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Quality Improvement Interventions and Implementation Strategies for Urine Culture Stewardship in the Acute Care Setting: Advances and Challenges

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Abstract

Purpose of Review—The goal of this article is to highlight how and why urinalyses and urine cultures are misused, review quality improvement interventions to optimize urine culture utilization, and highlight how to implement successful, sustainable interventions to improve urine culture practices in the acute care setting.

Recent Findings—Quality improvement initiatives aimed at reducing inappropriate treatment of asymptomatic bacteriuria often focus on optimizing urine test utilization (i.e., urine culture stewardship). Urine culture stewardship interventions in acute care hospitals span the spectrum of quality improvement initiatives, ranging from strong systems-based interventions like suppression of urine culture results to weaker interventions that focus on clinician education alone. While most urine culture stewardship interventions have met with some success, overall results are mixed, and implementation strategies to improve sustainability are not well understood.

Summary—Successful diagnostic stewardship interventions are based on an assessment of underlying key drivers and focus on multifaceted and complementary approaches. Individual intervention components have varying impacts on effectiveness, provider autonomy, and sustainability. The best urine culture stewardship strategies ultimately include both technical and socio-adaptive components with long-term, iterative feedback required for sustainability.

Keywords

Urine culture; Urinalysis; Diagnostic stewardship; Quality improvement; Implementation science

Background

A positive urine culture is considered the current gold standard for diagnosing urinary tract infection (UTI); however, there are many limitations to this test [1]. A positive urine culture

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in a person without genitourinary symptoms, or asymptomatic bacteriuria (ASB), is common in many populations, particularly with advancing age, hospitalization, or certain underlying conditions [2–4]. The prevalence of ASB ranges from 1 to 8% in nonpregnant women, 3 to 20% in elderly persons living in the community, and 15 to 50% in older residents of long-term care facilities [5]. ASB occurs in part because the urinary bladder hosts a complex community of asymptomatic colonizing microorganisms [6]. Catheter-associated bacteriuria, or positive urine cultures in catheterized patients, is also a common phenomenon due to bacterial colonization of the indwelling urinary catheter. Most indwelling catheters are colonized at the rate of 3 to 7% per day, reaching 100% colonization in long-term catheters [7, 8]. Asymptomatic pyuria or presence of white blood cells in urine is also quite common and occurs in 32% of young women, 90% of older residents in long-term care facilities, and 90% of patients on hemodialysis with ASB [9–11]. Because asymptomatic pyuria and bacteriuria are more common in those with comorbidities, ASB is considered a marker of aging and frailty [12]. Despite this, there are very few circumstances in adults (e.g., pregnancy, prior to urologic procedures) where antibiotic treatment of ASB improves outcomes. Instead, antibiotics should generally be avoided in most patients with ASB in order to prevent harm from unnecessary antibiotic use [5]. Antibiotic treatment of ASB contributes to adverse outcomes such as antimicrobial resistance, antibiotic-related adverse events, and *Clostridioides (C) difficile* infections [13, 14]. Nevertheless, many clinicians order urine cultures and prescribe antibiotics inappropriately in asymptomatic patients with bacteriuria or pyuria [3, 4, 15]. Below, we describe the diagnostic challenges associated with UTIs, review current urine testing practices, discuss different urine culture stewardship interventions, and highlight how to address organizational barriers to implementing diagnostic stewardship in the acute care setting.

Diagnostic Challenges with UTIs

Diagnosis of UTI is often a clinical challenge due to the high prevalence of asymptomatic bacteriuria, presence of non-specific symptoms, and lack of knowledge about appropriate indications for urine testing [15]. Surveillance criteria and clinical definitions have been used to diagnose UTI [16, 17], but even these definitions overcall many cases of ASB as UTI [18]. Overdiagnosis occurs because UTI is not a dichotomous outcome [9] but rather exists on a continuum spanning no detectable bacteriuria or pyuria, asymptomatic bacteriuria with or without pyuria, probable UTI, and clinical UTI (see Table 1). High incidence of ASB coupled with non-specific findings such as confusion, fever, or hypotension leads many clinicians to lean on laboratory findings to diagnose UTI [15, 19]. Increasing reliance on urine testing leads to overdiagnosis of UTI and antibiotic overuse, because a positive urine culture has a poor positive predictive value for diagnosing a UTI, in contrast to blood where pathogen detection equates to infection for most pathogens. Overdiagnosis of UTI also may cause alternative or true diagnoses to be missed. Advani et al. found that catheterized patients treated for a positive urine culture experienced a delay in other diagnoses likely due to anchoring to positive urine cultures [15].

Urine Testing Practices

Urine tests are misused and overused for various reasons. When faced with a patient who presents with fever, leukocytosis, hemodynamic instability, or non-specific symptoms, physicians often use a pan-culturing approach instead of symptom-directed evaluation [20]. Pan-culturing is a deep-rooted practice in medicine [20, 21], driven by fear of missing an infection combined with increasing reliance on laboratory tests over clinical findings. “Pan-culturing” usually provides instant gratification as it often yields positive results, albeit these results may be due to detecting colonization and contamination more often than true infection [15]. Testing may also be influenced by the convenience of sampling site. For example, clinicians order urine cultures as a part of initial workup of confusion more often than ordering a lumbar puncture [20]. Misuse of urine cultures also occurs in response to subjective findings such as change in color or odor of urine, change in mental status, positive urinalysis parameters, and initial workup of fever in patients without genitourinary symptoms [15]. In addition, urine cultures and urinalyses are often included as pre-selected tests in many order sets (e.g., pre-operative, admission). Overtesting is especially relevant to urine cultures, where the positive predictive value is heavily influenced by symptoms and collection techniques [22].

Urine Culture Stewardship Interventions

Because overtesting leads to overdiagnosis of UTI, initiatives aimed at reducing ASB-related antibiotic treatment often focus on optimizing urine test utilization—typically by decreasing urine cultures or urinalyses (i.e., urine culture stewardship). Broad categories of urine culture stewardship interventions are shown in Fig. 1. Because overtesting is ubiquitous, urine culture stewardship interventions span from systems-based to persons-focused approaches. Systems-based changes are generally viewed as stronger interventions and include forced functions, automation within the electronic medical record or laboratory, and standardization of processes and order sets [23]. As interventions become move towards more persons-focused, they provide more autonomy to the users but lose effectiveness if used in isolation (e.g., policies, rules, and education). We discuss each of these categories of interventions in detail below:

Forced Functions and Automation

Forced functions require users to perform actions in a certain order, by preventing the next action until the first is complete [24]. For example, an academic medical center in New York City developed a new protocol for urine collection that required indwelling catheter replacement prior to urine collection (if the catheter was in place for more than 24 h). This additional step prior to urine collection led to fewer urine culture orders and catheter-associated UTIs (CAUTI) [25]. In a similar approach, an orthopedic hospital changed their laboratory process to require physician communication through a phone call to process any urine culture ordered for pre-operative screening, which led to a substantial reduction in urine cultures ordered and antibiotics prescribed, without an increase in prosthetic joint infections [26].

To reduce ASB treatment, some hospitals use laboratory automation strategies such as "urinalysis with reflex to culture" as a diagnostic stewardship intervention [27]. In this laboratory intervention, a urinalysis order proceeds to culture when specific urinalysis parameters (e.g., leukocyte esterase, white blood cells (WBC), red blood cells (RBC), nitrite, yeast, or bacteria) or combination of parameters are found. Recent surveys of academic and community hospitals revealed more than half of surveyed hospital laboratories offer reflex urine cultures [28, 29]. Use of reflex urine cultures has resulted in a decline in urine cultures and CAUTI rates in many acute care hospitals, emergency departments, and long-term care facilities [30–35]. Similarly, use of stricter UA criteria for reflexing to culture resulted in a 45% reduction in the urine cultures ordered at the University of North Carolina Health System [36]. In another study, a simple change of raising the threshold for reporting urine cultures from 10^4 to 10^5 colony-forming units led to a decrease in treatment of almost one-third of cases of asymptomatic bacteriuria and candiduria among hospitalized patients [37].

Successful interventions often combine multiple approaches, like forced functions combined with laboratory automation (e.g., reflex urine cultures, rejection of contaminated urine samples). In a quasi-experimental study involving two general hospitals and 10 community clinics, urine cultures were processed and reported only if one of the following criteria were met: presence of white blood cells or bacteria on microscopy; labeled as "pregnancy," "urological procedure," "renal transplant," or "neutropenic"; or urine that was from a ureteric, nephrostomy, or suprapubic source [38]. For urine samples that did not fulfill these criteria, the microscopy results and a rejection comment were reported. This intervention led to a significant reduction in antimicrobial use and had no effect on patient mortality. There were no unintended patient consequences (e.g., bacteremia from untreated UTI) in this study [38].

Electronic Medical Record (EMR) Nudges and Reminders

An emerging body of research describes the impact of thoughtful choice architecture design and gentle nudges through the EMR to modify practitioner behavior and practices [39]. Choice architecture is the way in which choices are presented to users (e.g., the number of choices, order of choices, presence of default, and ease of choosing one choice over the other). Nudges include "any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives" [39]. Even small annoyances—such as having to spend a few minutes to enter indications—can cause users to forgo ordering tests [40]. Nudges through the EMR work by making the "right thing" easier and the"wrong thing" harder (but not impossible).

Examples of EMR nudges include removal of routine urinalysis and urine culture from admission, emergency department, or presurgical order sets or adding additional clicks or steps to order a urine culture [26, 36]. In several studies, requiring selection of indications for ordering urine cultures in catheterized patients led to an overall reduction in urine cultures ordered [41, 42]. Similar EMR enhancements increased adherence to guideline-based urine culture ordering for catheterized intensive care unit patients [43].

Similarly, cascading of microbiologic susceptibilities has been used to nudge clinicians to use narrowest antibiotic choice [44].

Nudges can also be outside the EMR. For example, in one study, the hospital laboratory suppressed urine culture results from non-catheterized inpatients and required clinicians to call the laboratory if result was desired [45]. Following this proof-of-concept study, the authors performed a randomized control trial to assess the impact of this modified laboratory reporting of urine cultures. Suppression of low-risk urine culture results resulted in a significant reduction in inappropriate antibiotic treatment without an increase in adverse events [46].

Standardization and Habits

Standardizing processes and workflows is one way to remove variation and confusion and promote predictability and consistency [47]. Dougherty and colleagues saw a decline in urine cultures with implementation of a urine culture standardization program which required order indications, standardized collection techniques, and reflex urine cultures [48]. Similarly, standardizing urine culture processing in the laboratory resulted in a decrease in monthly urine cultures and total number of patients starting a new antimicrobial in adult intensive care units [49]. Likewise, Davies et al. implemented standardized urine collection practices to reduce the risk of false-positive cultures. This resulted in a reduction of inappropriate urine culture orders and CAUTIs over the course of 5 months [50].

Checklists

Checklists were first identified as a way to standardize, avoid reliance on memory, and improve quality outside of medicine (e.g., in aviation) [51]. More recently, checklists have been used to reduce inappropriate urine cultures. For example, one study tested a checklist of approved testing indications for urine cultures in catheterized patients and found the checklist led to > 30% reduction in National Healthcare Safety Network-defined CAUTI rates by decreasing inappropriate urine cultures in intensive care units without a significant change in catheter utilization [52]. Sampathkumar and colleagues found similar reductions in CAUTI rates after implementing a quality improvement project focused on a checklist of bundle elements [53, 54].

Cognitive Aids, Rules, and Policies

As it is difficult to remember the massive amount of information needed to treat all diseases, approaches like cognitive aids, rules, and policies have been used to assist clinicians in the best course of action. Such approaches can have a modest impact on appropriate test utilization [20, 55]. A cluster-randomized trial of a diagnostic and therapeutic algorithm for suspected UTI failed to have any impact on the number of urine cultures ordered [56]. Together, these studies suggest that once “positive” urine culture results are reported, they are difficult to ignore.

Rules and policies are critical infrastructure for any improvement project but are unlikely to change practice without dissemination, integration, and bundling with other interventions. One of the more successful interventions using rules and policies combined a change in urine culture policy with cognitive aids and education. The chief medical officer, patient safety officer, and director of infection prevention issued a campus-wide memo about indications for urine cultures and harms of ordering urine culture as a part of fever workup. This memo was combined with education on the appropriate criteria for inpatient urine cultures to medical and nursing staff in the departments of surgery and medicine. In addition, a hospital-wide screensaver encouraged providers to stop sending urine cultures as part of routine nosocomial fever workups. These combined interventions reduced monthly urine cultures to half across most intensive care units and wards, with a corresponding decrease in CAUTI [57].

Education and Training

Education is a core element of any antibiotic stewardship program [58]. However, providing broad, general education alone is frequently insufficient to improve care. Providing real-time, directed educational feedback to clinicians, in the form of treatment algorithms, or just-in-time coaching, is modestly effective but resource intensive [56, 59, 60]. Education coupled with EMR changes is shown to be more impactful [61]. In a pilot study, nursing education and a clinical tool to enhance discussions on the necessity of urine cultures among nurses and hospitalists were associated with a reduction in urine cultures [62].

Training nurses regarding appropriate culturing practices and urine collection techniques is crucial [63–66].

Implementing Successful Stewardship Interventions

Though each of these interventions may be somewhat effective in isolation, a combination of interventions targeting both systems and persons is most effective. In an ideal world, the process of designing a successful intervention bundle should involve six crucial steps: (1) assessment of need and defining the underlying problem; (2) identifying which key barriers are modifiable, have the greatest potential for change, and would lead to the most benefit; (3) implementing one change at a time; (4) using complementary approaches; (5) testing the intervention in a pilot population; and (6) assessing outcomes at regular intervals [67]. We describe several complementary interventions in Table 2, which can be used to design a successful urine culture stewardship program.

Addressing Organizational Barriers to Urine Culture Stewardship

In addition to cognitive and diagnostic hurdles, organizational barriers like competing initiatives, organizational culture, and sustainability also need to be addressed for successful implementation of urine culture stewardship.

Competing Initiatives

In most health systems, sepsis initiatives and antimicrobial stewardship programs may appear to have opposing messages around antimicrobial prescribing (i.e., early empiric therapy vs. judicious, narrow antibiotic use). In the era of increasing antimicrobial resistance, there is a need for alignment between sepsis and antimicrobial stewardship initiatives. Quality management of sepsis includes time-dependent recognition, resuscitation pathways, and early initiation of antimicrobials [68]. To avoid potential unintended consequences from inappropriate antimicrobial prescribing, antimicrobial stewardship strategies including de-escalation protocols and stopping antimicrobials in non-infectious patients should be a fundamental component of sepsis quality improvement initiatives [69]. Preferably, antibiotic stewardship and sepsis initiatives to be designed with all stakeholders involved so that initiatives harmonize their message (e.g., watchful waiting vs. early empiric therapy based on patient risk and stability).

Organizational Culture

Organizational culture consists of the shared beliefs and values established by leaders, communicated to employees, reinforced through various methods, and ultimately shaping staff perceptions and behaviors [70]. Pertinent to antibiotic stewardship, an organization's culture can either promote or dissuade antibiotic overuse and overtreatment of ASB. One example of how culture can affect antibiotic use is a multi-center veteran affairs study of urologic procedures which found that facilities with higher rates of excessive antibiotic use for one procedure had higher rates for other procedures [71]. Similarly, in another study of 46 hospitals in the state of Michigan, inappropriate antibiotic treatment of ASB was linked to overdiagnosis of pneumonia (or inappropriate antibiotic treatment for patients without clinical pneumonia) [72]. These studies show the importance of addressing and changing the organizational culture to successfully implement new interventions.

Sustainability

Sustainability of urine test stewardship depends on the adaptive component of interventions and how initiatives align with the organizational culture [73]. There are a number of obstacles to sustainability of interventions including staff engagement, insufficient resources, and lack of stakeholder buy-in. While systems-based interventions may appear to be more effective, they may sometimes be viewed unfavorably due to decreasing prescriber autonomy and may lead to workarounds and diminishing effectiveness. Combining systems-based interventions like forced functions and automation with persons-based approaches like coaching and education are more likely to result in long-term success. To ensure sustainability, it is important to incorporate user feedback, flexibility, and adaptability in interventions to counter workarounds and continually update guidelines and other EMR changes so as not to become out of date.

Unintended Consequences of Urine Culture Stewardship

While diagnostic stewardship interventions generally result in a reduction in the number of urine cultures ordered, their impact on appropriate antimicrobial use or clinician's response to an abnormal urinalysis is not clear [74]. Abnormal urinalysis parameters in patients without urinary symptoms are a powerful stimulus to start antibiotic treatment, thwarting diagnostic and antibiotic stewardship interventions [75, 76]. The level of pyuria on urinalysis correlates with increasing use of urine cultures and inappropriate antimicrobial prescribing [74]. Routine urinalysis screening is a surprisingly common practice, used in about 25% of emergency department visits, but does not directly impact decisions of care and delays the final disposition in most patients [75, 77]. Similar misuse of urinalysis is associated

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with reflex urine cultures. In one study of reflex urine cultures, more patients with positive urinalysis but negative culture received antibiotics than those with a negative urinalysis (30.5 vs 7.1%) [78]. The urine culture standardization intervention by Dougherty and colleagues led to a reduction in urine cultures, but it resulted in a non-significant increase in urinalyses orders and surveillance CAUTIs [48]. Dietz et al. reported a reduction in urine culture orders and antibiotic use after stopping their reflex urine culture process [79]. These studies highlight that reflexing all urine samples with positive urinalysis parameters to culture regardless of symptoms can paradoxically lead to an increase in urine culture orders and overtreatment of ASB [28]. Universal use of reflex urine cultures in a hospital leads to the incorrect assumption that "positive" reflexed urine culture is more indicative of a UTI. Hence, future diagnostic stewardship interventions should address precursor tests like urinalysis by uncoupling it from urine cultures, interpreting urinalysis results in the context of their pre-test probability, and ideally, considering selective reporting of urinalysis criteria [80].

Conclusion

Urine culture stewardship interventions in acute care hospitals span across a spectrum of quality improvement initiatives, ranging from strong systems-based interventions to weaker interventions that focus on clinician education alone. While many interventions have been successful, overall results are mixed, and sustainability is poorly understood. To be most successful, urine culture stewardship interventions should be implemented after a detailed assessment of underlying key drivers and barriers and should utilize multifaceted and complementary approaches [81, 82]. For long-term results, interventions must rely on both the technical and socio-adaptive components to sustain improved patient care [83–85].

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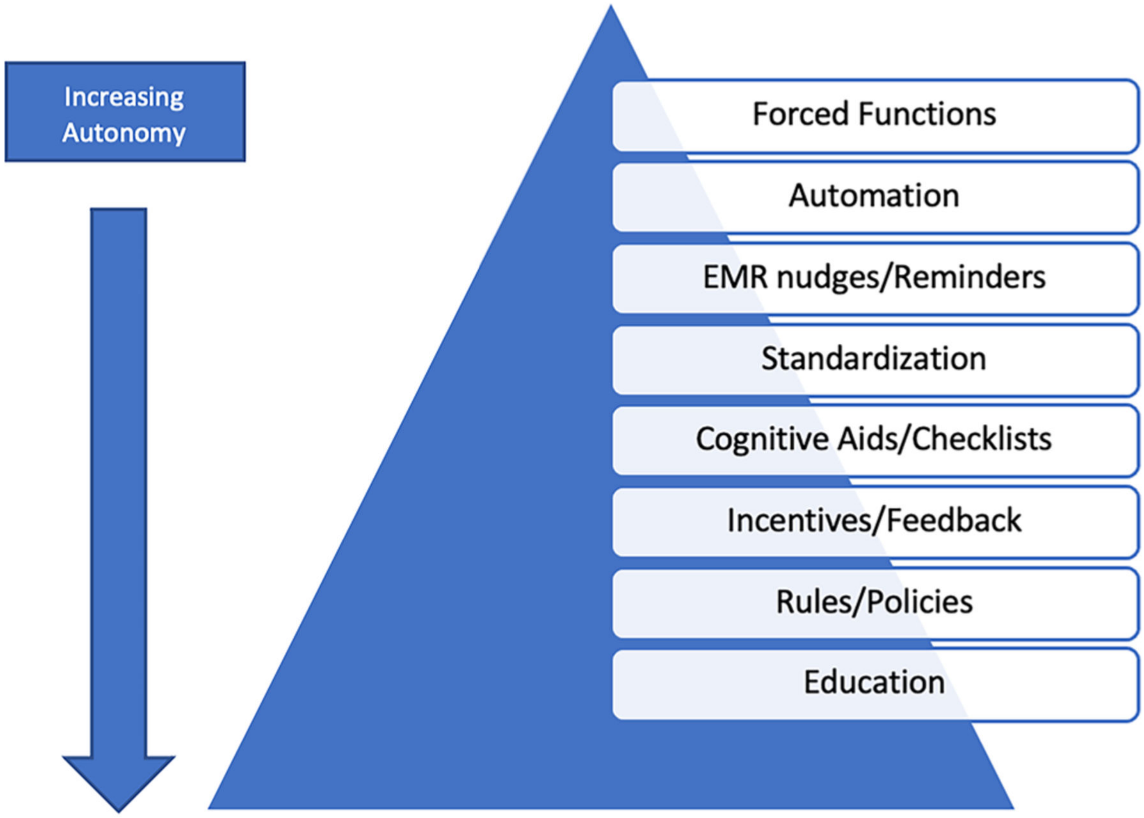

Fig. 1.
Broad categories of quality improvement interventions focusing on urine culture stewardship

Table 1

Continuum of UTI diagnosis

Not UTI or ASB	ASB	Probable UTI	UTI
Asymptomatic	No genitourinary symptoms + / − Non-specific symptoms attributable to different source	Cannot endorse symptoms or has non-specific symptoms (fever) not attributable to other source	+ Genitourinary symptoms
No bacteriuria	+ Bacteriuria	+ Bacteriuria	+ Bacteriuria
No pyuria	+ / − Pyuria	+ / − Pyuria	+ Pyuria

UTI urinary tract infection, *ASB* asymptomatic bacteriuria

Table 2

Multifaceted interventions for urine test stewardship

Type of intervention	Systems- or persons-focused	Intervention descriptions
Automation	Systems-based	Automatic rejection of some urine cultures (e.g., contaminated cultures, absence of pyuria)
Automation	Systems-based	Institute two-step processes in ED to reduce automatic culturing
EMR nudge	Systems-based	Remove urine cultures from admission, ED, and presurgical order sets (except urology)
EMR nudge	Systems-based	Suppressing urine culture results in certain scenarios (e.g., inappropriate indications, lower colony counts)
EMR nudge	Systems-based	Make ordering inappropriate urine cultures more difficult in EMR by requiring selection of appropriate indications
EMR nudge	Systems-based	Frame urine test results (i.e., positive urine cultures often represent ASB)
Standardization	Systems-based	Standardize institutional guidelines for urine culture ordering across inpatient, ED, and outpatient practices
Standardization	Systems-based	Standardize collection and transport of urine cultures (collect in containers with preservatives that allow specimens to be kept at room temperature; avoid transport delays)
Incentives and feedback	System-based	Incorporate outcomes into pay-for performance metrics
Incentives and feedback	Persons-focused	Provide just-in-time coaching of urine culture testing and treatment
Cognitive aids	User-focused	Use dashboards or monthly report cards that highlight ordering practices for ordering physicians
Policies	Systems-based	Update institutional guidelines to recommend against ordering urine cultures in patients without genitourinary treatment or treating patients with ASB
	Persons-focused	Engage and support champions from each specialty to promote appropriate testing
Education	Persons-focused	Educate nurses, physicians, and other relevant clinicians on indications for testing and treatment
Education	Persons-focused	Incorporate education (e.g., decision support or framing) into urine test ordering

EMR electronic medical record, *ED* emergency department, *ASB* asymptomatic bacteriuria