ISSN Print: 2664-6536
ISSN Online: 2664-6544
Impact Factor: RJIF: 5.51
IJBB 2025; 7(2): 57-64
www.biosciencejournal.net
Received: 05-08-2025
Accepted: 10-09-2025

Zhraa F Faruq
Al-Manara College for Medical Sciences, Maysan, Iraq

Marwa A Hassan
Department of Biology, College of Science, University of Misan, Amarah, Maysan, Iraq

Corresponding Author:
Zhraa F Faruq
Al-Manara College for Medical Sciences, Maysan, Iraq

Diagnostic value of urinalysis, microscopy, and inflammatory biomarkers in women with suspected urinary tract infection: A cross-sectional study from Maysan, Iraq

Zhraa F Faruq and Marwa A Hassan

DOI: https://www.doi.org/10.33545/26646536.2025.v7.i2a.155

Abstract
Background: Urinary tract infection (UTI) is one of the most common bacterial infections among women, yet distinguishing true bacterial infection from culture-negative symptomatic cases remains challenging. This study evaluated the diagnostic performance of urinalysis, microscopy, and systemic inflammatory biomarkers in women with suspected UTI.
Methods: A cross-sectional study was conducted at Maysan General Hospital, Iraq, from September 2024 to June 2025. One hundred twenty adult female patients were enrolled: 80 with culture-confirmed UTI and 40 with negative cultures. Urinalysis (leukocyte esterase, nitrite, blood), urine microscopy, and serum biomarkers (routine C-reactive protein [CRP], CRP-ELISA, and Serum Amyloid A [SAA]) were assessed. ESBL production in Escherichia coli isolates was determined using the combined disk synergy test.
Results: Nitrite and leukocyte esterase were significantly higher in culture-positive cases ($p < 0.05$). Mean urinary WBC and bacterial density differed markedly between groups ($p < 0.001$). Serum CRP, CRP-ELISA, and SAA were all significantly elevated in culture-positive patients ($p < 0.0001$). ESBL-producing E. coli accounted for 32.5% of isolates.
Conclusion: Combining dipstick and microscopy with inflammatory biomarkers enhances diagnostic accuracy for UTI in symptomatic women. The high prevalence of ESBL-producing *E. coli* highlights the need for rapid diagnostics and antibiotic stewardship in Iraqi healthcare settings.

Keywords: Urinary tract infection, C-reactive protein, serum amyloid A, urinalysis, ESBL, *Escherichia coli*

Introduction
Urinary tract infections (UTIs) are one of the most, if not the most, commonly observed bacterial infections in the world and women are affected by this more than men due to inherent anatomical and physiological risk factors (shorter urethra, close proximity to colonized perineal flora)1. UTI is still a major health issue in Iraq, with various community and hospital-based studies providing prevalence rates that reflect both the disease burden and the difficulties of diagnosis and treatment2.
Uropathogenic Escherichia coli (UPEC) is the most common cause of urinary tract infections (UTIs), and its virulence factors facilitate colonization, biofilm formation and immune evasion3. More recently, a study conducted in Zakho, Iraq, 969624 confirmed the predominance of E. coli among uropathogens isolated from outpatients15 confirming its central role in both community-4 and hospital-acquired UTIs.
Patients with urinary tract infection (UTI) typically see a range of symptoms from dysuria, frequency, urgency, suprapubic pain, but when it progresses to become pyelonephritis, may very commonly present with fever and/or flank pain if the infection has ascended to the upper urinary tract.1 But a diagnosis based on symptoms is limited: urine cultures are negative for many patients with symptoms suggestive of urinary tract infection from previously used antibiotics, unrecoverable organisms, or sterile pyuria5. Due to this, clinicalpathways for UTI diagnosis often resort to urinalysis (dipstick testing, microscopy)

and serum biomarkers of inflammation, however, the diagnostic accuracy of these tools is under further evaluation [6].

Dipstick parameters like leukocyte esterase and nitrite have a clear role in fast screening: a positive nitrite reflects bacterial nitrate conversion (commonly observed with Gram negative pathogens), and leukocyte esterase reflects neutrophil activity in the urine 7. Nevertheless, these tests have low sensitivity and specificity, notably the culture-negative symptomatic cases. At a microscopic level, pyuria (increased white blood cells), hematuria, and bacteria on urine sediment are suggestive of infection but may again not accurately correlate with culture findings [8, 9].

Moreover, by means of acute-phase proteins, systemic inflammatory responses induced by bacterial invasion can be measured. The best-known are C-reactive protein (CRP) and Serum Amyloid A (SAA) [10]. C-reactive protein (CRP) is an acute-phase reactant produced by hepatocytes in response to interleukin-6 and it has been clnicallly used for decades for the surveillance of infection and inflammation11. The other well-known acute-phase protein is serum amyloid A (SAA), which is frequently elevated more quickly and might be more sensitive in acute infections than CRP12. In fact, SAA levels have been studied in various infectious and inflammatory settings aside from UTIs, and it has been shown to have a high correlation to CRP in systemic inflammatory states (rho ≈ 0.755, $p < 0.001$)13.

In urinary sepsis secondary to UTI, recent investigations have evaluated the combined diagnostic performance of procalcitonin, CRP, and SAA and collectively found that the three may improve early diagnosis of systemic infection [14, 15]. However, data on the comparative use of CRP (routine and ELISA-based) and SAA in symptomatic UTI patients stratified based on culture positivity versus negativity are still scant, especially from our region, Iraq.

Having this scenario, we conducted a study including molecular and serological characterization of UTI isolates (ordinary features, urinalysis, microbiology and CRP), in addition to the study of demographic and clinical features including serum inflammatory biomarkers (routine CRP, CRP-ELISA, SAA) in woman presented with UTI symptomatic to Maysan General Hospital, Iraq. We sought to:

1. Evaluate which dipstick and microscopic parameters best distinguish culture-positive from culture-negative symptomatic cases.
2. Determine the discriminatory power of CRP and SAA levels in differentiating true bacterial infection versus symptoms alone.
3. Assess the prevalence of ESBL-producing E. coli among culture-positive cases in our region.

By integrating laboratory markers at multiple levels, we hope to provide a more refined diagnostic approach for clinicians in resource-limited settings and to contribute local epidemiological data on uropathogen resistance patterns.

Materials and Methods

Study Design and Setting

Methods: A cross-sectional study was done at the Department of Clinical Laboratory Sciences, Maysan General Hospital, Maysan Province, Iraq during the period for nine months between September 10, 2024 to June 10, 2025. Objective to assess the diagnostic characteristics of urinalysis, urine microscopy and systemic inflammatory biomarkers among women with symptoms suggestive of urinary tract infection (UTI). The Maysan General Hospital Ethics Committee approved the study, and written informed consent was obtained from all participants prior to sample collection.

Study Population

The study sample included 120 adult females aged 18 to 50 years attending the outpatient department for at least one lower urinary tract symptom (dysuria, frequency, urgency or suprapubic pain). On the basis of urine culture results, participants were grouped into two groups (Group I, n = 80; Included patients with significant bacteriuria ($\geq 10^5$ CFU/mL) and Group II, n = 40; included patients with sterile urine cultures. Patients were excluded if they were pregnant, on their period, had chronic kidney disease or diabetes mellitus, had undergone urological instrumentation within 48 h, or had been taking antibiotics within the previous 14 days to sampling. By this selection, study participants were excluded from systemic confounders, and that study samples reflected active infection status accurately.

Specimen Collection and Processing

All participants were instructed to provide a midstream clean-catch urine sample (10-15 mL) in a sterile, screw-capped container following proper perineal cleaning with antiseptic wipes. Samples were transported to the microbiology laboratory within one hour of collection or stored temporarily at 4°C for no longer than two hours before processing to maintain specimen integrity. Each urine sample was mixed gently and aliquoted for dipstick analysis, microscopic examination, and culture.

Urine Culture and Identification

For microbiological assessment, urine samples were inoculated onto Cystine Lactose Electrolyte Deficient (CLED) agar, MacConkey agar, and Blood agar (HiMedia Laboratories, India) using a calibrated 0.001 mL loop. Plates were incubated aerobically at 37°C for 18-24 hours, and colony counts were recorded to determine bacterial load. A growth of $\geq 10^5$ CFU/mL was interpreted as significant bacteriuria, while lower counts or mixed growths were considered contaminated or insignificant. Bacterial isolates were identified through standard biochemical tests, including Indole, Citrate utilization, Urease, Motility, and Triple Sugar Iron (TSI) reactions, following Clinical and Laboratory Standards Institute (CLSI) recommendations. All isolates that exhibited the biochemical profile characteristic of Escherichia coli were further confirmed through Gram staining and morphology.

Antimicrobial Susceptibility Testing and ESBL Detection

Antimicrobial susceptibility testing was performed using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar (HiMedia, India) according to CLSI 2023 guidelines. The antibiotics tested included ampicillin, cefotaxime, ceftazidime, ciprofloxacin, trimethoprim-sulfamethoxazole, nitrofurantoin, and imipenem. Detection of Extended-Spectrum Beta-Lactamase (ESBL) production was carried out by the Combined Disk Synergy Test (CDST) using ceftazidime (30 µg) and ceftazidime-clavulanic acid (30/10 µg) discs (Oxoid, UK). An increase of ≥5 mm in the inhibition zone in the presence of clavulanic acid was interpreted as a positive ESBL phenotype. Urinalysis Dipstick Examination

Immediate screening of fresh urine specimens was performed using URiSCAN 10 SGL reagent strips (YD Diagnostics, Korea), a diagnostic product widely used in Iraq. The strips were visually interpreted according to the manufacturer's color scale to detect leukocyte esterase, nitrite, and blood. Results were recorded semiquantitatively as negative, trace, +, ++, or +++. Daily quality control was performed using standard control solutions provided by the manufacturer to ensure accuracy and consistency of results.

Microscopic Examination of Urine

For microscopic analysis, 10 mL of well-mixed urine was centrifuged at 3,000 rpm for 5 minutes. The supernatant was discarded, and a drop of the sediment was placed on a clean glass slide and covered with a coverslip. The sediment was examined under an Olympus CX23 light microscope (Japan) at 400× magnification. White blood cells (WBCs) and red blood cells (RBCs) were counted in 10 high-power fields (HPFs), and the mean number per HPF was calculated. The presence of bacteria was graded semiquantitatively as 0 (none), 1 (few), 2 (moderate), or 3 (numerous). Findings were recorded for correlation with culture results.

Serum Biochemical and Inflammatory Marker Analysis

Venous blood samples (5 mL) were collected from each participant under aseptic conditions and allowed to clot at room temperature. The samples were centrifuged at 3,000 rpm for 10 minutes to separate serum for analysis. Serum creatinine and blood urea nitrogen (BUN) were determined using enzymatic colorimetric methods on a Mindray BS-240 Chemistry Analyzer (Shenzhen Mindray Bio-Medical Electronics, China) with reagent kits supplied by Spinreact (Spain). The estimated glomerular filtration rate (eGFR) was calculated using the CKD-EPI 2021 equation.

Inflammatory markers were measured as follows: C-reactive protein (CRP) was determined by turbidimetric immunoassay using Spinreact reagents on the same analyzer; high-sensitivity CRP (CRP-ELISA) was quantified with a commercial Bioassay Technology Laboratory (BT Lab, Shanghai, China) kit (Cat. No. E0806Hu); and Serum Amyloid A (SAA) was measured using the Elabscience Human SAA ELISA Kit (E-EL-H0176, Elabscience Biotechnology Inc., Wuhan, China). Optical densities were read on a BioTek ELx800 microplate reader (USA) at 450 nm, and concentrations were calculated from standard curves derived by four-parameter logistic regression.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), and categorical data were summarized as frequencies and percentages. The independent-samples t-test was applied to compare means between two groups after testing for normality using the Shapiro-Wilk test, while categorical variables were compared using the Chi-square test or Fisher's exact test where appropriate. A p-value < 0.05 was considered statistically significant.

Ethical Considerations

The study protocol was approved by the Ethics Committee of Maysan General Hospital (Approval No.: MGH/CL/2024/112). All research procedures complied with the ethical principles outlined in the Declaration of Helsinki (2013 revision). Written informed consent was obtained from all participants prior to inclusion in the study.

Results

This table summarizes the baseline demographic and clinical characteristics of the study participants, stratified into Positive-Cases (culture-confirmed UTI, n=80) and Negative-Cases (no growth on culture, n=40). The two groups were well-matched in terms of age, sex distribution, and Body Mass Index (BMI), with no statistically significant differences. While common UTI symptoms such as dysuria, frequency, and urgency were highly prevalent in both groups, they were consistently more frequent in the Positive-Cases group. Notably, systemic symptoms like fever (≥38°C) and flank pain were more common in the Positive-Cases, suggesting a greater proportion of upper UTIs or more severe infection in this cohort.

Table 1: Baseline Demographic and Clinical Characteristics of the Study Cohort

Characteristic	Positive-Cases (n=80)	Negative- Cases (n=40)	p-value
Age (years)			
Mean ± SD	32.4 ± 7.9	32.8 ± 7.6	0.8
Range	18-50	18-52	
Sex			
Female	80 (100%)	40 (100%)	-----
BMI (kg/m²)			
Mean ± SD	25.9 ± 4.2	25.6 ± 3.9	0.9
Symptoms			
Dysuria	77 (96.3%)	35 (87.5%)	0.8
Frequency	74 (92.5%)	32 (80.0%)	
Urgency	69 (86.3%)	27 (67.5%)	
Suprapubic pain	67 (83.8%)	26 (65.0%)	
Hematuria	35 (43.8%)	10 (25.0%)	
Fever ≥38°C	33 (41.3%)	9 (22.5%)	
Flank pain	25 (31.3%)	9 (22.5%)	

Independent samples t-test (presented as Mean ± SD). Chi-square test.

This table presents the results of the physical examination. A statistically significant difference was observed in body temperature, with the Positive-Cases group having a higher mean temperature and a greater proportion of patients with fever (≥38°C). Heart rate was elevated in the Positive-Cases but did not reach statistical significance, while blood pressure was similar between groups. Physical tenderness, particularly suprapubic and pyelonephritis signs (a composite of fever or flank pain), was more frequently documented in the Positive-Cases, aligning with their higher symptom burden.

Table 2: Comparative Analysis of Physical Examination Findings

Finding	Positive-Cases (n=80)	Negative- Cases (n=40)	p-value
Temperature (°C)			
Mean ± SD	37.8 ± 0.5	37.1 ± 0.5	<0.0001
≥38°C	33 (41.3%)	9 (22.5%)	----
Heart Rate (bpm)			
Mean ± SD	96.1 ± 12.8	88.5 ± 12.1	0.12
Blood Pressure (mmHg)			
SBP, mean ± SD	112.1 ± 11.8	114.2 ± 12.7	0.62
DBP, mean ± SD	73.6 ± 8.2	74.5 ± 8.9	0.71
Tenderness			
Suprapubic	45 (56.3%)	12 (30.0%)	0.7
CVA	7 (8.8%)	1 (2.5%)	
Pyelonephritis signs*	38 (47.5%)	9 (22.5%)	

*Fever ≥38°C or flank pain

This table details the results of the urinalysis dipstick test. The distribution of Leukocyte Esterase results was significantly different between groups, with a higher proportion of negative results in the Negative-Cases. The most striking finding was for Nitrite, which was positive in 65% of Positive-Cases compared to only 17.5% of Negative-Cases, a highly significant difference. The presence of blood on dipstick was more common in the Positive-Cases, but this difference was not statistically significant.

Table 3: Diagnostic Performance of Urinalysis Dipstick Parameters

Parameter	Positive-Cases (n=80)	Negative- Cases (n=40)	p-value
Leukocyte Esterase			
Negative	5 (6.3%)	10 (25.0%)	0.041
Trace	11 (13.8%)	6 (15.0%)	
+	16 (20.0%)	6 (15.0%)	
++	23 (28.8%)	7 (17.5%)	
+++	25 (31.3%)	11 (27.5%)	
Nitrite			
Positive	52 (65.0%)	7 (17.5%)	<0.0001
Negative	28 (35.0%)	33 (82.5%)	
Blood			
Negative	46 (57.5%)	30 (75.0%)	0.23
+	17 (21.3%)	6 (15.0%)	
++	9 (11.3%)	3 (7.5%)	
+++	8 (10.0%)	1 (2.5%)	

This table displays the findings from urine microscopy and the reference standard culture. Microscopic analysis revealed significantly higher mean white blood cell (WBC) and red blood cell (RBC) counts in the Positive-Cases. Furthermore, a markedly higher proportion of Positive-Cases had pyuria (>20 WBC/HPF). The semiquantitative grading of bacteria on microscopy also showed a significant difference between the groups. As per the study design, all Positive-Cases had a culture positive for E. coli, with a substantial subset (32.5%) exhibiting an Extended-Spectrum Beta-Lactamase (ESBL) phenotype.

Table 4: Urine Microscopy and Definitive Culture Results

Parameter	Positive-Cases (n=80)	Negative- Cases (n=40)	p-value
Microscopy WBC (cells/HPF)			
Mean ± SD	33.8 ± 19.7	6.9 ± 4.6	<0.0001
0-5	8 (10.0%)	17 (42.5%)	<0.001
6-20	21 (26.3%)	12 (30.0%)	
>20	51 (63.8%)	11 (27.5%)	
Microscopy RBC (cells/HPF)			
Mean ± SD	4.95 ± 4.3	2.2 ± 1.4	<0.001
Bacteria Grade (0-3)			
0	6 (7.5%)	11 (27.5%)	0.0162
1	15 (18.8%)	9 (22.5%)	
2	31 (38.8%)	9 (22.5%)	
3	28 (35.0%)	11 (27.5%)	
Culture Result			
E. coli positive	80 (100%)	0 (0%)	-----
Extended-Spectrum Beta-Lactamase Phenotype	26 (32.5%)	0 (0%)	----

This table compares serum biomarkers of inflammation and renal function. Renal function parameters (Serum Creatinine, BUN) were similar between groups, though the estimated Glomerular Filtration Rate (eGFR) was statistically significantly lower in the Positive-Cases, albeit still within a normal range. The most pronounced differences were observed in inflammatory biomarkers. Both routine CRP and the more sensitive CRP-ELISA, as well as Serum Amyloid A (SAA), were significantly elevated in the Positive-Cases group, indicating a systemic inflammatory response associated with culture-confirmed UTI.

Table 5: Comparison of Systemic Inflammatory and Renal Function Biomarkers

Biomarker	Positive-Cases (n=80)	Negative- Cases (n=40)	p-value
Serum Creatinine (mg/dL)			
Mean ± SD	0.91 ± 0.20	0.84 ± 0.19	0.14
BUN (mg/dL)			
Mean ± SD	14.3 ± 3.8	13.0 ± 4.0	0.29
eGFR (mL/min/1.73m²)			
Mean ± SD	97.6 ± 21.8	102.5 ± 23.4	<0.0001
CRP Routine (mg/L)			
Mean ± SD	33.5 ± 26.3	11.9 ± 14.1	<0.0001
CRP ELISA (mg/L)			
Mean ± SD	38.7 ± 33.5	14.6 ± 14.7	<0.0001
SAA ELISA (mg/L)			
Mean ± SD	99.4 ± 96.7	37.2 ± 41.8	<0.0001

Independent samples t-test.

Discussion

Abstract Background This cross-sectional research assessed the diagnostic value of urinalysis, urine microscopy, and systemic inflammatory biomarkers in symptomatic women with and without culture-proven urinary tract infections (UTIs) at Maysan General Hospital. Using culture-positive cases as the outcome, leukocyte esterase and nitrite positivity on dipstick were significantly associated with the former and hematuria lacked diagnostic specificity. These findings are in line with previous studies that have shown that among the 2 dipstick parameters that predict presence of bacteriuria, nitrite and leukocyte esterase provide the most clinically relevant information, though neither has optimal accuracy [7-18, 32]. The specificity was very high for nitrite (94.9%), but sensitivity was low (34.1%), according to one study. On the other hand, the sensitivity of leukocyte esterase was 87.8%, but the specificity was only 71.2%, showing it is more effective for UTI detection 16. Mohanna, *et al*. reported similar patterns. 17 that the dipstick results should supplement not supplant urine culture.

This study also showed strong diagnostic discrimination by the microscopy findings. Culture-positive participants had significantly higher mean white blood cell (WBC) counts and increased bacterial density compared to culture-negative individuals. This is in agreement with former investigation by Rishi, *et al*. 18, mentioning pyuria and bacteriuria as some of the most reliable laboratory correlates of infection. Nevertheless, some culture-negative symptomatic patients still showed pyuria or bacteriuria, known as the condition of sterile pyuria. It occurs due to incompletely treated infections, fastidious organisms such as Chlamydia trachomatis or Ureaplasma urealyticum, or inflammatory processes such as interstitial cystitis19. Hence, urine microscopy still serves as a useful but non-definitive method of diagnostic adjunct that must be interpreted with culture and clinical information.

One of the most relevant contributions of this study is the direct comparison between "normal" or "routine" CRP, CRP measured by the gold standard method (the enzyme-linked immunosorbent assay-ELISA), and Serum Amyloid A. These results confirmed the presence of a systemic inflammatory response to bacterial infection with all three biomarkers remaining significantly higher in culture-positive cases. DCRP and D SAA were significantly higher in infected patients than culture-negative patients ($p < 0.0001$), the mean values of CRP 168.65 ± 50.91 versus 8.96 ± 1.76 mg/l respectively, SAA 29.25 ± 6.76 versus 3.73 ± 0.29 mg/l respectively. The afore-mentioned findings offer further support to previous studies which revealed that the two proteins CRP and SAA represent sensitive acute-phase reactants which are produced by hepatocytes under the influence of the cytokine interleukin-620 in the context of infection and inflammation.

Similar to those described by Guan, *et al*, our findings are as follows. 21 showed that combined use of CRP together with SAA offers improved diagnostic sensitivity for bacterial infections compared to that based on CRP measurement alone. Likewise, increased concentrations of SAA have been shown to precede CRP elevation in sepsis and severe UTI, reflecting a more rapid hepatic response to cytokine stimulation22. Previous studies in China and Europe have also indicated that SAA could be of additional diagnostic value in distinguishing bacterial from viral or inflammatory noninfectious diseases 21. Thus, this finding in the present study suggests that a combination of CRP and SAA could help distinguish those with true bacterial infections, when the results of urinalysis or cultures are equivocal or borderline in patients undergoing urinary tract infections' diagnosis as CRP may increase in a few inflammatory conditions other than bacterial profusion.

By contrast, there were no significant differences in renal function parameters such as serum creatinine and blood urea nitrogen levels between the groups, suggesting that the severity of infection was restricted in this cohort to the lower or early upper urinary tract, without evidence of frank renal impairment. Partial impairment of renal function was observed, since aging eGFR (eGFR lowered) was lower in culture-positive patients, all values remain within normal limits as expected for a functional but reversible change. Levinson *et al* described almost similar patterns. 23- this reflects the transient reduction in eGFR during acute UTI

which is primarily due to inflammatory and hemodynamic effect and not structural kidney damage.

The finding of Extended-Spectrum Beta-Lactamase (ESBL) production in 32.5% of E. coli isolates in this study is alarming; however, it is still in line of regional reports. High prevalence of ESBL among uropathogenic E. coli in Iraq and neighboring countries has been reported, suggesting a widespread use of antibiotics with poor antimicrobial stewardship in the region. For instance, Khaleel, *et al*. Compared with the 28.4% prevalence of ESBL producers for community-acquired UTIs, 24 evident reports showed a much higher prevalence of ESBL-producing bacteria, as confirmed the isolates of urinary tract infections in Al-Hilla, Iraq, and isolated they were confirmed by 100% ESBL producers, Mohammed, *et al*. 25 high rates greater than 35% in Basrah. When it comes to similar research from Duhok, ESBL frequencies varied between 25% and 50%, depending on the detection method and patient populations26. Together, these findings demonstrate a concerning antimicrobial resistance burden in Iraq and a clear need for culture-guided therapy.

A high proportion of ESBL-producing E. coli isolates is clinically relevant, as evidenced by this report. Furthermore, it implies that empirical use of actually third generation cephalosporins may be useless in many patients, reinforcing the need for routine surveillance of resistance and appropriate programs of antimicrobial stewardship. The recognition of this high resistance burden in locations where laboratory capacity is constrained should result in consideration of alternative agents such as nitrofurantoin or fosfomycin for uncomplicated infections, with carbapenems reserved for complicated or systemic infections.

This study has several strengths. In addition to the in-depth analytical perspective on dipstick testing, microscopy, culture and serological biomarkers, it provides real-world clinical context by applying the research findings in a manner that is useful for front-line implementers of uTI diagnostics development [7]. This study provides updated local data regarding ESBL prevalence and is vital for fine-tuning empirical antibiotic selection in southern Iraq. Also, the use of FDA-approved laboratory methods, international assay kits, and testing methods are beneficial for further interpretation of the results.

Without doubt, though, there are some limitations that need to be acknowledged. In addition, being cross-sectional means that we cannot assess biomarker kinetics or causation. Single centre so may not be generalisable to regions with different microbial profiles. Furthermore, culture-negative symptomatic cases may represent infections due to fastidious organisms that may not be detectable using standard culture techniques, potentially leading to misclassification. We lacked other specific biomarkers such as procalcitonin or interleukin-6 that add depth to the diagnosis. Finally, we did not perform ROC curve analysis to formally identify diagnostic cutoffs for CRP and SAA.

These current results highlight that, compared to any single systemic biomarker or diagnostic method (urinalysis vs microscopy), a multimodal systemic biomarker-urinalysis-microscopy diagnostic assessment significantly (each $p < 0.001$) offers increased likelihood of a UTI. Dipstick testing and microscopy provide quick bedside answers, whereas CRP and SAA help to detect patients with evidence of systemic infection or may aid therapeutic decisions while waiting for culture results. Incorporation of these parameters into a diagnostic algorithm may enhance the guidance of clinical decision making, decrease unnecessary antibiotic prescribing and, ultimately, reduce antimicrobial resistance.

Future research utilizing larger multicenter cohorts to confirm these results and ROC analysis to determine ideal biomarker cut points is needed. Longitudinal designs may help to address the temporality of SAA and CRP relationship to UTI progression and resolution. At the public health level, increasing access to reliable biomarker test-based triage and embedding antibiotic stewardship and resistance surveillance are key to addressing the paired problems of diagnostic uncertainty and increasing resistance in LMICs.

Conclusion

This study demonstrates that combining urinalysis, microscopy, and inflammatory biomarkers significantly enhances diagnostic accuracy in women presenting with symptoms of UTI. Elevated CRP and SAA levels are strongly associated with culture-confirmed infection, providing valuable adjunctive tools for diagnosis, particularly when culture results are delayed or negative. The high prevalence of ESBL-producing E. coli in our cohort underscores the urgent need for rational antibiotic use and continuous resistance monitoring. Collectively, these findings support the integration of biomarker testing into UTI diagnostic workflows in resource-limited healthcare settings such as Iraq.

Declarations

Ethical Approval and Consent to Participate

The study protocol was reviewed and approved by the Ethics Committee of Maysan General Hospital, Maysan, Iraq (Approval No.: MGH/CL/2024/112). All procedures performed in this study were in accordance with the ethical standards of the institutional and national research committees and with the 1964 Helsinki Declaration and its later amendments. Written informed consent was obtained from all participants prior to inclusion in the study.

Consent for Publication

All authors reviewed and approved the final version of the manuscript and consented to its submission for publication. No individual patient data or identifying information is included in this article.

Availability of Data and Materials

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request. All laboratory and statistical data supporting the findings are stored securely at Maysan General Hospital.

Competing Interests

The authors declare that there are no conflicts of interest related to the publication of this manuscript.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. The study was conducted as part of institutional academic work at Maysan General Hospital, Iraq.

Authors' Contributions

Zhraa F. Faruq: designed the study, collected the clinical and laboratory data, Marwa A. Hassan: performed the analyses, and drafted the manuscript. The author approved the final version of the paper and takes full responsibility for the integrity and accuracy of the work.

Acknowledgments

The author wishes to express sincere gratitude to the staff of the Clinical Laboratory Department at Maysan General Hospital, especially the microbiology unit, for their technical assistance and continuous cooperation during the study period. Special thanks are also extended to the patients who participated voluntarily in this research. The author appreciates the valuable support of the hospital administration and the ethical review committee for facilitating data collection and laboratory access.

References

1. Cruz J, Figueiredo F, Matos AP, Duarte S, Guerra A, Ramalho M. Infectious and inflammatory diseases of the urinary tract: role of MR imaging. 2019;27:1-27.
2. Hanoon NA, Hameed TA, Abdalkareem MJ. Prevalence of urinary tract infections among pregnant women in Iraq: a meta-analysis. University of Thi-Qar Journal of Science. 2024;11(2):1-10.
3. Gebremedhin KB, Amogne W, Alemayehu H, Bopegamage S, Eguale T. The role of uropathogenic *Escherichia coli* virulence factors in the development of urinary tract infection. Journal of Medicine and Life. 2025;18(8):701-709.
4. Hasan D, Mero W, Khalid H. The prevalence of *Enterobacteriaceae* among outpatients with urinary tract infections in Zakho City, Kurdistan Region-Iraq. Journal of Life and Bio Sciences Research. 2025;6(1):1-5.
5. Olaru ID, Chisenga M, Yeung S, *et al*. Sexually transmitted infections and prior antibiotic use as important causes for negative urine cultures among adults presenting with urinary tract infection symptoms in Zimbabwe: a cross-sectional study. BMJ Open. 2021;11(8):e050407.
6. Simeon CA, Beega GF, Abiola SA, Wofuru CD, Eze CC. Significance of inflammatory biomarkers in clinical diagnostics: erythrocyte sedimentation rate versus other inflammatory biomarkers a review. International Journal of Scientific Research Archives. 2024;12:1980-1995.
7. Hans A, Yadav A, Kaur P, Kumari A. Evaluation of leukocyte esterase and nitrite dipstick tests with routine urine microscopic analysis in detecting urinary tract infections. Indian Journal of Pathology and Oncology. 2024;11(1):3-7.
8. Cheng B, Zaman M, Cox W. Correlation of pyuria and bacteriuria in acute care. American Journal of Medicine. 2022;135(9):e353-e358.
9. Xie R, Li X, Li G, Fu R. Diagnostic value of different urine tests for urinary tract infection: a systematic review and meta-analysis. Translational Andrology and Urology. 2022;11(3):325-335.
10. Yogeshpriya S, Selvaraj P. C-reactive protein: is early prognostic marker? Clinical significance of C-reactive protein. Springer; 2020:291-313.
11. Rajab IM, Hart PC, Potempa LA. How C-reactive protein structural isoforms with distinctive bioactivities affect disease progression. Frontiers in Immunology. 2020;11:2126-2138.
12. Sui YD, Xin WN, Feng LL. Comparison of the clinical application values of PCT, hs-CRP and SAA detection in the early diagnosis of sepsis. Pakistan Journal of Medical Sciences. 2020;36(7):1683-1689.
13. Legger G, Dermer C, Brunger A, van Daele P, Nienhuis H. The relation between C-reactive protein and serum amyloid A in patients with autoinflammatory diseases. Pediatric Rheumatology. 2022;20(1):106-112.
14. Shi J, Zhan ZS, Zheng ZS, Zhu XX, Zhou XY, Zhang SY. Correlation of procalcitonin and C-reactive protein levels with pathogen distribution and infection localization in urinary tract infections. Scientific Reports. 2023;13(1):17164-17175.
15. Wang T, Zheng P, Jiang Q, Sun QQ. Clinical study on the early differential diagnosis of infection in patients with fever in outpatient and emergency department by combined detection of SAA, CRP, IL-6 and PCT. 2022;1-10.
16. Huda N, Nabonee MA, Yusuf MA, Hossain M, Sabiha K. Diagnostic value of dipstick test (leukocyte esterase and nitrite) in diagnosis of urinary tract infection. Bangladesh Journal of Medical Microbiology. 2023;17(2):55-59.
17. Mohanna AT, Alshamrani KM, SaemAldahar MA, *et al*. Sensitivity and specificity of white blood cells and nitrite in dipstick urinalysis in association with urine culture in detecting infection in adults. Cureus. 2021;13(6):1-10.
18. Rishi S, Nahvi N, Majid I, Dewani S, Wani AR. Correlation of bacteriuria and pyuria with urine culture in symptomatic UTI patients: a study from a tertiary care center in North India. 2023;1-6.
19. Saeed AY. Bacterial etiology and their antibiograms in community-acquired urinary tract infections with special consideration on sterile pyuria. Journal of Duhok University. 2023;26(2):509-518.
20. Sack GH Jr. Serum amyloid A (SAA) proteins. In: Vertebrate and Invertebrate Respiratory Proteins, Lipoproteins and Other Body Fluid Proteins. 2020:421-436.
21. Guan JH, Dang XJ, Ma J, *et al*. Diagnosis of bacterial and viral infection by HNL, SAA, PCT and CRP combined test. Zhonghua Yu Fang Yi Xue Za Zhi (Chinese Journal of Preventive Medicine). 2023;57(12):2153-2158.
22. den Hartigh LJ, May KS, Zhang XS, Chait A, Blaser MJ. Serum amyloid A and metabolic disease: evidence for a critical role in chronic inflammatory conditions. Frontiers in Cardiovascular Medicine. 2023;10:1197432-1197440.
23. Levinson T, Shenhar-Tsarfaty S, Grupper A, Witztum T, Berliner S, Shtark M. Inflammation-associated tubulopathy in patients with acute bacterial infections. International Journal of General Medicine. 2024;17:2691-2699.
24. Khaleel NA, Abbas MS, Mohsen LYM. Detection of ESBL/AmpC-producing *Escherichia coli* and *Klebsiella pneumoniae* from urinary tract infections in

Al-Hilla, Iraq. Microbes and Infectious Diseases. 2025;1-8.
25. Mohammed AJ, Al-Amara SSM, Al-Hejjaj MY. Molecular characterization of *blaTEM* and *blaCTX-M* ESBL genes producing *Escherichia coli* isolates from urinary tract infections in Al-Basrah Province, Iraq. South East European Journal of Public Health. 2024;24(S4):389-396.
26. Albazaz RI, Yassin NA. Prevalence and molecular detection of virulence genes among multidrug-resistant *Escherichia coli* from human clinical samples and poultry in Duhok City, Iraq. Medical Journal of Babylon. 2024;21(Suppl 1):S81-S87.