Diagnostic Stewardship: Changing Behavior One Urine Culture At A Time

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Diagnostic Stewardship: Changing Behavior One Urine Culture at a Time
Beth Warne

Yale School of Public Health
Master of Public Health
Epidemiology of Infectious Diseases
2024

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Abstract

Urinalysis and urine cultures are important diagnostic tools for diagnosing urinary tract infections. Often urine cultures are ordered without appropriate clinical indications of infection attributable to the urinary tract. Inappropriate urine culture ordering can have significant downstream effects and contribute to the unnecessary use of antibiotics, increased prevalence of *Clostridioides difficile* infections and antibiotic resistance, as well as wasted resources. A quality improvement project was undertaken at the Veterans Affairs Connecticut Healthcare System (VACHS) to decrease the ordering of inappropriate urine cultures.

A new, optional electronic medical record urine culture ordering note requiring documented indication for the test was implemented on August 23, 2023. Additionally, education sessions on urine culture ordering guidelines occurred periodically starting November 2023 with the bulk of the education taking place at the beginning of November 2023. Data on all inpatient VACHS urine culture orders from January 1, 2023, to February 9, 2024, were collected and reviewed for appropriateness. After review, analysis was performed on the pre-intervention and intervention data to determine if any changes in urine culture ordering practices occurred.

There were 418 urine culture orders reviewed for this period with 292 included in the pre-intervention period and 126 in the intervention period. The analysis indicated no statistically significant change in ordering practices after the November 2023 education sessions (21.2% appropriate vs 25.3% appropriate, p=0.42). Demographic information of all urine culture orders demonstrated that the medicine clinical provider team was responsible for the majority (49%) of the VACHS’s urine culture ordering, regardless of appropriateness.

Behavior change is an incredibly challenging area to target with diagnostic stewardship interventions. Due to this difficulty, the impact of these interventions is often insignificant. The
VACHS intervention utilized a passive approach to diagnostic stewardship to start and would benefit from more active efforts. The next steps for this urine culture diagnostic stewardship initiative at VACHS consist of a mandatory ordering note to guide clinicians and continuing to reinforce appropriate urine culture ordering guidelines for providers through education. A mandatory ordering note should reduce the opportunity for inappropriate urine culture ordering and has previously been shown to be effective at VACHS for *C. difficile* testing.
Acknowledgments

I would like to extend appreciation and a sincere thank you to my primary advisor, Dr. Louise Dembry, for her continued support, guidance, and the extra time she dedicated to chart review. I’ve learned so much throughout this project and truly appreciate all her efforts. I would also like to thank Dr. Andrew Chou, my secondary advisor, for including me in this project and providing invaluable input on all my drafts. I am also grateful to Dr. Duc Nguyen for his speedy and thorough chart review. Finally, I’d like to thank my family and friends for encouraging and supporting me throughout this process.
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Background

Urinalysis and urine cultures serve as diagnostic tools for urinary tract infections and are ordered for patients with or without indwelling urinary catheters. Ideally, they should be ordered for symptomatic patients, nephrostomy patients, preoperatively for select urologic procedures, when screening for asymptomatic bacteriuria in pregnancy, or in spinal cord injury patients (Centers for Disease Control and Prevention [CDC], 2019). Patients are at an increased risk for urinary tract infections if they have diabetes, kidney disease, frequent intercourse, a weakened immune system, and/or a catheter in place. Patients with a catheter in place develop catheter-associated urinary tract infections (CAUTIs) in one of two ways. Around 65% of all CAUTIs occur through the extraluminal route where the bacteria ascend the outside of the catheter tubing into the bladder from an external source, such as from the patient’s skin or contact with healthcare personnel, while the alternate route is the intraluminal entry of bacteria into the bladder from inside the catheter which occurs most commonly when the closed sterile system is breached (Saint & Chenoweth, 2003).

A urine culture is negative when there is no growth of bacteria or yeast and is considered positive with the growth of bacteria or yeast. An abnormal result can indicate an infection when combined with signs or symptoms of infection, or colonization which describes the presence of a microorganism that is not causing harm to the person. For an individual with a catheter in place, bacteriuria, or the presence of bacteria in the urine, is inevitable after about a month, so an abnormal culture result is highly likely even without an infection present (Saint & Chenoweth, 2003). Antibiotic treatment for a patient with asymptomatic bacteriuria is usually ineffective and not recommended except in rare circumstances, so identifying a true infection from colonization is important for providing with patients the correct care.
The goal of urine culture diagnostic stewardship is to ensure the right test is ordered for the right patient and to avoid unnecessary antibiotic use. Urine cultures are frequently ordered without clear clinical indications and are considered to be inappropriate urine culture orders (Silver et al., 2009). Examples of inappropriate ordering of urine cultures include ordering a urine culture out of habit, ease of ordering, vague symptoms not necessarily associated with urinary tract infection, or as part of pan-culturing for workup of a fever despite the absence of symptoms referable to the urinary tract. Pan-culturing is more likely to detect colonization or contamination (Advani et al., 2019). Inappropriate urine culture ordering creates significant trickle-down public health and clinical adverse effects. A positive culture result, whether related to an infection or colonization, usually results in the initiation of antibiotics. This leads to increased pressure for the development and transmission of antimicrobial-resistant organisms which can lead to future untreatable infections. Catheterized populations often have high rates of colonization. They can also have contaminated specimens from the collection process, so these patients often have low predictive values for true infection which can result in inappropriate treatment (Yarrington et al., 2023).

A positive urine culture without clinical signs or symptoms of infection (i.e. colonization or contamination) creates a huge potential for the overuse of antibiotics. Avoidable and excessive antibiotic use can result in antibiotic resistance, an increase in adverse drug reactions, or further infection, such as *Clostridioides difficile* infection which is associated with increased morbidity and mortality. *Clostridioides difficile* is a bacteria that can cause life-threatening diarrhea and often occurs in people who have taken antibiotics for any reason or duration (CDC, 2019). These infections are one of the most common healthcare-associated infections and can be incredibly costly to the healthcare system with an estimated $6.3 billion of attributable healthcare costs.
spent annually (Claeys & Johnson, 2023). The use of antibiotics, regardless of the presence of an infection, greatly disrupts the gut microbiome and can often trigger *Clostridioides difficile* infection (Stevens et al., 2011). A large-scale data analysis found that patients with lab results suggestive of a hospital-acquired urinary tract infection (UTI) treated with antibiotics were at roughly 3 times higher risk (RR=3.28) for hospital-onset *C. difficile* compared to healthcare-associated infection-free patients (Kelly et al., 2020). Both UTI and *C. difficile* infections often become recurrent, intensifying the cyclic antibiotic use, and compounding the detrimental impacts of antibiotics. Since catheterized patients often have bacteriuria and may be considerably impacted by inappropriate urine culture ordering, this population, which is generally more medically vulnerable, may experience a greater misuse of antibiotics and more of these unfavorable effects.

Diagnostic stewardship often works in tandem with antimicrobial stewardship efforts and shares the challenge of changing provider behavior. There are a variety of approaches to urine culture diagnostic stewardship with varying levels of impact and provider autonomy. These diagnostic stewardship tools include but are not limited to, forced functions, automation, electronic medical record (EMR) nudges/reminders, standardization, cognitive aids/checklists, incentives/feedback, rules/policies, and education (Advani & Vaughn, 2021). Combining some of these methods may result in a more effective diagnostic stewardship intervention that encourages long-term change. Previous studies indicate that urine culture ordering for catheterized patients can be generally reduced along with improved appropriateness through EMR-based interventions (Shirley et al., 2016).

Changing human behavior is an incredible challenge and requires considerable initiative, strategy, and commitment. Generally, people can feel uncomfortable with change and may not
welcome it, especially for some providers who have been practicing medicine a certain way for decades or feel uncertain about new data to support practice changes. A successful intervention aimed at improving urine culture ordering should be proactive to remove the downstream issues associated with inappropriate urine culture ordering. To create sustainable change in a healthcare environment, it is essential to engage and educate providers and ultimately evaluate if these efforts made an impact or need adjustment.

At the VACHS, the current state of provider urine culture ordering practices is not ideal and has space for substantial improvement with high CAUTI rates and evidence that urine culture orders not meeting clinical criteria are being placed. These orders likely represent colonization rather than true infection requiring treatment. Current urine culture ordering practice at the VACHS does not require providers to justify a urine culture lab order with an explicit clinical rationale, which creates an opportunity for unnecessary ordering. The current VACHS algorithm for ordering a urine culture for non-catheterized and catheterized patients heavily emphasizes symptom-based ordering and highlights asymptomatic bacteriuria as a potential outcome of inappropriate testing leading to unnecessary antibiotic use and increased adverse events. However, the algorithm is not readily available at the point of ordering a urine culture.

This problem creates an excellent opportunity for a urine culture diagnostic stewardship intervention at the VACHS. The initial intervention to decrease the ordering of inappropriate urine cultures focuses on 1) a voluntary note in the electronic medical record to guide ordering providers and 2) an education program to make providers aware of the issue and how improving their ordering practice will positively affect patient care. Altering the way urine cultures are ordered at the VACHS and providing targeted education sessions will produce insightful data into if and how urine culture ordering can be modified in this patient population. The results of
this evaluation will be used to determine if additional interventions are needed to affect the
ordering of urine cultures and decrease the proportion of inappropriate orders.

**Methods**

The Veterans Affairs Connecticut Healthcare System-West Haven Campus is a Yale
University-affiliated teaching hospital dedicated to serving the diverse veteran population in
Connecticut. VACHS-West Haven Campus is a 284-authorized-bed facility that provides
primary, secondary, and tertiary care services in multiple care areas and provides specialized
services for specific clinical problems.

The VACHS infection prevention team is providing targeted education to providers in
various medical groups highlighting the guidelines for ordering an appropriate urine culture and
the new ordering note in their electronic medical record. The optional urine culture ordering note
requiring an appropriate indication was incorporated into the VACHS’s Computerized Patient
Record System (CPRS), the Veterans Affairs electronic medical record system, on August 23, 2023.

Outpatient, emergency department, community living center, and rehab patients were
excluded from this study. This left units in the VACHS on floors 3 East, 4 West, 5 East, 5 West,
and 6 East. Most floors are mixed medical and surgical patients; the intensive care units and
step-down units may also be mixed medical and surgical patients depending on the patient
census and staffing. The largest education efforts took place on November 2, 2023, and
November 3, 2023, targeting the medicine resident teams, the medical intensive care units, step-
down units, 1-4W and 1-6E, medicine teams on 1-4E, and surgical intensive care units.
Additional education sessions took place on December 20, 2023, for lone hospitalists, January
19, 2024, for medicine resident teams with Dr. Daniel Federman, the chief of medicine at VACHS, and February 1, 2024, for the new group of residents and medicine section chiefs (Appendix 2).

The education was provided in PowerPoint form and highlighted urine culture stewardship at the VACHS West Haven campus. Specifically, providers were reminded of the guidelines for ordering a urine culture, provided with case studies, and shown VACHS-specific statistics on urine culture ordering. The providers were also made aware of the newly designed urine culture order note in CPRS requiring providers to indicate why a patient needs a urine culture (i.e., choose which criteria for ordering were met). This educational and CPRS-based intervention relies on a voluntary behavior change for the individual ordering the urine culture. It was designed with the input of multiple providers in varying specialties to ensure the note was as useful and accessible as possible.

A retrospective chart review of VACHS inpatient urine culture orders reported by the laboratory database was performed from CPRS from January 1, 2023, to February 9, 2024. All urine cultures are not necessarily distinct patient events, there may be multiple orders per patient. Each patient has a code for the unit location and the clinical care team. The factors relevant to appropriate urine culture ordering and basic demographic information were collected through manual chart review. These relevant elements of urine culture ordering consist of demographic data, presence or absence of urinary tract infection signs and symptoms, catheterization status, information about the urinalysis and urine culture, and laboratory test results (e.g., complete blood count) (Appendix 3). All urine cultures were reviewed by Dr. Duc Nguyen (second-year Infectious Diseases Fellow) and data was entered into an Excel spreadsheet. The VACHS urine culture ordering algorithm (catheterized and non-catheterized patients) was used to determine if a
urine culture was appropriate or not for the clinical case (Appendix 1). Dr. Nguyen flagged cases that were not clearly appropriate or inappropriate for further review by Dr. Louise Dembry (a hospital epidemiologist and infectious diseases physician). After her independent review of the CPRS chart and case designation, discrepant cases were reviewed and discussed with Dr. Nguyen and a consensus designation was made. Dr. Dembry also reviewed a random sample of cases (approximately 10% of all cases) and discrepant cases were similarly adjudicated. After the data was documented and deidentified, additional variables relevant to the analysis and urinary tract infections were coded, such as patients below and above 65 years of age and catheterization status. For each patient’s date of birth, only birth year was documented in an additional effort to de-identify the data, so any patient born in or before 1959 was considered 65 or older. A patient was considered catheterized if they had a documented Foley, suprapubic, or intermittent catheter either on admission or placed during admission. Patients with nephrostomy tube(s) were separated into a unique category since they will not have classic signs of UTI or CAUTI and may have other indications for a urine culture. Each urine culture was assigned to a clinical provider group (e.g., medicine, surgery) which was determined based on the medical team providing care and placing the urine culture order, not the patient location nursing team. The clinical provider groups were divided into medicine (MED), medical intensive care (MICU), medical step-down (MSDU), surgical (SURG), surgery intensive care (SICU), and surgical step-down (SSDU). Each urine culture was associated with one clinical provider group determined by which group the ordering provider belonged to. Additionally, each urine culture was designated to its respective floor (i.e., location). With multiple education, or “intervention” dates, and most providers educated at the beginning of November, November 1, 2023, was determined to be the official start of the intervention period data.
Demographic characteristics and urine culture data were compared for the pre-intervention period and various intervention periods using $\chi^2$. A $P$-value $\leq 0.05$ was considered statistically significant. Additionally, descriptive statistics were used to further analyze the dataset. The data was analyzed using SAS version 9.4.

Results

During the study period, 418 urine culture orders met the criteria for review. Although the voluntary ordering note was implemented during the study period, it was only used twice, so its impact could not be assessed. Although floor 4E was provided with education, there were no urine culture orders from this location during the study period.

Pre-Intervention

There were 292 pre-intervention urine cultures from January 2023 to October 2023. Of the 292 urine cultures, 62, or 21.2%, were appropriately ordered while 230, or 78.8%, were ordered without valid clinical symptoms or indications (Table 1). Most urine culture orders were placed for $\geq 65$-year-old men. Additionally, most urine cultures were ordered by medicine clinical provider teams (49.0%). For 70.2% of orders, the clinician’s reason for ordering the test was documented in a CPRS patient note.
Table 1: Pre-Intervention Urine Culture Orders, Jan. 2023-Oct. 2023

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>N (%)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Appropriate</td>
<td>62 (21.2)</td>
</tr>
<tr>
<td>Not Appropriate</td>
<td>230 (78.2)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>284 (97.3)</td>
</tr>
<tr>
<td>Female</td>
<td>8 (2.7)</td>
</tr>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>≥65 years of age</td>
<td>250 (85.6)</td>
</tr>
<tr>
<td>&lt;65 years of age</td>
<td>42 (14.4)</td>
</tr>
<tr>
<td>Catheterized*</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>106 (36.3)</td>
</tr>
<tr>
<td>Nephrostomy</td>
<td>25 (8.6)</td>
</tr>
<tr>
<td>No</td>
<td>166 (56.8)</td>
</tr>
<tr>
<td>Documented Indication</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>205 (70.2)</td>
</tr>
<tr>
<td>No</td>
<td>87 (29.8)</td>
</tr>
<tr>
<td>By Floor</td>
<td></td>
</tr>
<tr>
<td>1-3 East</td>
<td>42 (14.4)</td>
</tr>
<tr>
<td>1-4 West</td>
<td>87 (29.8)</td>
</tr>
<tr>
<td>1-5 East</td>
<td>34 (11.6)</td>
</tr>
<tr>
<td>1-5 West</td>
<td>60 (20.5)</td>
</tr>
<tr>
<td>1-6 East</td>
<td>69 (23.6)</td>
</tr>
<tr>
<td>By Clinical Provider Team</td>
<td></td>
</tr>
<tr>
<td>MED</td>
<td>143 (49.0)</td>
</tr>
<tr>
<td>MICU</td>
<td>34 (11.6)</td>
</tr>
<tr>
<td>MSDU</td>
<td>67 (22.9)</td>
</tr>
<tr>
<td>SURG</td>
<td>13 (4.5)</td>
</tr>
<tr>
<td>SICU</td>
<td>21 (7.2)</td>
</tr>
<tr>
<td>SSDU</td>
<td>14 (4.8)</td>
</tr>
</tbody>
</table>

* Patients with a Nephrostomy and Foley without an indicated culture site were included in both the “Yes” and “Nephrostomy” categories, so all percentages will not add up to 100%.

**Intervention Period, November-December 2023**

The intervention period data from November to December 2023 contains 87 urine culture orders with 22, or 25.3% being ordered for an appropriate indication (Table 2). Similar to the pre-intervention data, the majority of urine cultures were ordered for males older than 65 years of age.
age. The majority of urine culture orders were placed by medicine clinical providers (49.4%) with the orders by floor ranging from 11.6%-29.8%.

Table 2: Intervention Period Urine Culture Orders, Nov. 2023-Dec. 2023

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>N (%)*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td></td>
</tr>
<tr>
<td>Appropriate</td>
<td>22 (25.3)</td>
</tr>
<tr>
<td>Not Appropriate</td>
<td>65 (74.7)</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>81 (93.1)</td>
</tr>
<tr>
<td>Female</td>
<td>6 (6.9)</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
</tr>
<tr>
<td>≥65 years of age</td>
<td>78 (89.7)</td>
</tr>
<tr>
<td>&lt;65 years of age</td>
<td>9 (10.3)</td>
</tr>
<tr>
<td><strong>Catheterized</strong></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>38 (43.7)</td>
</tr>
<tr>
<td>Nephrostomy</td>
<td>10 (11.5)</td>
</tr>
<tr>
<td>No</td>
<td>41 (46.1)</td>
</tr>
<tr>
<td><strong>Documented Indication</strong></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>60 (69.0)</td>
</tr>
<tr>
<td>No</td>
<td>27 (31.0)</td>
</tr>
<tr>
<td><strong>By Floor</strong></td>
<td></td>
</tr>
<tr>
<td>1-3 East</td>
<td>10 (11.5)</td>
</tr>
<tr>
<td>1-4 West</td>
<td>25 (28.7)</td>
</tr>
<tr>
<td>1-5 East</td>
<td>14 (16.1)</td>
</tr>
<tr>
<td>1-5 West</td>
<td>17 (19.5)</td>
</tr>
<tr>
<td>1-6 East</td>
<td>21 (24.1)</td>
</tr>
<tr>
<td><strong>By Clinical Provider Team</strong></td>
<td></td>
</tr>
<tr>
<td>MED</td>
<td>43 (49.4)</td>
</tr>
<tr>
<td>MICU</td>
<td>16 (18.4)</td>
</tr>
<tr>
<td>MSDU</td>
<td>19 (21.8)</td>
</tr>
<tr>
<td>SURG</td>
<td>3 (3.5)</td>
</tr>
<tr>
<td>SICU</td>
<td>2 (2.3)</td>
</tr>
<tr>
<td>SSDU</td>
<td>4 (4.6)</td>
</tr>
</tbody>
</table>

*Patients with a Nephrostomy and Foley without an indicated culture site were included in both the “Yes” and “Nephrostomy” categories, so all percentages will not add up to 100%.

**Pre vs. Intervention Period**

When looking at the months immediately following the major education sessions in November, none of the variables are statistically significant when comparing the pre-and
intervention period data indicating no discernible impact on urine culture ordering (Table 3). The rates of appropriate urine culture ordering were similar in the pre-intervention and the intervention period (21.2% vs 25.3%, p=0.42).

Table 3: Pre vs Intervention Period Data, Jan. 2023-Dec. 2023

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Pre-Intervention (n = 292)</th>
<th>Intervention Period (n = 87)</th>
<th>p (DF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male, n (%)</td>
<td>284 (97.3)</td>
<td>81 (93.1)</td>
<td>0.07 (DF=1)</td>
</tr>
<tr>
<td>≥65 years of age, n (%)</td>
<td>250 (85.6)</td>
<td>78 (90.0)</td>
<td>0.33 (DF=1)</td>
</tr>
<tr>
<td>Catheterized*, n (%)</td>
<td></td>
<td></td>
<td>0.28 (DF=2)</td>
</tr>
<tr>
<td>Yes</td>
<td>106 (36.3)</td>
<td>38 (43.7)</td>
<td></td>
</tr>
<tr>
<td>Nephrostomy</td>
<td>25 (8.6)</td>
<td>10 (11.5)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>166 (56.8)</td>
<td>41 (46.1)</td>
<td></td>
</tr>
<tr>
<td>Documented indication, n (%)</td>
<td>205 (70.2)</td>
<td>60 (69.0)</td>
<td>0.82 (DF=1)</td>
</tr>
<tr>
<td>Appropriate, n (%)</td>
<td>62 (21.2)</td>
<td>22 (25.3)</td>
<td>0.42 (DF=1)</td>
</tr>
<tr>
<td>By floor, n (%)</td>
<td></td>
<td></td>
<td>0.82 (DF=4)</td>
</tr>
<tr>
<td>1-3 East</td>
<td>42 (14.4)</td>
<td>10 (11.5)</td>
<td></td>
</tr>
<tr>
<td>1-4 West</td>
<td>87 (29.8)</td>
<td>25 (28.7)</td>
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<tr>
<td>1-5 East</td>
<td>34 (11.6)</td>
<td>14 (16.1)</td>
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<td>1-5 West</td>
<td>60 (20.5)</td>
<td>17 (19.5)</td>
<td></td>
</tr>
<tr>
<td>1-6 East</td>
<td>69 (23.6)</td>
<td>21 (24.1)</td>
<td></td>
</tr>
<tr>
<td>By clinical provider team, n (%)</td>
<td></td>
<td></td>
<td>0.40 (DF=5)</td>
</tr>
<tr>
<td>MED</td>
<td>143 (49.0)</td>
<td>43 (49.4)</td>
<td></td>
</tr>
<tr>
<td>MICU</td>
<td>34 (11.6)</td>
<td>16 (18.4)</td>
<td></td>
</tr>
<tr>
<td>MSDU</td>
<td>67 (22.9)</td>
<td>19 (21.8)</td>
<td></td>
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<tr>
<td>SURG</td>
<td>13 (4.5)</td>
<td>3 (3.5)</td>
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<tr>
<td>SICU</td>
<td>21 (7.2)</td>
<td>2 (2.3)</td>
<td></td>
</tr>
<tr>
<td>SSDU</td>
<td>14 (4.8)</td>
<td>4 (4.6)</td>
<td></td>
</tr>
</tbody>
</table>

*Patients with a nephrostomy and Foley without an indicated culture site were included in both the “Yes” and “Nephrostomy” categories, so percentages will not add up to 100% and the “Yes” category contains the double-counted orders.
All Data

Of the 418 urine cultures ordered from January 2023 to February 9, 2024, 330 lacked clinical justification while 88 were deemed appropriate (Table 4). The relationship between having an appropriate or inappropriate urine culture ordered and having documented indication is statistically significant (92.1% vs 65.2%, p<0.05). Additionally, catheterization status is statistically significant (p<0.05).

Table 4: All Data by Appropriate vs Not Appropriate Urine Culture Orders, Jan. 2023-Feb. 9, 2024

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Appropriate (n = 88)</th>
<th>Not Appropriate (n = 330)</th>
<th>p (DF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male, n (%)</td>
<td>87 (98.9)</td>
<td>312 (94.6)</td>
<td>0.08 (DF=1)</td>
</tr>
<tr>
<td>65 or older, n (%)</td>
<td>81 (92.1)</td>
<td>278 (84.2)</td>
<td>0.06 (DF=1)</td>
</tr>
<tr>
<td>Catheterized*, n (%)</td>
<td></td>
<td></td>
<td>&lt;0.05 (DF=2)</td>
</tr>
<tr>
<td>Yes</td>
<td>29 (33.0)</td>
<td>129 (39.1)</td>
<td></td>
</tr>
<tr>
<td>Nephrostomy</td>
<td>17 (19.3)</td>
<td>18 (5.5)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>45 (51.1)</td>
<td>187 (56.7)</td>
<td></td>
</tr>
<tr>
<td>Documented indication, n (%)</td>
<td>81 (92.1)</td>
<td>215 (65.2)</td>
<td>&lt;0.05 (DF=1)</td>
</tr>
<tr>
<td>By floor, n (%)</td>
<td></td>
<td></td>
<td>0.70 (DF=4)</td>
</tr>
<tr>
<td>1-3 East</td>
<td>9 (10.2)</td>
<td>47 (14.2)</td>
<td></td>
</tr>
<tr>
<td>1-4 West</td>
<td>24 (27.3)</td>
<td>99 (30.0)</td>
<td></td>
</tr>
<tr>
<td>1-5 East</td>
<td>10 (11.4)</td>
<td>42 (12.7)</td>
<td></td>
</tr>
<tr>
<td>1-5 West</td>
<td>22 (25.0)</td>
<td>67 (20.3)</td>
<td></td>
</tr>
<tr>
<td>1-6 East</td>
<td>23 (26.1)</td>
<td>75 (22.7)</td>
<td></td>
</tr>
<tr>
<td>By clinical provider team, n (%)</td>
<td></td>
<td></td>
<td>0.18 (DF=5)</td>
</tr>
<tr>
<td>MED</td>
<td>46 (52.3)</td>
<td>159 (48.2)</td>
<td></td>
</tr>
<tr>
<td>MICU</td>
<td>10 (11.4)</td>
<td>44 (13.3)</td>
<td></td>
</tr>
<tr>
<td>MSDU</td>
<td>25 (28.4)</td>
<td>75 (22.7)</td>
<td></td>
</tr>
<tr>
<td>SURG</td>
<td>1 (1.1)</td>
<td>15 (4.6)</td>
<td></td>
</tr>
<tr>
<td>SICU</td>
<td>1 (1.1)</td>
<td>22 (6.7)</td>
<td></td>
</tr>
<tr>
<td>SSDU</td>
<td>5 (5.7)</td>
<td>15 (4.6)</td>
<td></td>
</tr>
</tbody>
</table>
* Patients with a nephrostomy and Foley without an indicated culture site were included in both the “Yes” and “Nephrostomy” categories, so all percentages will not add up to 100%.

Figure 1: Urine Culture Orders, January 2023- February 9, 2024

The number of monthly urine culture orders at the VACHS remained relatively consistent throughout 2023 until the end of October and into November where there was a significant spike in urine culture ordering that declined by December.

Discussion

One of the greater challenges of many diagnostic stewardship interventions is relying on behavior change to impact rates of appropriate urine culture ordering. The data from this study indicates there was no statistically significant change in provider behavior after the dissemination of the educational campaign in the VACHS. This lack of impact on urine culture ordering is not entirely unexpected since these practices can be exceptionally difficult to alter. Additionally, the
demographic data of urine cultures at the VACHS follow the same trends regardless of the intervention implementation with the majority of patients with urine cultures being male and 65 or older. This demographic bias is not surprising since healthcare settings often see older populations and the VACHS cares for veterans who are characteristically male and older (U.S. Department of Veterans Affairs, 2022).

Interestingly, there was a large spike in urine culture ordering during November right after the main education initiative (Figure 1). A variety of possibilities could explain this increase. This spike may be due to a typical uptick in urine culture ordering in these months and would require additional, long-term data to determine if this trend is expected at the VACHS. Alternatively, there could have been an increase in the number of admitted patients in these months to justify the increase in urine culture ordering indicating the data is proportional to the patient population (note: we do not yet have patient days or patient admissions during the entire study period to present urine cultures as a rate). Additionally, it is plausible that the education sessions drew providers’ attention to urine culture ordering resulting in a hyper-awareness of their behaviors and an overcompensation of ordering.

The VACHS urine culture diagnostic stewardship intervention was likely unsuccessful due to a variety of weaknesses. The educational initiatives and voluntary urine culture ordering note in CPRS were passive interventions and could have benefited from an active diagnostic stewardship component. Additionally, the education efforts were limited, and not all departments were aware of or familiar with the new ordering note when it went live. The intervention purely targeted clinical providers, which disregarded a significant portion of individuals providing care for patients, particularly nurses. Engaging nurses in diagnostic stewardship efforts is crucial for the success of the intervention as they are the first point of contact with patients and relay
changes in patient status to physicians (Advani et al., 2019). Nurse’s communication with providers may influence their decision to order a urine culture, so providing diagnostic stewardship education for nurses and encouraging an open dialogue between providers and nurses regarding the appropriateness of a urine culture order may reduce orders without clinical justification (Adams et al., 2020).

Regardless of who was not educated on best urine culture ordering practices or awareness of the voluntary ordering note, behavior is incredibly difficult to modify and could have interfered with the success of the VACHS urine culture ordering intervention. There are a variety of behavioral strategies for diagnostic stewardship to address barriers, cognitive biases, and social factors, including the socio-ecological model and the behavior change wheel. The socio-ecological model highlights the interaction between individuals and their social and physical environment in shaping health outcomes and may be important to incorporate into future diagnostic stewardship efforts at VACHS. The key steps of the socio-ecological model to promoting diagnostic stewardship are to identify key stakeholders, understand the factors influencing diagnostic decision-making, develop a multilevel intervention strategy, and implement and evaluate the intervention (Advani & Claeys, 2023). This model may be most useful for the VACHS intervention since it emphasizes the combination of factors influencing diagnostic decision-making and allows for multilevel approaches to the intervention strategy, so additional healthcare providers can receive targeted education. Since organizational culture, established by leadership, shapes staff perceptions and behaviors, this may be an equally important factor influencing diagnostic decision-making and a future target for improvement (Advani & Vaughn, 2021). Overall, behavior change is an essential component of diagnostic
stewardship and requires significant investment and strategy from leadership to produce substantial change.

In addition to enhanced efforts surrounding behavioral change strategies, the VACHS urine culture diagnostic stewardship intervention could have benefited from additional modifications that may have improved the results. Broader awareness of the new urine culture ordering note closer to when it went live in CPRS may have stimulated more use. Multiple education sessions for each clinical provider team to reinforce clinical guidelines for urine culture ordering could have also reduced urine cultures without appropriate clinical indications. Furthermore, heavily targeting providers who primarily practice at VACHS, specifically attendings and hospitalists, may address the issues with resident turnover at this educational institution.

Focusing or altering the target (e.g., catheterized patients only) of the VACHS diagnostic stewardship education efforts may result in reductions in urine culture ordering as numerous studies involving urine culture ordering interventions successfully focus primarily on CAUTIs. Each episode of urinary catheter-related bacteriuria is conservatively estimated to increase healthcare costs by at least $2,836, so this would be an economically relevant group to address (Saint & Chenoweth, 2003). Additionally, Advani et al. (2019) identified that patients with catheters receiving treatment for a positive urine culture encountered a delay in being considered or evaluated for other diagnoses, possibly attributed to a preoccupation with the positive urine culture, further emphasizing the benefits of focusing on CAUTI-specific diagnostic stewardship. While the VACHS intervention has room for improvement, it provides the foundation for the next steps to a successful, fully developed approach to tackling unjustified urine culture ordering.
Successful diagnostic stewardship initiatives are essential to improving patient outcomes, reducing unnecessary antibiotic use, decreasing healthcare costs, and interfering with the development of antibiotic resistance. Excessive and unnecessary antibiotic use for suspected urinary tract infections without clinical indication creates additional opportunities for adverse events including developing *C. difficile* infection, so effective diagnostic stewardship interventions are essential for reducing this risk. The most successful diagnostic stewardship approaches incorporate a variety of methods and utilize a multidisciplinary approach. Ideally, a diagnostic stewardship initiative should have institutional support, involve collaboration between many patient care stakeholders, and use a multimodal approach involving education and feedback, clinical indication requirements for urine culture ordering, and additional elements promoting diagnostic stewardship (Morado & Wong, 2022). The plan is to incorporate some of these optimal diagnostic stewardship components into the future of the VACHS urine culture ordering initiatives.

The initial VACHS diagnostic stewardship efforts provide the foundation for the future steps of improving urine culture ordering and highlight the poor effect of a voluntary note and education alone. The future of this project involves a forced CPRS order note function for urine cultures to bring about a positive change in practice and sustained improvements. The transition to a mandatory urine culture ordering note requiring clinical indications provides education opportunities and avoids clinically unsupported orders simultaneously. This alteration further supports a proactive approach to diagnostic stewardship and eliminates the problem from the ground floor. A mandatory ordering note should reduce the opportunity for inappropriate urine culture ordering and has been previously shown to be effective at VACHS for *C. difficile* testing and improvement has been sustained to date.
Instituting a mandatory urine culture ordering note is a low-effort, electronic medical record-focused intervention that other healthcare institutions have implemented successfully. A quality improvement-focused mandatory urine culture ordering note without explicit educational initiatives spanning an 11-hospital safety net system reduced inpatient urine culture ordering by more than 20% (Krouss et al., 2023). A similar diagnostic stewardship initiative also had success in reducing urine culture ordering rates, however, their analysis indicated that there was some mismatch in selected indications and actual indications as well as a predominance of nonspecific indications selected (Shirley et al., 2016). This highlights a potential pitfall for the VACHS mandatory urine culture ordering note and might be an area to watch.

While systems-based changes, like mandatory ordering notes alone, can be effective, they may not be institutionally supported and can be more successful with stakeholder buy-in through provider and staff engagement. Person-focused initiatives, such as targeted or personalized education, provide more autonomy but can be less successful when used alone (Advani & Vaughn, 2021). The fully implemented VACHS diagnostic stewardship initiative contains a systems-based (mandatory note with appropriate indications) and person-focused (education) intervention to ensure institutional engagement and create a sustainable intervention. Research by Advani & Vaughn (2021) has demonstrated that the combination of electronic medical record changes, such as a mandatory note, and improved education sessions are incredibly impactful on urine culture ordering rates and alleviate some of the avoidable downstream consequences of clinically unsupported urine culture orders.

The urine culture data, and lack of impact, from this initial education effort provide background and support the need for additional targets for the expansion of VACHS diagnostic stewardship education and other measures. Further development of the education sessions may
be necessary to enhance the impact of the sessions and including additional patient and provider populations may create a more significant impact on rates of appropriate urine cultures. Although not highlighted in this research, primary care providers, the emergency department, and some outpatient providers were also educated on the guidelines for appropriate urine culture ordering and the new ordering note. Further analysis of the urine culture orders from these providers could establish if the education sessions were more effective in other populations.

The VACHS urine culture data provides some insight into the distribution of orders throughout the healthcare system. There is a clear majority of urine cultures ordered by the medicine clinical provider teams, so these providers will be an important group to target for continued and future education. Some adjustments to the current state of the VACHS education sessions guided by other successful urine culture stewardship educational initiatives could make them more impactful in the future. One of these adjustments is through reinforcing and maintaining providers’ attention on the intervention by distributing follow-up communications from recognized community members or leadership and encouraging everyone to continue supporting the initiative (Kalorin et al., 2022). Another possible expansion of the educational portion of the intervention could mirror other education-focused diagnostic stewardship interventions and require a brief training module for all, or select nursing staff, medical staff, house staff, and medical students (Kalorin et al., 2022). Small alterations to the current state of the VACHS education initiative could result in a more engaged audience and maintain the success of the urine culture diagnostic stewardship program.

Beyond the actual implementation of the urine culture diagnostic stewardship program, further analysis, and data collection on antibiotic use at the VACHS could provide more insight into the magnitude of the problem. By looking back at the clinically unsupported urine cultures
from this study period, the full burden of inappropriate antibiotic use can be determined. At a different VA hospital in Minneapolis, with a similar patient demographic, their retrospective chart review and analysis of positive urine cultures found that 72% of their asymptomatic bacteriuria cases resulted in antibiotic therapy (Claeys et al., 2020). This provides a huge opportunity for additional antibiotic stewardship efforts coupled with the current urine culture diagnostic stewardship efforts. Many key elements essential to rewarding diagnostic stewardship programs overlap with antibiotic stewardship efforts, so these programs may be more successful in tandem.

One of the fundamental components of any diagnostic stewardship effort is ensuring sustainable change has occurred and is maintained. To create sustainable, facility-wide change, it’s crucial to incorporate user input, create flexible and adaptable interventions to address workarounds, and consistently update guidelines and other EMR changes (Advani & Vaughn, 2021). Prioritizing these needs and creating a collaborative program ensures prolonged stakeholder buy-in and increases the potential for long-term urine culture ordering change at the VACHS.

Aside from the weaker initial implementation of the diagnostic stewardship interventions and areas for improvement, an important element that may have reduced the success of the diagnostic stewardship intervention, but cannot be altered, is that the VACHS West Haven campus is a teaching hospital with constantly shifting personnel. This adds an interesting challenge to consider regarding changing the urine culture ordering practices of providers since most are not primarily based at VACHS. Due to this continuous turnover, the VACHS urine culture diagnostic stewardship educational sessions may not reach all providers and limit the
impact of the intervention. The lack of emphasis on educating surgery and nursing teams is also a significant limitation of the intervention.

An additional disadvantage of this study design is the short duration of the intervention. Without substantial time to create meaningful data, the analysis may not be entirely representative or definitive. However, preliminary data for January and February 2024 (data not included in the study results) shows that the rate of appropriate cultures has declined to 9.9%. To understand if this is a seasonal effect, we would need to compare the data to January and February 2023. The passive implementation of the new urine culture ordering note relied heavily on provider behavior change for its success, so the impact on urine culture ordering was bound to be limited from the introduction of this initiative. Potential consequences of the education and urine culture ordering note intervention were not assessed.

The data itself is also skewed toward a particular demographic of patients. Due to the VA healthcare system serving veterans, the patient population is mainly older males, which may distort the results since this patient population is not similar to or representative of the general population. Another potential limitation of the data is the process in which it was collected. A retrospective chart review creates opportunities for human error and missed information. The reviewers themselves are also not providing care for these patients and providers’ notes are not always exhaustive, so they may not provide a full picture of the clinical circumstances leading to the ordering of a urine culture for an individual patient.

Conclusion

Without clinical indications, abnormal urine culture results provide a lack of actionable information for providers. They create opportunities for negative ensuing consequences for the
healthcare system, patients, and public health (e.g., inappropriate antibiotic use, adverse effects of antibiotics, costs, etc.). Addressing the problems leading to inappropriate urine culture ordering from a proactive approach is the optimal way to reduce urine culture ordering rates. The VACHS urine culture diagnostic stewardship intervention incorporates an educational component in tandem with a voluntary ordering note and was shown to be unsuccessful at reducing urine culture ordering rates.

Although the initial program was unsuccessful, the ordering note has room for improvement by making it mandatory. This has the potential to lead to a significant and sustained reduction in inappropriate urine culture ordering. The intervention period data provided some insight into where to target future education sessions with medicine clinical provider teams ordering the biggest share of urine cultures. Additionally, the future of the initiative will expand to incorporate a mandatory EMR nudge to improve diagnostic stewardship and reduce inappropriate ordering. These EMR nudges work by encouraging the “right thing” by making it straightforward while discouraging the “wrong thing” by making it challenging, but not impossible (Advani & Vaughn, 2021). With the incorporation of these additional components into the VACHS diagnostic stewardship efforts, the future of urine culture ordering for only appropriate indications should be drastically improved.
References


Appendices

Appendix 1: VACHS Urine Culture Ordering Algorithm for Catheterized and Non-Catheterized Patients
Appendix 2: Timeline of Intervention

**INTERVENTION TIMELINE**

8/2023
- CPRS urine culture ordering note implemented

10/2023
- CAUTI Work Group Created

11/2023
- Education Sessions for Medicine resident teams, the MICU, SDU, 1-4W and 1-6E, medicine teams on 1-4E, and SICU

12/2023
- Education Session for Lone Hospitalists

1/2024
- Education Session for resident teams with the chief of medicine, Dr. Daniel Federman

2/1/2024
- Education Session for new residents and section chiefs

Late spring/2024
- Mandatory CPRS urine culture ordering note?
Appendix 3: Data Collected for Urine Culture Orders

| Patient name | Last 4 digits of SSN | Collection sample | Location name | Specimen taken date time | Date of birth | Gender | Admission date | Foley | Foley date | Intermittent catheter | Suprapubic catheter | Suprapubic catheter date | Nephrostomy tube | Nephrostomy tube date | Nephrostomy tube site | Spinal cord injury | Urinary procedure | Urinary procedure date | Symptom date | Fever | Dysuria | Hematuria | Frequency | Urgency | Suprapubic pain | Costovertebral tenderness (CVA) | Altered mental state (AMS) | Foul smell | Cloudy urine | Spasticity | Dysreflexia | White blood cell count (WBC) | Bands | WBC date | Urinalysis (UA) WBC | Documented indication | Appropriate culture | Note |