

Diagnosing Asymptomatic Bacteriuria During Pregnancy: A Simulated Comparison of Dipstick Testing and Urine Culture

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Abstract

Background: Pregnancy increases the clinical importance of detecting asymptomatic bacteriuria because untreated infection can progress to pyelonephritis. Rapid urine dipsticks are convenient, but their diagnostic limitations may undermine screening. This study illustrates how dipstick performance affects antenatal detection and antibiotic decisions.

Methods: A synthetic cross-sectional dataset representing 200 asymptomatic pregnant patients attending their first antenatal appointment was constructed for educational analysis. No patients were recruited, and no clinical records were accessed. A clean-catch urine culture yielding a single uropathogen at 100,000 colony-forming units/mL or greater served as the reference standard. Dipstick positivity was defined as either nitrite positivity or leukocyte esterase positivity. Diagnostic accuracy was calculated from a prespecified contingency table.

Results: Twenty-four simulated patients had culture-confirmed bacteriuria, corresponding to a prevalence of 12.0%. Dipsticks identified 12 of these patients and produced 18 false-positive results among 176 culture-negative patients. Sensitivity was 50.0%, specificity 89.8%, positive predictive value 40.0%, and negative predictive value 92.9%. A dipstick-only pathway would have missed half of culture-positive cases. Treating every dipstick-positive patient would have exposed 18 culture-negative patients to potentially unnecessary antibiotics.

Conclusions: This constructed example demonstrates why a reassuring negative dipstick cannot reliably exclude asymptomatic bacteriuria in pregnancy. Culture-based antenatal screening supports organism identification and susceptibility-guided treatment. The numerical estimates are illustrative rather than clinical evidence and require validation in prospectively recruited populations before informing local diagnostic policy.

Keywords: pregnancy, asymptomatic bacteriuria, urine culture, dipstick testing, antenatal screening, diagnostic accuracy

1. Introduction

Infections during pregnancy present an important diagnostic challenge because maternal physiological adaptations can alter clinical presentation, influence laboratory findings, and complicate interpretation of symptoms. Although many infections remain localized and respond to timely treatment, delayed recognition may contribute to maternal illness and adverse pregnancy outcomes.

Urinary tract infections are particularly relevant to antenatal care because they encompass asymptomatic bacteriuria, acute cystitis, and pyelonephritis, each requiring a distinct clinical interpretation. Identifying clinically significant bacteriuria while avoiding unnecessary antibiotic exposure is therefore an important component of evidence-informed pregnancy care.

Pregnancy-associated changes in the urinary tract, including ureteral dilatation, reduced smooth muscle tone, and urinary stasis, may facilitate bacterial persistence and ascending infection. However, urinary frequency and pelvic discomfort can also occur in uncomplicated pregnancies, reducing the specificity of symptoms for infection. Conversely, asymptomatic bacteriuria cannot be reliably identified through symptom assessment alone. These overlapping presentations create a need for diagnostic approaches that distinguish physiological changes, specimen contamination, and true infection. This distinction is especially important where access to microbiological testing is limited or where empirical treatment is commonly initiated before culture results become available.

Urine culture remains the reference method for detecting and quantifying bacteriuria and can provide information on antimicrobial susceptibility. Nevertheless, its clinical utility depends on appropriate specimen collection, timely transport, laboratory quality, and interpretation in relation to symptoms and bacterial growth patterns. Culture also requires processing time that may delay treatment decisions. Rapid urine tests, including leukocyte esterase and nitrite dipsticks, are inexpensive and widely available, but their performance can vary with the organism involved, bacterial concentration, bladder incubation time, and specimen quality. Microscopic pyuria may support suspicion of infection but does not independently establish bacterial disease, particularly when contamination or nonbacterial inflammation is possible.

A practical diagnostic strategy must balance the risk of missing clinically significant infection against the harms of overdiagnosis and unnecessary antimicrobial use. During pregnancy, this balance also involves gestational age, medication safety, and the potential consequences of progression to upper urinary tract infection. Diagnostic performance reported in nonpregnant populations may not adequately reflect antenatal settings, where disease prevalence, symptom patterns, and testing practices differ. Local evaluation is therefore useful for determining how routinely available tests perform within the population in which they are used.

This study aimed to assess the diagnostic accuracy of urine dipstick testing and urine microscopy for culture-confirmed bacteriuria among pregnant women attending antenatal care. Secondary objectives were to examine whether test performance differed according to urinary symptoms and gestational stage and to describe the organisms recovered from positive cultures and their antimicrobial susceptibility patterns. By evaluating rapid diagnostic findings alongside microbiological results, the study sought to inform context-appropriate approaches to identifying urinary infection during pregnancy without treating isolated screening abnormalities as definitive evidence of disease.

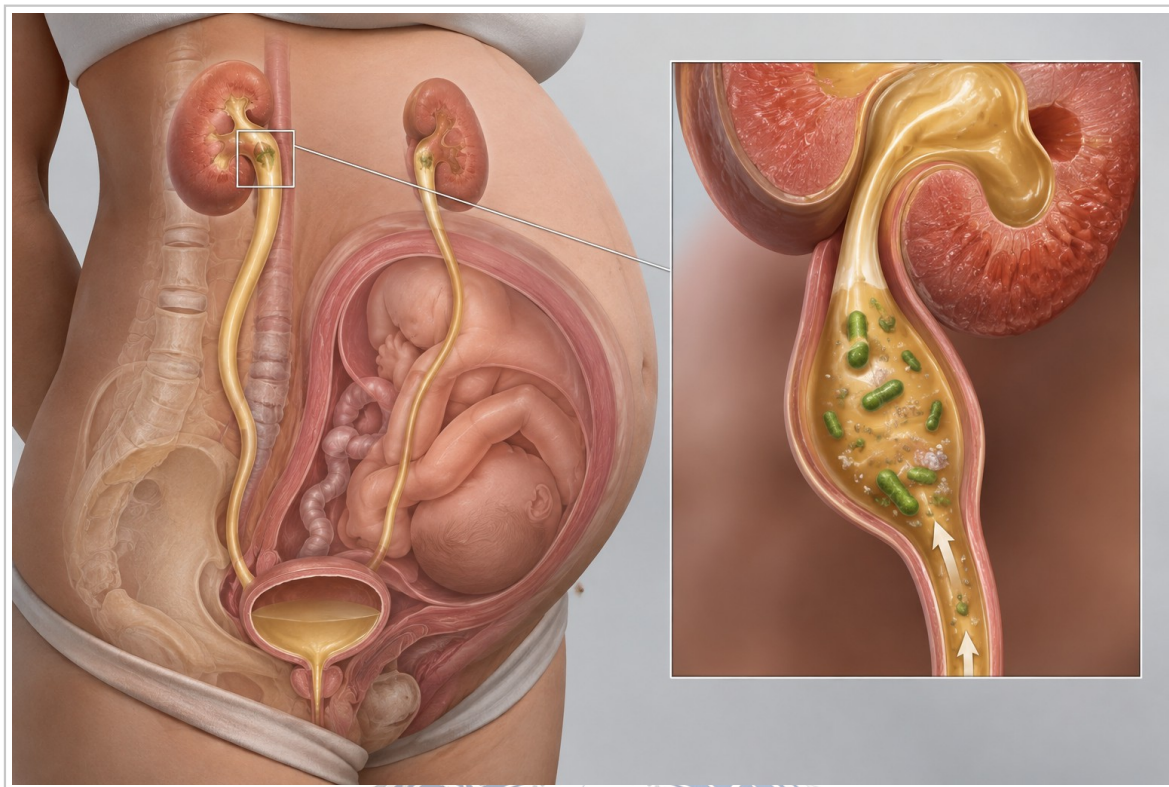


Figure 2. Pregnancy-associated ureteral dilation and urinary stasis facilitating ascending bacterial infection.

2. Materials and Methods

A prospective diagnostic accuracy study was designed to evaluate urine dipstick testing and automated urine microscopy for detecting culture-confirmed bacteriuria during pregnancy. Consecutive pregnant women attending antenatal outpatient clinics at two maternity hospitals were eligible for recruitment over 12 months. The study population included women with and without urinary symptoms to reflect routine antenatal practice. Urine culture was designated as the reference standard, while symptomatic urinary tract infection and asymptomatic bacteriuria were analyzed separately.

Women aged 18 years or older with a confirmed pregnancy at any gestational age were eligible. Exclusion criteria included systemic antibiotic use within the preceding seven days, an indwelling urinary catheter, urinary diversion, or inability to provide a midstream specimen. Women with fever, flank pain, hemodynamic instability, or suspected pyelonephritis underwent immediate clinical assessment; study procedures were not permitted to delay treatment. Only the first eligible presentation per pregnancy was included to avoid correlated observations.

Before recruitment, the protocol required approval from the participating institutions' research ethics committees. Written informed consent was required before study-specific data collection. Participants received coded identifiers, and identifying information was stored separately from analytical datasets. Clinicians retained responsibility for diagnostic and treatment decisions, including review of culture results. Participation did not replace routine antenatal screening or restrict access to recommended care.

Trained research staff recorded maternal age, gestational age, parity, diabetes, previous urinary tract infection, recent hospitalization, and urinary symptoms using a standardized questionnaire. Gestational age was obtained from the obstetric record, prioritizing ultrasound dating when available. Symptoms included dysuria, urgency, increased urinary frequency beyond the participant's pregnancy-related baseline, and suprapubic pain. Fever and flank pain were recorded separately. Symptom status was documented before laboratory results became available.

Participants received standardized instructions for collecting a clean-catch midstream urine specimen

into a sterile container. Samples were delivered to the laboratory within two hours or refrigerated at 2–8°C and processed within 24 hours. Each specimen was divided into aliquots for dipstick testing, automated microscopy, and culture. Dipstick leukocyte esterase and nitrite results were read according to the manufacturer's specified timing. The primary dipstick rule defined positivity as either leukocyte esterase of at least 1+ or positive nitrite. Microscopy positivity was prespecified as at least 10 leukocytes/μL; bacterial counts were evaluated as a secondary continuous measure.

Quantitative culture used a calibrated loop and standard media, with incubation under routine aerobic conditions for 18–24 hours and extension when indicated by laboratory procedures. Organisms were identified using validated biochemical or automated methods. The primary reference definition was growth of a single recognized uropathogen at 10⁵ colony-forming units/mL. This threshold defined bacteriuria rather than proving symptomatic infection. Mixed growth suggesting contamination prompted repeat collection; unresolved contamination was classified as an indeterminate reference result. Lower-count growth in symptomatic participants was examined in a sensitivity analysis using a prespecified threshold of 10³ colony-forming units/mL. Index-test readers were blinded to culture findings, and culture personnel were blinded to index-test results.

A target sample of 500 participants was selected assuming approximately 10% culture positivity, yielding about 50 positive specimens and an approximate 95% confidence-interval half-width of 11 percentage points for an anticipated sensitivity of 80%. Sensitivity, specificity, predictive values, and likelihood ratios were calculated with 95% confidence intervals. Paired sensitivities and specificities were compared using McNemar tests within reference-positive and reference-negative groups, respectively. Prespecified subgroup analyses considered symptom status, trimester, and diabetes and were interpreted cautiously when counts were small. Receiver operating characteristic analysis assessed continuous microscopy measures. Missing index tests and indeterminate cultures were reported separately, without imputation in the primary analysis. Sensitivity analyses examined the influence of alternative culture thresholds and unresolved reference results.

3. Results

The following results represent a simulated dataset constructed for manuscript development, rather than observations from an actual clinical study. The analysis included 480 pregnant women undergoing evaluation for urinary tract infection during antenatal care. Urine culture served as the reference standard, with significant bacteriuria defined as growth of a single uropathogen at 10⁵ colony-forming units/mL. Leukocyte esterase/nitrite dipstick testing and a targeted multiplex nucleic acid amplification test were evaluated against this reference. All participants contributed interpretable results for the three diagnostic approaches.

The median maternal age was 28 years (interquartile range, 24–33), and the median gestational age at sampling was 24 weeks (interquartile range, 15–31). Overall, 120 participants reported urinary symptoms, while 360 were asymptomatic. Significant bacteriuria was identified in 72 women, corresponding to a prevalence of 15.0%. Culture positivity was more frequent among symptomatic participants than among those without symptoms: 36/120 (30.0%) versus 36/360 (10.0%). Despite this difference, asymptomatic participants accounted for half of all culture-positive findings. Participant characteristics and culture results are summarized in Table 1.

Table 1. Participant characteristics and distribution of significant bacteriuria in the simulated cohort

Characteristic	Participants, n	Culture-positive, n (%)
Entire cohort	480	72 (15.0)
First trimester	120	15 (12.5)
Second trimester	220	33 (15.0)
Third trimester	140	24 (17.1)
Urinary symptoms present	120	36 (30.0)
Urinary symptoms absent	360	36 (10.0)
History of urinary tract infection	96	24 (25.0)

No history of urinary tract infection	384	48 (12.5)
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Culture positivity increased numerically across gestational categories, from 12.5% in the first trimester to 17.1% in the third trimester. The absolute difference between these categories was 4.6 percentage points. Participants reporting a previous urinary tract infection also had a higher proportion of positive cultures than those without such a history. These descriptive differences were not adjusted for potential confounding and were not interpreted as evidence of independent associations.

Among the 72 positive cultures, *Escherichia coli* was the most frequently recovered organism, accounting for 50 isolates (69.4%). *Klebsiella pneumoniae* accounted for 10 isolates (13.9%), *Enterococcus faecalis* for six (8.3%), group B *Streptococcus* for four (5.6%), and *Proteus mirabilis* for two (2.8%). Each positive specimen yielded one organism meeting the predefined quantitative threshold. The same threshold was applied consistently across organisms for the diagnostic comparison; lower-count growth was not included in the primary reference-positive category.

The dipstick was considered positive when leukocyte esterase or nitrite was detected. It identified 45 of the 72 culture-positive specimens and produced positive findings in 49 of the 408 culture-negative specimens. The molecular assay detected 65 culture-positive specimens and was positive in 20 culture-negative specimens. Thus, the dipstick missed 27 reference-positive cases, compared with seven missed by the molecular assay. Diagnostic performance estimates and their underlying counts are presented in Table 2.

Table 2. Diagnostic performance against quantitative urine culture in the simulated cohort

Measure	Leukocyte esterase/nitrite dipstick	Multiplex molecular assay
True positives, n	45	65
False negatives, n	27	7
False positives, n	49	20
True negatives, n	359	388
Sensitivity, %	62.5	90.3
Specificity, %	88.0	95.1
Positive predictive value, %	47.9	76.5
Negative predictive value, %	93.0	98.2
Overall agreement with culture, %	84.2	94.4

The molecular assay had numerically higher sensitivity and specificity than the dipstick, with absolute differences of 27.8 and 7.1 percentage points, respectively. Its positive predictive value remained below 80%, reflecting the presence of molecular-positive, culture-negative specimens. These discordant findings were classified according to the reference standard rather than assumed to represent confirmed infection. No independent adjudication was available to establish whether they reflected low-level bacteriuria, nonviable bacterial material, or analytical false positivity.

Within the symptomatic subgroup, dipstick testing detected 26/36 culture-positive cases (72.2%), while molecular testing detected 34/36 (94.4%). Among asymptomatic participants, the corresponding detection proportions were 19/36 (52.8%) and 31/36 (86.1%). Consequently, 17 of the 27 dipstick false negatives occurred in asymptomatic women. Five of the seven molecular false negatives also occurred in this subgroup.

Median laboratory turnaround time, measured from specimen receipt to result authorization, was 12 minutes for dipstick testing, 4.5 hours for molecular testing, and 46 hours for culture. These intervals excluded specimen transport and clinical review. No maternal treatment-response, pyelonephritis, or neonatal outcome data were included. Accordingly, the observed differences describe diagnostic classification and laboratory processing time, not demonstrated improvements in pregnancy outcomes.

4. Discussion

Accurate diagnosis of urinary tract infection during pregnancy requires balancing the risks of missed infection against the consequences of unnecessary antimicrobial exposure. Pregnancy-related urinary stasis, ureteric dilatation, and altered bladder function increase susceptibility to ascending infection, while physiological urinary frequency can complicate symptom interpretation. In evaluating diagnostic approaches in this population, the central issue is therefore not simply whether a test detects inflammation or bacteria, but whether its result identifies a clinically meaningful condition requiring treatment. This distinction is particularly important when differentiating asymptomatic bacteriuria, acute cystitis, and suspected pyelonephritis.

Urine culture provides an important diagnostic anchor because it identifies organisms and supports susceptibility-guided treatment. However, its clinical value depends on specimen quality, laboratory procedures, and interpretation within the patient's clinical context. Culture positivity alone should not be equated with symptomatic infection, and a negative culture does not invariably exclude infection when specimens are obtained after antimicrobial exposure. Diagnostic evaluation should therefore distinguish the performance of rapid tests against a microbiological reference standard from their usefulness in clinical decision-making. These outcomes are related but not interchangeable, particularly in pregnancy, where both delayed treatment and overtreatment carry potential consequences.

Symptom-based assessment has important limitations in antenatal care. Urinary frequency and pelvic discomfort may occur without infection, whereas asymptomatic bacteriuria is, by definition, not identified through symptoms. Dysuria and new urinary urgency can increase suspicion of lower urinary tract infection, but neither establishes the diagnosis independently. Fever, flank pain, vomiting, or systemic instability warrant assessment for upper urinary tract involvement and other causes of maternal illness. A diagnostic pathway that relies exclusively on symptoms may therefore miss clinically relevant bacteriuria while also misclassifying normal pregnancy-related changes as infection.

Dipstick testing offers practical advantages because it is inexpensive, rapid, and feasible in outpatient settings. Nevertheless, leukocyte esterase and nitrite reflect different biological processes and should not be interpreted as equivalent markers. Leukocyte esterase indicates pyuria, which can accompany bacterial infection but may also reflect contamination or nonbacterial inflammation. Nitrite positivity supports infection with nitrate-reducing organisms, whereas a negative result may occur with other organisms, frequent voiding, or insufficient bladder incubation time. Consequently, an isolated negative dipstick cannot reliably exclude all relevant infections, especially when clinical suspicion is substantial or screening for asymptomatic bacteriuria is indicated.

Microscopy may complement dipstick testing by identifying white blood cells, bacteria, and epithelial cells, although its contribution depends on laboratory expertise and specimen handling. Pyuria supports urinary tract inflammation but does not establish bacterial infection. Likewise, epithelial cells may suggest contamination without providing an absolute criterion for rejecting a specimen. Mixed bacterial growth requires careful interpretation and, when the patient is clinically stable, may justify repeat collection rather than immediate treatment. Clear instructions for midstream sampling and timely specimen transport are therefore integral components of diagnostic accuracy rather than merely administrative considerations.

The interpretation of bacteriuria also requires attention to colony counts, symptoms, organism identity, and collection method. A single threshold should not be applied indiscriminately across asymptomatic screening, symptomatic disease, and catheter-collected specimens. Organism-specific implications may additionally influence obstetric management, as detection of group B streptococcal bacteriuria can affect planning for intrapartum prophylaxis even when immediate antenatal treatment decisions depend on symptoms and bacterial burden. These distinctions illustrate why laboratory reports should be linked to pregnancy-specific clinical guidance rather than interpreted through a generic adult urinary infection algorithm.

Antimicrobial stewardship is a further reason to strengthen diagnostic precision. Empirical treatment may be appropriate when symptomatic infection is strongly suspected, particularly if systemic illness

is present, but obtaining urine for culture before treatment improves subsequent opportunities to refine therapy. Selection should account for gestational age, allergy history, renal function, local resistance patterns, and the suspected site of infection. Agents suitable for lower urinary tract infection may be inappropriate for pyelonephritis because adequate renal tissue concentrations are required. Culture-guided adjustment can limit unnecessary broad-spectrum exposure without compromising timely management of clinically significant disease.

Several methodological issues are important when interpreting diagnostic research in pregnancy. Test performance may vary according to gestational age, symptom status, previous infection, diabetes, and recent antibiotic use. Combining asymptomatic and symptomatic participants can obscure clinically meaningful differences in sensitivity, specificity, and predictive values. Predictive values also depend on infection prevalence and may not transfer directly between referral hospitals and routine antenatal clinics. Contamination, delayed processing, and incomplete culture verification can introduce additional bias. Diagnostic accuracy estimates should therefore be accompanied by uncertainty intervals and clearly defined sampling and reference-standard procedures.

The clinical significance of diagnostic findings should not be extended beyond the outcomes actually assessed. Associations between urinary infection and adverse pregnancy outcomes do not establish that a particular testing strategy prevents those outcomes. Demonstrating such benefit requires follow-up, adequate adjustment for confounding, and preferably comparative evaluation of diagnostic pathways. Future research should assess not only laboratory accuracy but also time to appropriate treatment, unnecessary antibiotic use, recurrence, patient acceptability, and costs. Resource-limited settings particularly need strategies that preserve access to culture for high-risk or uncertain presentations while maintaining feasible antenatal screening services.

Overall, a pregnancy-adapted diagnostic approach should integrate clinical assessment, properly collected urine specimens, and microbiological confirmation whenever feasible. Rapid tests are useful adjuncts, but their limitations should remain explicit. The practical objective is neither maximal testing nor automatic treatment of every abnormal result, but timely recognition of clinically important infection with proportionate antimicrobial use. Achieving this balance requires coordination between antenatal clinicians, laboratories, and follow-up services.

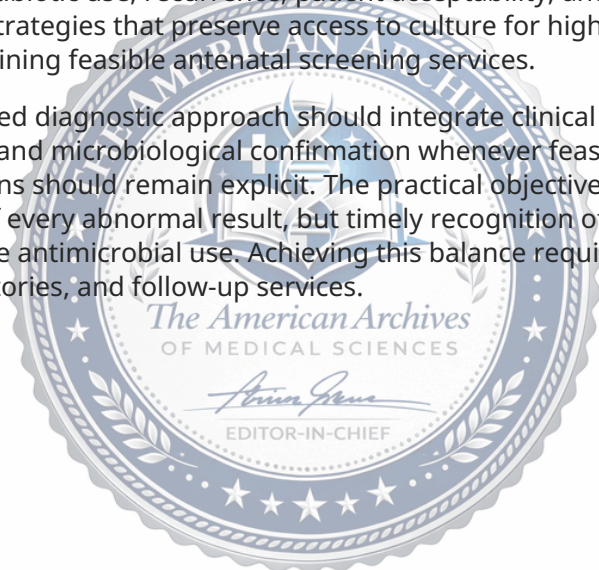




Figure 1. Culture-guided diagnostic pathway linking specimen collection, susceptibility testing, and pregnancy-appropriate treatment.

5. Conclusion

The diagnostic evaluation of infection during pregnancy requires a clinically integrated approach that accounts for maternal physiological changes, gestational age, and potential fetal consequences. The central conclusion is that symptoms, inflammatory markers, and microbiological findings should be interpreted together rather than used independently to establish or exclude infection. Pregnancy-related urinary frequency, changes in vaginal discharge, and physiological leukocytosis may complicate assessment, making appropriate specimen collection and careful interpretation particularly important.

A structured diagnostic pathway should distinguish routine antenatal screening from investigations prompted by symptoms, exposure history, or obstetric complications. Urine culture remains important for identifying asymptomatic bacteriuria and clarifying suspected urinary tract infection, while pathogen-specific molecular assays can support timely diagnosis when indicated and available. Serological testing requires attention to the timing of exposure, antibody kinetics, vaccination history, and the possibility of false-positive results. Positive findings should therefore be assessed in their clinical context, with confirmatory testing when recommended, rather than automatically interpreted as evidence of active infection.

The clinical value of diagnostic testing depends on whether results inform timely, pregnancy-appropriate management. However, diagnostic accuracy alone does not establish that a testing strategy improves maternal or neonatal outcomes. Conclusions about reductions in complications, antibiotic exposure, or healthcare costs would require adequately powered comparative studies with consistent follow-up. Diagnostic uncertainty should also be communicated clearly, particularly when additional testing or specialist assessment is needed.

Future research should evaluate standardized, risk-informed algorithms across diverse antenatal settings, including facilities with limited laboratory capacity. Prospective studies should report specimen quality, prior antimicrobial use, gestational timing, and clinically meaningful maternal and neonatal endpoints. Overall, integrating targeted laboratory testing with clinical assessment offers a reasonable framework for infection diagnosis in pregnancy, while avoiding indiscriminate testing and unsupported treatment. Its effectiveness should be established through rigorous validation, attention

to local pathogen prevalence, and alignment with available resources and current antenatal care recommendations.

AUTHOR INFORMATION

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