14]. Correct answers received a score of 1 point, and all correct answers were summed for a total maximum score of 12.

Statistical Analysis

Comparisons of practice patterns on chart review and percent correct responses on the survey were done using the chi-square test. The difference in mean total scores between participants by postgraduate year (PGY), occupation, and site were assessed using the Student *t* test and analysis of variance, as appropriate. For the purpose of comparisons between nurses and physicians, attending physician and physician trainee scores were reported under "physicians." Post hoc power analysis was done to detect the effect estimate of interest with the sample size that we eventually achieved. Data analyses were performed using Stata, version 15.0, software (StataCorp, College Station, TX).

RESULTS

Chart Review Results

During the 2-year review period, we identified 184 surveillance CAUTI episodes, 79% of which were at the tertiary care center. Urine cultures were ordered in an initial workup of 62% of these episodes despite an alternative infectious reason for fever or instability. Eventually, 44% of episodes were either not treated with antimicrobials or were treated for <7 days. Repeat urine cultures were obtained in 90 episodes (49%) within 2 weeks of the initial urine culture. The review of practices for tertiary care and community medical centers is described in Table 1. The reviewers agreed on 83.7% of the observations, leading to a kappa statistic of 0.62.

In 159 episodes (86%), urine cultures were ordered for inappropriate indications. Overall, urine culture practices at community hospitals were not significantly different from those of the tertiary care center, as shown in Table 2. In 20 episodes (11%), patients experienced complications likely due to anchoring to the CAUTI diagnosis (Supplement 2). Only cases agreed on by both primary and secondary reviewers were eventually included in the Supplementary Data due to the subjectivity of this process. There were 7 episodes of partial or delayed management of other infections, 2 cases of drug-related adverse effects, and 11 cases of new or concurrent CDI. The 3 cases of concurrent CDI were included as these patients developed refractory CDI. Ninety percent (n = 18/20) of these adverse events occurred at the tertiary care center.

Survey Instrument Results: Tertiary Medical Center

During the survey period, we received 405 of 894 responses at our tertiary care center, for a response rate of 45.3%. Survey data from community medical centers are discussed later due to lower response rates. Overall, responses were heavily weighted toward internal medicine and medicine subspecialties, with 197 (48%) responses, followed by surgical, obstetric and women services (26%), pediatrics (9%), neurology (7.6%), and emergency medicine, anesthesia, and interventional services (4.4%). The remaining responses were from multiple specialties (pathology, medicine-pediatrics, float nurses). The overall mean assessment score for the tertiary medical center (SD) was 7.2 (2.42). Mean scores among physicians were higher than among nurses (7.77 vs 6.50; $P < .05$) and increased as training progressed. Survey demographics and average scores by occupation are summarized in Table 3.

Responses to survey questions by occupation are compared in Figure 1. On stratifying survey responses by occupation, nurses were more likely than physicians to consider change in appearance (61% vs 23%; $P < .05$) and odor (74% vs 42%; $P < .05$) of urine as an indication to order urine cultures. Physicians were more likely to order urine cultures based on varying levels of pyuria and for dysuria in a catheterized patient. Peri-urologic surgery with anticipated mucosal injury, though an acceptable indication for culturing, was one of the least-selected answers (25% and 12% for physicians and nurses, respectively) (Figure 1). On the survey, 70% of physicians preferred a symptom-based approach to culturing, rather than a pan-culturing approach. Based on post hoc analysis, the survey had a 100% power to detect differences in responses between physicians and nurses for a sample size of 405.

Table 1. Chart Review of Practices in Patients With Catheter-Associated Urinary Tract Infections

Practices	Tertiary Care Center (n = 145), No. (%)	Community Medical Center (n = 39), No. (%)	*P* Value
Alternative reason for fever or instability present when urine cultures ordered	95 (65.5)	19 (48.7)	.06
CAUTI criteria met by pan-culturing	92 (63.4)	22 (55.0)	.33
Episodes with pan-culturing and imaging	64 (44.1)	17 (43.6)	.95
Repeat urine cultures within 2 wk	73 (50.3)	17 (43.6)	.46
CAUTI not treated with antimicrobials	15 (10.3)	8 (20.5)	.09
Urinary catheter removed or replaced on day of CAUTI diagnosis	33 (22.7)	11 (28.2)	.47
CAUTI treated for <7 d	45 (31.0)	13 (33.3)	.78
Concurrent or new *C. difficile* infection within 3 wk of CAUTI diagnosis	8 (5.5)	3 (7.7)	.61

Abbreviation: CAUTI, catheter-associated urinary tract infection.

Table 2. Indications for Ordering Urine Cultures in Patients With Catheter-Associated Urinary Tract Infections

Indications	Urine Cultures at Tertiary Care Center (n = 145), No. (%)	Urine Cultures at Community Medical Center (n = 39), No. (%)	*P* Value
Inappropriate indications	127 (87.6)	32 (82.1)	.38
Indication not documented	11	4	
Urine character (ie, appearance or odor)	14	4	
Fever[a]	85	18	
Other nonspecific signs or symptoms[b]	11	7	
Change in mental status[a]	7	0	
Positive urinalysis	15	3	
Leukocytosis/leukopenia	15	4	
Appropriate indications	18 (12.4)	7 (17.9)	.37
Flank pain	1	2	
Dysuria, frequency, urgency, retention after catheter removal	8	1	
Acute hematuria	6	1	
Fever with urologic procedure	0	1	
Purulence around urinary catheter	1	0	
New shock	4	2	

Episodes may have more than 1 indication for ordering urine cultures.

[a]Without ruling out other causes.

[b]Other nonspecific symptoms include generalized abdominal pain, hypotension, diarrhea, and discomfort from catheterization (excluding fever and shock).

Survey Instrument Results: Community Medical Centers

We received 199 of 2294 responses from our community medical centers, with a response rate of 8.7%. This lower response rate is due to the presence of inactive email accounts and nonclinical staff on the community medical center listservs. Mean scores for staff at community medical centers were lower than for the tertiary care center (6.8 vs 7.2, respectively; $P = .03$). Survey demographics and scores are summarized in Table 3. Staff at the community medical centers were significantly more likely to order urine cultures for cloudy urine, foul-smelling urine, sediment in catheter tubing, and checking for clearance after treatment. They were also more likely to choose a pan-culturing approach compared with the tertiary care center ($P < .05$) (Figure 2).

DISCUSSION

Our chart review of practice patterns revealed that urine cultures were ordered in most cases in spite of an alternative reason for fever or instability. The practice of pan-culturing was similar across academic and community medical centers on chart reviews. This highlights 2 major issues. First, urine cultures are frequently ordered in the initial evaluation of catheterized patients with fever, despite guidelines recommending initial testing only for high-risk patients [2, 15]. Second, the practice of pan-culturing is more likely to detect colonization and contamination. This is especially relevant to urine cultures, where positive predictive value is heavily influenced by symptoms and collection techniques. We also identified several inappropriate urine culture ordering practices that relied on nonspecific

Table 3. Survey Demographics and Scores Stratified by Occupation and Practice Site

	Tertiary Care Center (n = 405)		Community Medical Center (n = 199)	
Occupation/Role	Demographics, No. (%)	Scores (Range, 1–12)	Demographics, No. (%)	Scores (Range, 1–12)
Nurses	185 (45.7)	6.50	140 (70.4)[a]	6.58
Attending physicians, APPs	49 (12.1)	7.77	19 (9.5)	7.26[a]
Medical students	9 (2.2)	5.62	11 (5.5)[a]	6.36
Resident PGY1	42 (10.3)	7.23	13 (6.5)	7.61
Resident PGY2	43 (10.6)	8.28	3 (1.5)[a]	8.33
Resident PGY3+	50 (12.3)	8.04	10 (5.0)[a]	8.0
Fellows	23 (5.7)	8.21	N/A	N/A
Pharmacists	4 (1)	9	N/A[b]	N/A

Abbreviations: APP, Advanced Practice Provider; PGY, postgraduate year.

[a]Statistically significant values compared with the tertiary care center.

[b]Three support staff scores not reported.

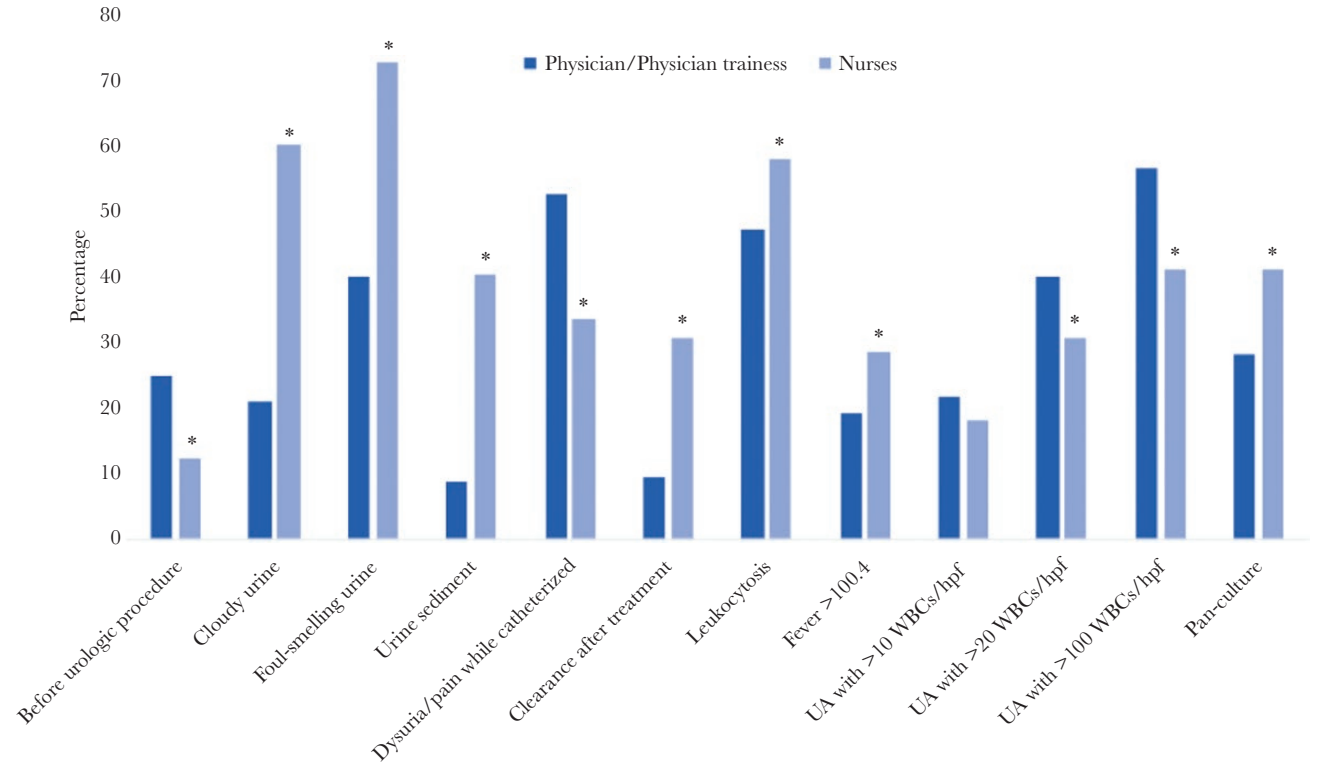

Figure 1. Percent correct responses for each question on the survey comparing nurses (n = 185) and physicians/physician trainees (n = 216). *Significant differences. Abbreviations: UA, urinalysis; WBC, white blood cell count.

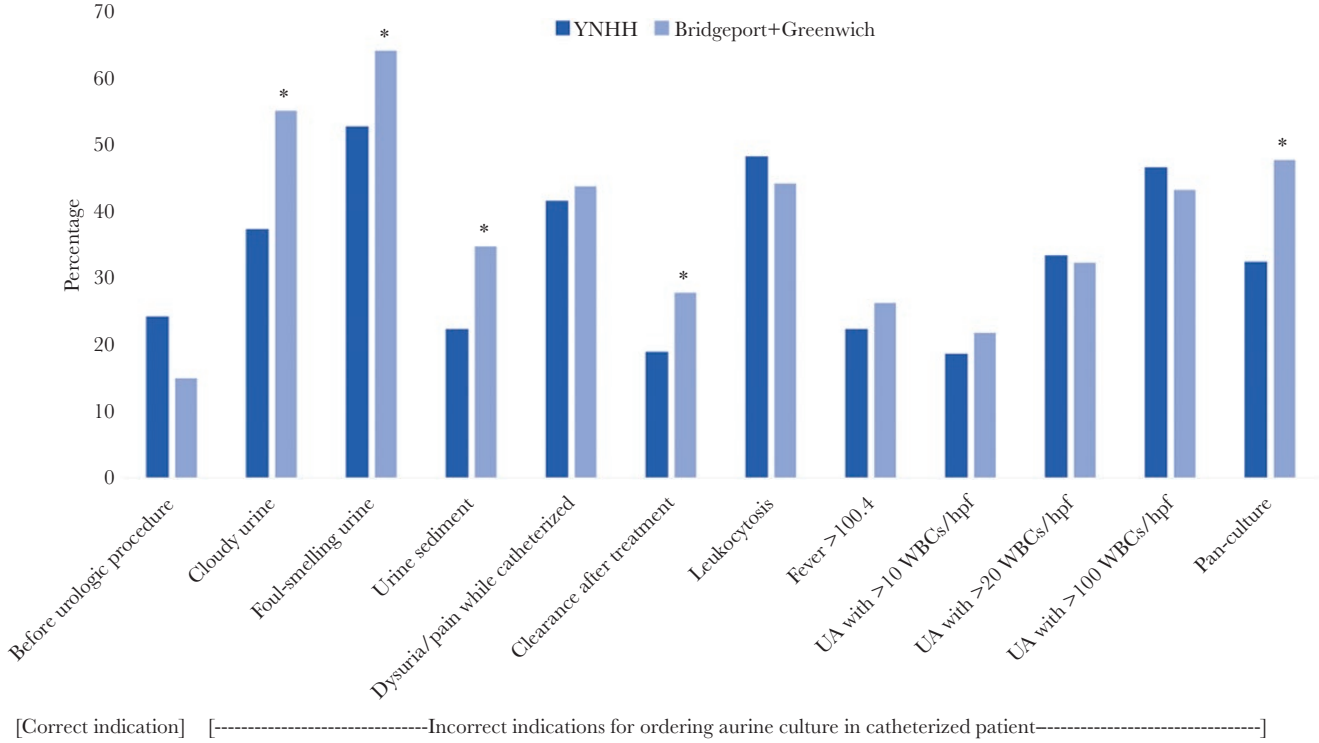

Figure 2. Percent correct responses for each question on the survey comparing tertiary (YNHH, n = 405) and community medical centers (Bridgeport+Greenwich, n = 199). *Significant differences. Abbreviations: UA, urinalysis; WBC, white blood cell count; YNHH, Yale New Haven Hospital.

symptoms, character of urine, or urinalysis parameters. About half of CAUTIs were not treated with antimicrobials or treated for <7 days, in spite of a bacterial threshold >100 000 CFU/mL in urine cultures. Twenty-four percent of all cases had a catheter removal or replacement in response to culture. This suggests that some clinicians recognized that positive urine cultures may represent colonization or contamination. Some cases who were treated for a CAUTI experienced a delay in management of other infections, drug adverse effects, or developed CDI, likely due to anchoring to the positive urine cultures. Most of these adverse effects and inappropriate practices were seen at our tertiary care center, secondary to a higher burden and increasing complexity of cases.

Our survey data reveal that the majority of physicians and nurses within our health care system were unable to accurately identify indications for ordering urine cultures in catheterized patients. Physicians had higher mean scores than nurses, and scores proportionately increased with level of training. This could be due to education about antimicrobial stewardship, exposure to evidence-based guidelines, and complexity of care as training progresses. Nurses were more likely to recommend ordering urine cultures based on the character of the urine. This is an important finding, as nurses' communication to physicians about these findings may influence provider perceptions. Physicians were more likely to order cultures for varying levels of pyuria and dysuria in a catheterized patient. When assessing dysuria in catheterized patient, it is important to note that pain in a catheterized patient is likely to be due to the catheter itself, with associated bladder spasms [16, 17]. On the other hand, dysuria after catheter removal is an appropriate indication for ordering a urine culture. IDSA guidelines also recommend against using laboratory parameters like pyuria or bacteriuria as the only indication for checking urine cultures in catheterized patients [4]. On the survey, staff at community hospitals were more likely to select inappropriate indications for ordering urine cultures. These data can help tailor diagnostic stewardship education to specific knowledge gaps based on occupation and practice site.

Our findings also shed light on the challenges associated with diagnosing CAUTIs. Patients with an indwelling catheter do not typically present with lower urinary tract symptoms like urgency, frequency, and dysuria, as they may have symptoms of discomfort due to the catheter itself [16]. Most cases labeled as CAUTI are actually catheter-associated bacteriuria [18–20]. In patients with an indwelling urinary catheter, the daily rate of catheter colonization is as high as 3%–8% [18, 19, 21]. In addition, poor urine collection techniques can lead to contamination [22]. Overall, urine cultures have poor positive predictive value for diagnosing CAUTI [23]. In joint guidance from the American College of Critical Care Medicine and IDSA, urine cultures are recommended only in certain cases for evaluation of fever in a catheterized critically ill patient: (1) kidney transplant recipients, (2) neutropenic patients, (3) patients who have recently undergone genitourinary surgery, and (4) patients with evidence of genitourinary obstruction [2]. However, there is a significant gap between these guidelines and clinical practice [24–26].

Many physicians approach a patient with fever, leukocytosis, or hemodynamic instability with a pan-culturing approach instead of symptom-directed evaluation. Pan-culturing is a well-established and overused practice in medicine driven by a reflexive rather than reflective approach. Vaughn et al. suggest that pan-culturing may also be influenced by the convenience of sampling rather than diagnostic yield. Though pan-culturing usually provides instant gratification, as it may yield positive results, it often has negative consequences over time. Reviews of 151 positive blood cultures at the University of Michigan Medical Center over 3 months revealed 52 (34%) contaminants. Despite reporting these as contaminants, many of these patients underwent further diagnostic tests and remained on antibiotic treatment [9]. Similarly, pan-culturing in catheterized patients can result in higher numbers of positive urine cultures due to colonization or contamination, leading to inappropriate antimicrobial therapy and an increase in CDI. Additionally, the NHSN CAUTI definition does not allow for attributing fever to an alternative diagnosis for surveillance purposes. This is in contrast to the clinical definition, where CAUTI is considered a diagnosis of exclusion. Hence, the practice of pan-culturing can increase the diagnosis of NHSN CAUTIs and negatively impact an institution's Hospital Acquired Condition Reduction Program (HAC) score [27, 28].

One of our limitations is that our chart review of practice evaluated the outcome of NHSN CAUTI. Hence, our study likely under-reports the impact of inappropriate culture orders on catheter-associated bacteriuria. Although there are some concerns with the NHSN CAUTI definition, it is a good reflection of the rate of culturing within an inpatient setting [29]. A major limitation of our work is hindsight bias from the retrospective nature of our study and the subjectivity of chart reviews, especially for a publicly reported health care–associated infection. In addition, we performed a regression analysis for risk of over-treating by provider type, years of training, and specialty, but our adjusted analysis was not powered to show significant results.

We propose 2 important strategies based on our findings. First, human factors engineering (HFE) approaches are needed to improve urinary catheter and culturing practices [30]. HFE approaches can be used to improve the design of our decision support tools, tasks, processes, machines, environments, and systems [30–34]. These include forced functions to assess the indications for urinary catheter continuation on a daily basis, stop orders for catheter removal (that require action after a specific time duration), removal of urine culture orders from presurgical screening or "fever-bundles," and standardization

of current policies across the health systems [35–37]. Systems engineering and HFE approaches have led to significant reductions in catheter utilization and CAUTIs at a 610-bed academic medical center [38]. Local physician champion engagement and education to change the culture is an approach that works better in community settings [39]. Second, it is imperative to train nurses and engage them as partners in diagnostic stewardship efforts, as nurses are the first point of contact with patients and relay changes in patient status to physicians. Training nurses regarding appropriate culturing practices and urine collection techniques is crucial [5–7, 40].

In conclusion, lack of symptom-directed evaluation, reliance on pan-culturing, and inappropriate culturing practices may have led to overdiagnosis of NHSN CAUTIs in our health care system. Diagnostic stewardship education has shown reductions in inappropriate urine culture orders, although education coupled with EMR changes is more likely to be more sustainable [41]. Our next steps are to use these data to develop a tailored diagnostic stewardship educational curriculum and integrate decision support into the EMR to reduce inappropriate urine culture orders. The long-term goal of such an initiative is to reduce the diagnosis and treatment of catheter-associated bacteriuria, inappropriate antibiotic use, and CDI rates [42].

Supplementary Data

Supplementary materials are available at *Open Forum Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

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