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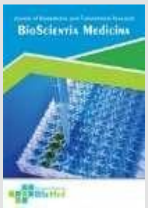

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# Advances in Urinary Tract Infection Screening Among Pregnant Women: A 5-Year Systematic Review

**Qonita Prasta Agustia[1]*, Rahajeng[2]**

[1]Department of Obstetrics and Gynecology, Dr. Saiful Anwar Regional General Hospital/Universitas Brawijaya, Malang, Indonesia

[2]Division of Urogynecology, Department of Obstetrics and Gynecology, Dr. Saiful Anwar Regional General Hospital/Universitas Brawijaya, Malang, Indonesia

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***Corresponding author:**
Qonita Prasta Agustia

**E-mail address:**
*qonitaprastaagustia@gmail.com*

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**A B S T R A C T**

**Background:** Urinary tract infections (UTIs), including asymptomatic bacteriuria (ASB), represent a significant clinical challenge during pregnancy, posing risks to both mother and fetus. Physiological changes increase susceptibility. Urine culture remains the diagnostic gold standard. This review assessed recent evidence on UTI clinical manifestations and diagnostic approaches in pregnant women. **Methods:** A systematic literature search of PubMed and Google Scholar was conducted for experimental studies published in the last 5 years (2019-2023) focusing on UTI diagnosis in pregnancy. Search terms included "urinary tract infection," "pregnant women," "diagnosis," and "experimental study". Studies were selected using PRISMA guidelines and PICOS criteria. Data extraction and risk of bias assessment were performed. **Results:** Fifteen experimental studies involving 4,377 pregnant participants were included. Common clinical manifestations included urgency, lower abdominal/pelvic pain, dysuria, fever, and hematuria. Urine culture was the primary diagnostic tool used. *Escherichia coli* was the most prevalent Gram-negative isolate, followed by *Klebsiella spp.* and *Pseudomonas spp. Streptococcus aureus*, *Enterococcus faecalis*, and *Staphylococcus aureus* were common Gram-positive isolates. Urine pH varied, with Gram-positive infections associated with more alkaline urine. **Conclusion:** Clinical presentations of UTI in pregnancy were consistent across recent studies. Gram-negative bacteria, particularly *E. coli*, predominated. Urine culture remains the cornerstone of diagnosis, with urine pH potentially offering adjunctive diagnostic information.

## 1. Introduction

Urinary tract infection (UTI) is a prevalent clinical issue that affects a notable proportion of individuals, accounting for approximately 1–6% of therapeutic referrals. These infections manifest within the urinary tract, involving the bladder, kidneys, and related structures. The presentation of UTIs can vary, with some individuals experiencing a range of symptoms while others remain asymptomatic. Asymptomatic bacteriuria (ASB), characterized by the presence of bacteria in the urine without accompanying symptoms, is particularly significant due to the lack of obvious clinical indicators. Pregnancy introduces a unique set of physiological and anatomical changes within the urinary tract. These alterations, coupled with hormonal fluctuations, create an environment that increases susceptibility to ASB. In some cases, ASB can progress to symptomatic infection, posing potential risks to both the pregnant mother and the developing fetus. Several factors have been identified as contributing to the increased risk of UTI in pregnant individuals. These include advancing maternal age, parity (number of previous pregnancies), presence of diabetes mellitus, sickle cell trait, a history of prior UTIs, underlying urinary tract disorders, and compromised immunity. The global impact of UTIs and their associated complications is substantial, contributing to approximately 150 million deaths annually. However, it is important to note that regional differences exist in the prevalence and management of UTIs. For instance, in the United States, rates of pyelonephritis during pregnancy have been observed to be relatively low. This may be attributed to the widespread implementation of screening and treatment protocols for ASB in pregnant women. Conversely, a meta-analysis conducted in Iran, encompassing 31 studies and a total of 20,309 patients, estimated the prevalence of ASB in pregnant women to be 8.7%, with variations noted across different trimesters of pregnancy.[1-4]

The development of a urinary infection is a complex process influenced by a combination of factors. These factors include the susceptibility of the host, the size of the bacterial inoculum, and the virulence characteristics of the infecting microorganism. Inoculation, the initial step in the development of a UTI, most commonly occurs via the ascending route. This process involves the colonization of the perineal region by enteric bacteria, followed by their ascent through the urethra into the bladder. *Escherichia coli* (*E. coli*) has been consistently identified as the most frequently isolated microorganism in both UTI and ASB. The pathogenicity of *E. coli* is attributed to specific virulence factors, such as type 1 fimbriae, which have been strongly associated with cystitis. Other fimbriated strains of *E. coli* have been linked to the development of pyelonephritis, a more serious upper urinary tract infection. Urine culture is the most reliable diagnostic tool for UTI, enabling the detection and quantification of the causative pathogen. Despite its importance, routine urine culture tests are not consistently implemented as standard practice during antenatal care in many developing nations. The detection of a pathogen in urine, particularly in conjunction with clinical symptoms, remains the gold standard for UTI diagnosis. This diagnostic approach is crucial not only for patients presenting with typical UTI symptoms but also for those with non-specific presentations.[5-8]

Urine culture provides valuable information, including pathogen identification and quantitative estimation of bacteriuria. A bacterial count exceeding 103 Colony Forming Units per milliliter (CFU/mL) in urine, accompanied by significant pyuria (the presence of an elevated number of white blood cells in the urine), is generally considered indicative of a urinary tract infection. While bacterial isolation is associated with the diagnosis of acute cystitis, specific quantitative thresholds for diagnosing UTI in pregnant women have not been definitively established through research. In addition to the microbiological aspects of UTI in pregnancy, several risk factors have been identified. These factors can increase a pregnant woman's susceptibility to developing a UTI and include parity, gravidity (number of pregnancies), gestational age, history of UTI, diabetes, anemia, socioeconomic and educational status, sexual activity, and urinary catheterization. Researchers have also explored various diagnostic approaches involving serum and urinary biomarkers. However, the specificity of blood-based immune markers has been limited due to potential cross-reactivity from other infections or inflammatory conditions. Urinary biomarkers, which reflect local bladder epithelial immune responses, have also been investigated. These biomarkers include nerve growth factor (NGF), chemokines (such as IL-8/CXCL8), antimicrobial peptides (AMPs) like human α-defensin 5 (HD5), and neutrophil gelatinase-associated lipocalin (NGAL). Despite these investigations, comprehensive biomarker screening studies specifically focused on UTI in pregnant women remain limited. While existing reviews have analyzed newer diagnostic techniques for UTI, their specific application in pregnant women requires further study.[9-12] Therefore, this systematic review aims to evaluate modalities for diagnosing UTI among pregnant women. The review will specifically examine experimental studies published within the last five years to consolidate recent advancements in screening and diagnostic practices relevant to this population.

## 2. Methods

A systematic search of electronic databases was performed to identify all relevant studies. The primary databases searched were PubMed and Google Scholar, two of the most comprehensive sources for biomedical and health-related literature. The search strategy was developed to capture a wide range of articles focusing on UTI, pregnancy, and diagnostic techniques. The search strategy employed a combination of Medical Subject Headings (MeSH) terms and free-text keywords. MeSH terms are a controlled vocabulary used for indexing articles in PubMed, which helps to standardize and refine the search. Free-text keywords were used to capture articles that may not have been indexed with specific MeSH terms. The following search terms were used; ("urinary tract infection" OR "UTI") AND ("pregnant women" OR "pregnancy") ("diagnosis" OR "screening") AND ("experimental study" OR "novel diagnostic method") ("bacterial infection" AND "urine test"). These search terms were combined using Boolean operators (AND, OR) to create comprehensive search strings. The search was limited to studies published within the last 5 years (2019-2023) to focus on the most recent advancements in the field. In addition to the electronic database searches, the reference lists of all selected articles were manually screened to identify any potentially relevant studies that may have been missed by the database searches. This process, known as "snowballing," helps to ensure that no relevant studies are overlooked.

The study selection process was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. PRISMA provides a standardized framework for reporting systematic reviews, ensuring transparency and completeness. Eligibility criteria were defined based on the PICOS framework; Population: The population of interest was pregnant women, including both those presenting with symptoms of UTI and those who were asymptomatic. This broad definition ensured that the review captured studies on both symptomatic UTI and asymptomatic bacteriuria (ASB), which is particularly relevant in pregnancy; Intervention: The intervention of interest was any diagnostic technique aimed at detecting bacterial infection within the urinary tract. This included traditional methods such as urine culture, as well as newer or experimental diagnostic approaches; Comparator: Where applicable within the study design, the comparator was traditional or standard diagnostic methods, such as urine culture. This allowed for the evaluation of the performance of newer diagnostic techniques in comparison to the current gold standard; Outcome: The outcomes of interest were measures related to the diagnostic tool's performance. These included accuracy, sensitivity, specificity, feasibility, and clinical utility; Study Design: The review was restricted to experimental studies. This included randomized controlled trials (RCTs), non-randomized trials, and controlled laboratory-based investigations. The exclusion criteria were applied to ensure that only the most relevant and high-quality studies were included in the review. The following criteria were used to exclude studies; Case reports, conference abstracts, editorials, existing systematic reviews, and meta-analyses. These study types were excluded as they do not provide primary data or may duplicate existing reviews; Studies for which full-text access could not be obtained; Duplicate publications; Articles not published in English. While no language restrictions were applied during the initial search, only English language articles were included in the final analysis due to resource constraints; Studies not specifically focused on the pregnant population. The study selection process involved two independent reviewers to minimize bias and ensure consistency. The reviewers initially screened the titles and abstracts of all retrieved records against the pre-defined inclusion criteria. This initial screening allowed for the removal of clearly irrelevant studies. The full-text articles of potentially eligible studies were then retrieved and reviewed in detail by both reviewers to make final inclusion decisions. Any disagreements that arose during the study selection process were resolved through discussion between the two reviewers. If consensus could not be reached, a third reviewer was consulted to arbitrate and make the final decision. The entire study selection process was documented and illustrated using a PRISMA flow diagram. This flow diagram visually represents the number of records identified, the number of records excluded at each stage, and the number of studies included in the final review.

A standardized data extraction form was developed and utilized to systematically collect relevant information from each included study. The use of a standardized form ensured that data was extracted consistently across studies, facilitating comparison and synthesis. The following data points were extracted from each included study; Study design: This included the type of study (randomized controlled trial, cross-sectional study); Sample size: The number of participants included in the study; Mean follow-up duration: The average length of time participants were followed in the study; Specific diagnostic modality employed: The diagnostic technique used to detect UTI; Reported sensitivity, specificity, and accuracy of the test: Measures of the diagnostic test's performance; Overall success or recurrence rates; clinical outcomes related to UTI. Two reviewers independently extracted the data from each study, and any discrepancies were resolved through discussion and consensus.

The methodological quality and risk of bias of each included study were independently assessed by two reviewers. Assessing the risk of bias is a critical step in a systematic review, as it allows for an evaluation of the reliability and validity of the included studies. The tools used for risk of bias assessment varied depending on the study design; For randomized controlled trials, the Cochrane Risk of Bias Tool (RoB 2.0) was employed. RoB 2.0 is a comprehensive tool for assessing the risk of bias in RCTs, considering various domains such as bias arising from the randomization process, bias due to deviations from intended interventions, bias due to missing outcome data, bias in measurement of the outcome, and bias in selection of the reported result; For non-randomized studies, the Newcastle-Ottawa Scale (NOS) was used. The NOS is a quality assessment tool for non-randomized studies, evaluating studies based on three broad perspectives: the selection of the study groups, the comparability of the groups, and the ascertainment of the outcome of interest. Each study was evaluated across key domains to identify potential sources of bias. These domains included; Selection bias: Bias due to how participants were selected or allocated to groups; Performance bias: Bias due to differences in the care or interventions received by participants in different groups; Detection bias: Bias due to how outcomes were measured or assessed; Attrition bias: Bias due to loss of participants during the study; Reporting bias: Bias due to selective reporting of results. Any discrepancies in the risk of bias assessments between the two reviewers were resolved through discussion and consensus.

The data synthesis in this review was primarily qualitative. Given the heterogeneity in study designs, populations, and diagnostic modalities, a quantitative meta-analysis was not deemed appropriate. Instead, the findings of the included studies were synthesized narratively, focusing on identifying common themes, patterns, and differences across studies. The data was organized and presented in tables and figures to facilitate comparison and understanding. Key findings related to clinical manifestations of UTI, diagnostic tools used, major pathogens identified, and other relevant outcomes were summarized. The qualitative synthesis involved the following steps; Data organization: Extracted data were organized into tables and figures to provide a clear overview of the included studies and their findings; Thematic analysis: The findings were analyzed to identify common themes and patterns related to UTI diagnosis in pregnant women; Narrative synthesis: A narrative summary of the findings was developed, highlighting key findings, consistencies, and inconsistencies across studies; Comparison of findings: The findings of different studies were compared to identify factors that may explain variations in results. This approach allowed for a comprehensive overview of the current evidence on UTI diagnosis in pregnant women, despite the limitations of not performing a meta-analysis.

## 3. Results

The PRISMA flow chart visually illustrates the process by which studies were identified, screened, and ultimately included in the systematic review.

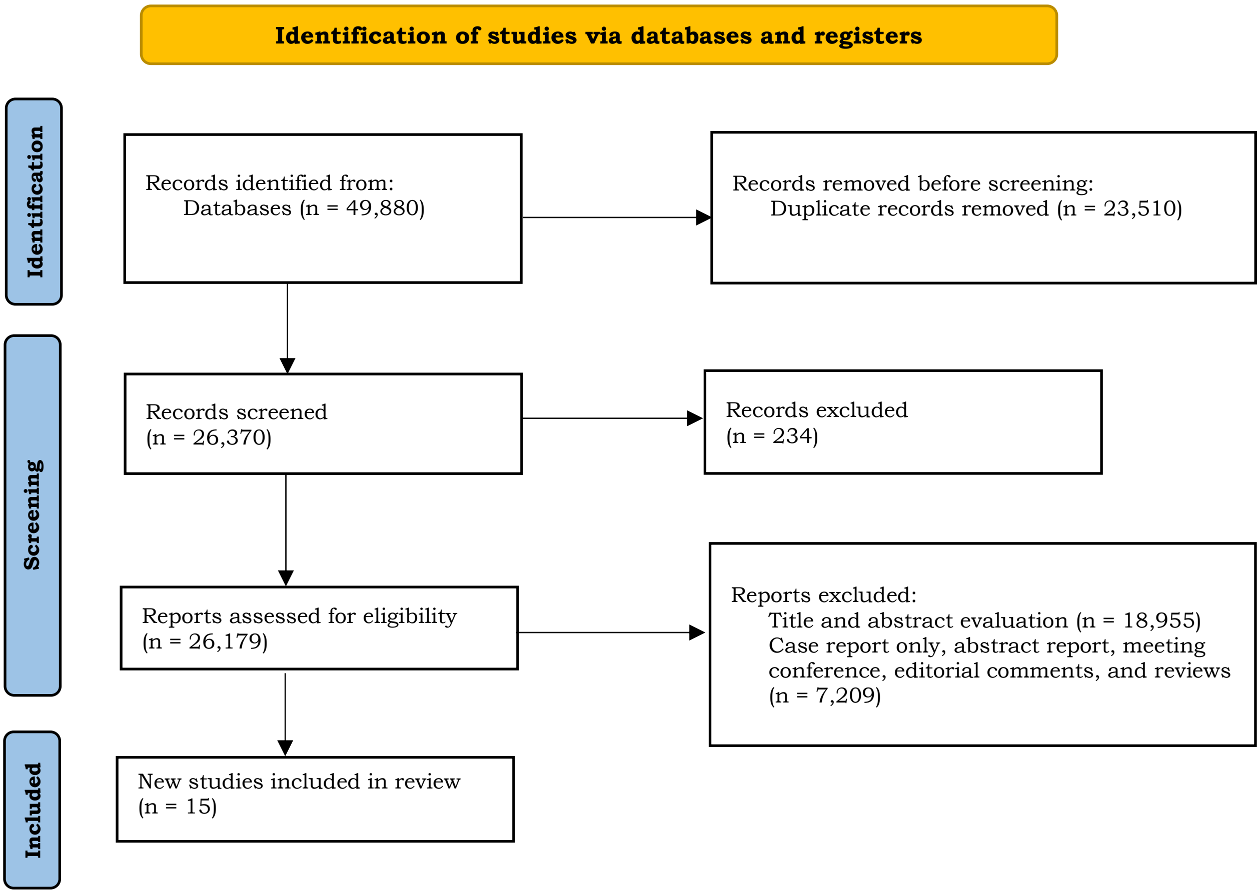


Figure 1. PRISMA flow diagram.

Table 1 presents the synthesis of findings from included on UTI screening in pregnant women; Study 1: This cross-sectional study involved 145 pregnant women attending antenatal care, utilizing clean-catch midstream urine culture and antimicrobial susceptibility testing. The study focused on women presenting with lower abdominal pain. *E. coli* was the most frequently isolated pathogen, followed by *S. aureus*, *Klebsiella* spp., *P. aeruginosa*, and *Proteus* spp. The peak incidence of UTI was observed in the 26-30 year age group; Study 2: Another cross-sectional study, this one included 422 pregnant women. Clean-catch midstream urine culture and antimicrobial susceptibility testing were used. This study included both asymptomatic and symptomatic women, with symptoms including urgency, lower abdominal pain, dysuria, fever, and hematuria. *E. coli* was again the predominant isolate, followed by CoNS, *S. aureus*, *K. pneumoniae*, and *P. aeruginosa*. The peak incidence of UTI was in the 31-35 year age group; Study 3: This cross-sectional study analyzed 192 pregnant women using clean-catch midstream urine for macroscopic examination, culture, and antimicrobial susceptibility testing. It included both asymptomatic and symptomatic women, with symptoms similar to Study 2. *E. coli* was the most frequent isolate, followed by *S. aureus* and *K. pneumoniae*. The study primarily focused on the bacteriological profile of UTIs; Study 4: A cross-sectional study of 303 pregnant women attending obstetrics/gynecology clinics employed clean-catch midstream urine for macroscopic examination, culture, and antimicrobial susceptibility testing. It included both asymptomatic and symptomatic women. *E. coli* was the most common isolate, followed by *K. pneumoniae*, *S. aureus*, and *Proteus* spp. The study also assessed risk factors and noted that *Enterococcus faecalis* was reported as the predominant Gram-positive organism in other studies; Study 5: This cross-sectional study involved 300 pregnant women from primary health centers, using general urine examination (for pus cells, RBC, pH, bacteria, glucose, urea, albumin). It included both asymptomatic and symptomatic women. Organism data was not specified, as the study used general urine examination rather than culture. The peak UTI incidence was in the 15-25 year age group; Study 6: A cross-sectional study of 100 pregnant women aged 24-50 used clean-catch midstream urine culture and antimicrobial susceptibility testing. It included both asymptomatic and symptomatic women. *E. coli* was the most frequent isolate, followed by *K. pneumoniae*, with a low prevalence of *S. aureus*, *S. saprophyticus*, and *S. faecalis*. This study was conducted in a specific hospital setting; Study 7: This cross-sectional study of 480 pregnant women aged 18-40 utilized clean-catch midstream urine culture and antimicrobial susceptibility testing. It included both asymptomatic and symptomatic women. *E. coli* was the most common isolate, followed by *S. aureus*, *K. pneumoniae*, *P. aeruginosa*, and *Enterococcus* sp. The study assessed risk factors and showed a higher incidence percentage in older age groups, although the sample size distribution was not fully clear; Study 8: A cross-sectional study of 177 pregnant women with suspected UTI symptoms used urine turbidity, pH, Gram stain, and urine culture. Symptoms included urgency, lower abdominal pain, pelvic/waist pain, dysuria, fever, and hematuria. Organism data was not specified, with the study focusing on predicting UTI based on simpler tests. It found urine pH was more acidic with Gram-negative bacteria compared to Gram-positive, and Gram stain was associated with UTI. The peak incidence was in the 26-34 year age group; Study 9: This cross-sectional study involved 400 pregnant women with symptomatic UTI, employing clean-catch midstream urine culture and antimicrobial susceptibility testing. Symptoms included lower abdominal pain, frequency, burning/painful micturition, nausea/vomiting, hematuria, and fever. *K. pneumoniae* was the most frequent isolate, followed by *E. coli*, *S. aureus*, *P. aeruginosa*, and *P. mirabilis*. The study focused specifically on symptomatic UTI, with a peak incidence in the 27-33 year age group; Study 10: A cross-sectional study of 100 pregnant women attending primary health care centers used the UTISA questionnaire. Symptoms assessed included polyuria, urgency, dysuria, incomplete emptying, lower abdominal pressure, low back pain, and hematuria. Organism data was not applicable, as the study used a questionnaire for diagnosis. The peak incidence was in the 15-25 year age group; Study 11: This cross-sectional study analyzed 227 archived urine samples from patients with UTI signs/symptoms, using clean-catch midstream urine culture and antimicrobial susceptibility testing, focusing on specific pathogens. Symptoms included fever, lower abdominal pain, flank/back pain, painful urination, dysuria, hematuria, and frequency (but culture-negative with >125 leukocytes). The study focused on specific urogenital pathogens, identifying *N. gonorrhoeae* and *Trichomonas vaginalis*. It used archived samples and had an age range of 23-51, with 100% positive for the studied pathogens; Study 12: A cross-sectional study of 180 pregnant women aged 18-45 used clean-catch midstream urine culture and antimicrobial susceptibility testing. It included both asymptomatic and symptomatic women. *E. coli* was the most frequent isolate, followed by *Klebsiella* spp., *S. aureus*, *Pseudomonas* spp./*aeruginosa*, and *Candida albicans*. The study was conducted in a tertiary care rural hospital; Study 13: This cross-sectional study of 587 pregnant women with asymptomatic bacteriuria

(ASB) used clean-catch midstream urine culture and antimicrobial susceptibility testing. It focused specifically on ASB, defined as the absence of UTI signs/symptoms. *E. coli* was the most frequent isolate, followed by *S. aureus*, *K. pneumoniae*, *P. aeruginosa*, and *Enterococcus*. The peak incidence was in the >29 years age group; Study 14: A cross-sectional study of 560 pregnant women attending antenatal care used clean-catch midstream urine culture and antimicrobial susceptibility testing. It included both asymptomatic and symptomatic women. *E. coli* was the most frequent isolate, followed by CoNS, *Proteus* sp., *E. faecalis*, *Klebsiella* sp., and *S. aureus*. The study assessed associated factors, with a peak UTI incidence in the 21-25 year age group; Study 15: This cross-sectional study of 203 pregnant women attending antenatal care used clean-catch midstream urine culture and antimicrobial susceptibility testing. It included both asymptomatic and symptomatic women. Organism data was not specified, as the focus was likely on antimicrobial resistance patterns. The peak incidence was shared between the 25-29 and 30-34 year age groups.

**4. Discussion**

The physiological and anatomical transformations inherent to pregnancy establish a unique environment that predisposes women to an elevated risk of UTIs. These changes are multifaceted and begin early in gestation, contributing to both symptomatic infections and asymptomatic bacteriuria (ASB). Ureteral dilatation, a common occurrence during pregnancy, leads to a widening of the ureters, the tubes that carry urine from the kidneys to the bladder. This dilatation, often attributed to hormonal influences, particularly the increase in progesterone, reduces the peristaltic activity of the ureters. Peristalsis, the rhythmic muscular contractions that propel urine flow, becomes less efficient, resulting in a slowing of urine transit. Alongside ureteral dilatation, pregnancy also induces an increase in bladder volume coupled with a decrease in bladder muscle tone. The expanding uterus exerts pressure on the bladder, reducing its capacity to empty completely. This incomplete emptying, combined with the reduced muscle tone, leads to urinary stasis, a condition where urine remains in the bladder for longer periods. Urinary stasis is a significant risk factor for bacterial proliferation, as it provides an ideal environment for microorganisms to multiply. Hormonal effects further contribute to the increased susceptibility to UTIs by influencing local immunity within the urinary tract. Hormonal changes can alter the composition of vaginal and urinary flora, potentially reducing the protective effects of beneficial bacteria and increasing the colonization of pathogenic bacteria. These complex interplay of physiological, anatomical, and hormonal factors explains why pregnant women experience a heightened vulnerability to UTIs, including ASB, with this increased risk manifesting as early as the sixth week of gestation. Understanding these changes is crucial for implementing effective screening and preventive strategies during prenatal care.[13-17]

The clinical symptoms of UTI reported across the studies included in this review demonstrate a notable consistency, aligning with the typical presentation of UTIs in the general population. Common manifestations encompass urinary urgency, the frequent and compelling need to urinate, dysuria, characterized by pain or burning during urination, lower abdominal and pelvic pain, indicating inflammation within the urinary tract, fever, a systemic sign of infection, and hematuria, the presence of blood in the urine. These symptoms, while indicative of UTI, can sometimes overlap with other discomforts experienced during pregnancy, posing a diagnostic challenge. However, a critical aspect highlighted by the reviewed studies is the significant prevalence of asymptomatic bacteriuria (ASB) among pregnant women. ASB, by definition, is the presence of bacteria in the urine without the accompanying typical UTI symptoms. This absence of overt clinical signs makes ASB particularly insidious, as it can go undetected and untreated, potentially leading to serious complications. The importance of screening for ASB during antenatal care is underscored by the observation that regions with robust ASB screening programs tend to have lower rates of pyelonephritis, a severe kidney infection, in pregnant women. Effective screening protocols are therefore essential to identify and manage ASB, mitigating the risk of adverse outcomes for both mother and fetus.[18-21]

Table 1. Synthesis of findings from included studies on UTI screening in pregnant women.

| Study ID | Study design | Population (N) & characteristics | Diagnostic tools used | Key clinical manifestations reported / Inclusion criteria | Major pathogens identified (%) | Key findings / Notes |
|---|---|---|---|---|---|---|
| Study 1 | Cross-sectional | 145 pregnant women (ANC attendees) | Clean-catch midstream urine (MSU) culture & AST | Lower abdominal pain complaints | *E. coli* (25.9), *S. aureus*(20.9), *Klebsiella* spp. (14.8), *P. aeruginosa*(14.8), *Proteus* spp. (13.7) | Peak UTI incidence in 26-30 year age group (38.6%). |
| Study 2 | Cross-sectional | 422 pregnant women | Clean-catch MSU culture & AST | Included asymptomatic & symptomatic (urgency, lower abdominal pain, dysuria, fever, hematuria) | *E. coli* (43.5), CoNS (15.9), *S. aureus* (13), *K. pneumoniae*(8.7), *P. aeruginosa*(7.2) | Peak UTI incidence in 31-35 year age group (29.6%). |
| Study 3 | Cross-sectional | 192 pregnant women | Clean-catch MSU (macroscopic, culture, AST) | Included asymptomatic & symptomatic (urgency, lower abdominal pain, dysuria, fever, hematuria) | *E. coli* (68.4), *S. aureus*(21.1), *K. pneumoniae*(10.5) | Focused on bacteriological profile. |
| Study 4 | Cross-sectional | 303 pregnant women (Obstetrics/Gynecology clinic attendees) | Clean-catch MSU (macroscopic, culture, AST) | Included asymptomatic & symptomatic (urgency, lower abdominal pain, dysuria, fever, hematuria) | *E. coli* (37), *K. pneumoniae*(27), *S. aureus*(17.6), *Proteus* spp. (8.2) | Also assessed risk factors. Reports *Enterococcus faecalis* as predominant Gram-positive in other studies. |
| Study 5 | Cross-sectional | 300 pregnant women (Primary health center attendees) | General urine examination (pus cells, RBC, pH, bacteria, glucose, urea, albumin) | Included asymptomatic & symptomatic (urgency, lower abdominal pain, dysuria, fever, hematuria) | Organism data not specified. | Used general urine exam, not primarily culture. Peak UTI incidence in 15-25 year age group (53.7%). |
| Study 6 | Cross-sectional | 100 pregnant women (age 24-50) | Clean-catch MSU culture & AST | Included asymptomatic & symptomatic (urgency, lower abdominal pain, dysuria, fever, hematuria) | *E. coli* (25.5), *K. Pneumoniae* (11). Low prevalence of *S. aureus*, *S. saprophyticus*, *S. faecalis*(0.5% each). | Study conducted in a specific hospital setting. |
| Study 7 | Cross-sectional | 480 pregnant women (age 18-40) | Clean-catch MSU culture & AST | Included asymptomatic & symptomatic (urgency, lower abdominal pain, dysuria, fever, hematuria) | *E. coli* (40.6), *S. aureus*(28.3), *K. pneumoniae*(16.4), *P. aeruginosa*(8.2), *Enterococcus* sp. (3.6) | Assessed risk factors. Showed higher incidence percentage in older groups (41-50 years), though sample size distribution not fully clear from table. |
| Study 8 | Cross-sectional | 177 pregnant women with suspected UTI based on symptoms | Urine turbidity, pH, Gram stain, Urine culture | Urgency, lower abdominal pain, pelvic/waist pain, dysuria, fever, hematuria | Organism data not specified. Focus on predicting UTI based on simpler tests. | Found urine pH more acidic with Gram-negative bacteria (mean 6.30) vs. Gram-positive (mean 6.71). Gram stain associated with UTI. Peak incidence 26-34 years (80.7%). |
| Study 9 | Cross-sectional | 400 pregnant women with symptomatic UTI | Clean-catch MSU culture & AST | Lower abdominal pain, frequency, burning/painful micturition, nausea/vomiting, hematuria, fever | *K. pneumoniae*(37.41), *E. coli*(28.78), *S. aureus* (23.57), *P. aeruginosa*(5.04), *P. mirabilis* (5.04) | Focused specifically on symptomatic UTI. Peak incidence 27-33 years (reported as 3.5% overall prevalence, age group details in table). |
| Study 10 | Cross-sectional | 100 pregnant women (Primary Health Care attendees) | UTISA questionnaire | Polyuria, urgency, dysuria, incomplete emptying, lower abdominal pressure, low back pain, hematuria | Organism data not applicable (questionnaire-based diagnosis). | Used a symptom assessment questionnaire (UTISA) as the primary tool. Peak incidence in 15-25 year age group (50%). |
| Study 11 | Cross-sectional | 227 archived urine samples (patients with UTI signs/symptoms) | Clean-catch MSU culture & AST (focus on specific pathogens) | Fever, lower abdominal pain, flank/back pain, painful urination, dysuria, hematuria, frequency (but culture negative with >125 leucocytes) | *N. gonorrhoeae*(11), *Trichomonas vaginalis*(10.6). Focused on specific urogenital pathogens. | Used archived samples. Focused on urogenital pathogens beyond common bacteria. Age range 23-51 (100% positive for studied pathogens). |
| Study 12 | Cross-sectional | 180 pregnant women (age 18-45) | Clean-catch MSU culture & AST | Included asymptomatic & symptomatic (urgency, lower abdominal pain, dysuria, fever, hematuria) | *E. coli* (54.55), *Klebsiella* spp. (24.24), *S. aureus* (12.12), *Pseudomonas*spp./*aeruginosa*(3.03 each), *Candida albicans* (3.03) | Study conducted in a tertiary care rural hospital. |
| Study 13 | Cross-sectional | 587 pregnant women with ASB | Clean-catch MSU culture & AST | Asymptomatic Bacteriuria (ASB) - absence of UTI signs/symptoms | *E. coli* (46.4), *S. aureus*(32.1), *K. pneumoniae*(7.1), *P. aeruginosa*(7.1), *Enterococcus*(7.1) | Specifically focused on ASB prevalence and bacteriology. Peak incidence >29 years (40.9%). |
| Study 14 | Cross-sectional | 560 pregnant women (ANC attendees) | Clean-catch MSU culture & AST | Included asymptomatic & symptomatic (urgency, lower abdominal pain, dysuria, fever, hematuria) | *E. coli* (27.8), CoNS (13.5), *Proteus* sp. (12.6), *E. faecalis* (11.2), *Klebsiella* sp. (10.3), *S. aureus* (6.7) | Assessed associated factors. Peak UTI incidence in 21-25 year age group (36.4%). |
| Study 15 | Cross-sectional | 203 pregnant women (ANC attendees) | Clean-catch MSU culture & AST | Included asymptomatic & symptomatic (urgency, lower abdominal pain, dysuria, fever, hematuria) | Organism data not specified. Focus likely on antimicrobial resistance patterns. | Focused on antimicrobial resistance. Peak incidence shared between 25-29 and 30-34 year age groups (28.8% each). |

Notes: ANC: Antenatal Care; ASB: Asymptomatic Bacteriuria; AST: Antimicrobial Susceptibility Testing; CoNS: Coagulase-Negative Staphylococci; MSU: Midstream Urine; RBC: Red Blood Cell; spp.: species; UTI: Urinary Tract Infection.

Urine culture has consistently emerged as the cornerstone of UTI diagnosis in the studies included in this review. A substantial majority, specifically 12 out of the 15 studies, relied on urine culture as a fundamental diagnostic method. This widespread use reinforces its status as the gold standard for accurately identifying the presence and quantifying the amount of bacteria in the urine. Furthermore, urine culture often serves as a crucial guide for antimicrobial therapy, as it allows for antimicrobial susceptibility testing, which determines the effectiveness of different antibiotics against the isolated bacteria. The emphasis on proper specimen collection techniques, particularly the clean-catch midstream urine method, is implicitly acknowledged in its frequent mention across the studies. This technique minimizes the risk of contamination from the external genitalia and perineum, which can lead to false-positive results. Contamination can result in the unnecessary prescription of antibiotics, contributing to antibiotic resistance and increased healthcare costs. Therefore, the accuracy and reliability of urine culture heavily depend on meticulous collection procedures. While urine culture remains the predominant method, some studies incorporated alternative or supplementary diagnostic approaches. These included general urine examinations, which assess various parameters such as pH, the presence of pus cells (white blood cells), red blood cells, and other components. Dipstick tests, rapid chemical tests that can detect certain substances in the urine, were also implied through the reporting of pH testing. Gram staining, a technique that classifies bacteria based on their cell wall properties, was another adjunct method employed. Finally, one study utilized a symptom assessment questionnaire, the UTISA questionnaire, as the primary diagnostic tool. These alternative and supplementary methods highlight the ongoing exploration of diagnostic strategies for UTI in pregnant women.[22-24]

The study conducted by Hattah et al. presents intriguing preliminary data that suggests the potential utility of urine pH and Gram stain as adjuncts in UTI diagnosis, particularly in the context of pregnant women. The study revealed a correlation between urine pH and the type of bacteria present in the urine. Specifically, it was observed that urine samples with Gram-negative bacterial infections tended to have a more acidic pH. This finding offers a potential avenue for rapid, initial assessment in clinical settings. The underlying mechanism for this pH difference may be linked to the urease activity of bacteria. Urease is an enzyme produced by some bacteria that catalyzes the hydrolysis of urea into ammonia and carbon dioxide. Ammonia is alkaline, and its production can lead to an increase in urine pH. Many common Gram-positive bacteria, such as *Staphylococcus saprophyticus* and *Enterococcus faecalis*, possess urease activity, which could explain the more alkaline urine pH associated with Gram-positive infections. In contrast, predominant Gram-negative bacteria, like *E. coli*, often lack urease activity, potentially contributing to the more acidic urine pH observed in those infections. While these findings are promising, it is crucial to emphasize that urine pH and Gram stain should be considered adjunct tests and not replacements for urine culture. Urine culture remains the gold standard for definitive UTI diagnosis due to its ability to accurately identify and quantify bacteria, as well as determine antimicrobial susceptibility. Further validation is necessary to establish the reliability and clinical utility of urine pH and Gram stain as screening or predictive tools. This validation should involve larger studies with diverse populations of pregnant women, comparing the results of these adjunct tests with urine culture outcomes.[25-27]

## 5. Conclusion

This systematic review highlights the consistent presentation of UTI symptoms in pregnant women across recent studies, which typically include urgency, dysuria, lower abdominal and pelvic pain, fever, and hematuria. The prevalence of asymptomatic bacteriuria (ASB) in this population underscores the importance of screening to prevent potential complications. Urine culture remains the predominant diagnostic tool for UTI, reaffirming its status as the gold standard for accurate bacterial identification and quantification. The reliance on proper urine collection techniques, such as the clean-catch midstream method, is crucial for minimizing contamination and ensuring accurate results. While urine culture is the primary diagnostic method, adjunctive approaches like urine pH testing and Gram staining may offer additional clinical insights. Specifically, urine pH has shown potential in differentiating between Gram-negative and Gram-positive bacterial infections, which could aid in rapid initial assessments. However, these supplementary tests should not replace urine culture, which remains essential for definitive diagnosis and antimicrobial susceptibility testing. Further research is warranted to validate the clinical utility of urine pH and Gram staining in diverse pregnant populations and to explore other potential biomarkers for UTI diagnosis.

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