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ORIGINAL ARTICLE / ÖZGÜN MAKALE

Urinary Tract Infections and Antibiotic Susceptibility Patterns in Sheki, Azerbaijan

Azerbaycan, Şeki Bölgesi'nde İdrar Yolu Enfeksiyonları ve Antibiyotik Duyarlılık Profili

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Abstract

Objectives: Urinary tract infections are among the most common bacterial infections worldwide and carry significant clinical and epidemiological importance in both outpatient and inpatient settings. Effective management relies on the accurate identification of causative pathogens and the determination of their antibiotic susceptibility. This study evaluated the distribution of bacterial species isolated from urine samples and their antibiotic susceptibility profiles based on microbiological analyses conducted at Sheki District Central Hospital. As the first study of its kind in the region, it holds considerable relevance.

Methods: A total of 85 urine samples submitted to the Microbiology Laboratory of Sheki District Central Hospital between September 2024 and April 2025 were analyzed. All samples were incubated on sheep blood agar and EMB agar. Bacterial identification has been performed using a semi-automated system with test kits designed for Gram-positive and Gram-negative bacteria. Antibiotic susceptibility has been assessed using the disk diffusion method according to EUCAST standards.

Results: Microorganisms were isolated from 42(49.4%) of the 85 urine samples. The most frequently encountered pathogen is Escherichia coli (47.6%), of which four strains (20%) were extended-spectrum beta-lactamase (ESBL) positive; one of these additionally exhibited resistance to quinolones and aminoglycosides. All Hafnia alvei strains demonstrated resistance to penicillin and cephalosporins. Among Klebsiella spp., one strain (16.7%) is ESBL positive, and another (16.7%) is resistant to aminoglycosides and cephalosporins. Resistance to penicillin has been observed in one Proteus spp. strain, while Raoultella spp. strains showed resistance to penicillin and cephalosporins, with one also resistant to aminoglycosides. Both Citrobacter spp. strains exhibited resistance to quinolones. No antibiotic resistance has been detected among Gram-positive bacteria.

Conclusion: The findings indicate that UTIs in Sheki District are more prevalent among women, with Escherichia coli being the most frequently isolated pathogen. Some strains exhibited ESBL positivity and resistance to various antibiotic classes. Given that increasing antibiotic resistance complicates treatment, enhanced antibiotic stewardship and regular antibiogram testing are recommended in the region. These results may contribute to optimizing empirical treatment strategies and informing decisions regarding rational antibiotic use.

Keywords: Antibiotic Resistance, ESBL, Escherichia coli, Klebsiella spp.,Urinary Tract Infection (UTI)

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Öz

Amaç: İdrar yolu enfeksiyonları, dünya genelinde en sık görülen bakteriyel enfeksiyonlar arasında yer almakta olup, hem ayaktan hem de yatan hasta grubunda önemli klinik ve epidemiyolojik sonuçlar doğurmaktadır. Etkin tedavi, etken patojenlerin doğru tanımlanması ve antibiyotik duyarlılıklarının belirlenmesine bağlıdır. Bu çalışma, Şeki Rayon Merkez Hastanesi'nde idrar örneklerinden izole edilen bakteriyel türlerin dağılımını ve antibiyotik duyarlılık profillerini değerlendirmeyi amaçlamaktadır. Bölgedeki bu kapsamda yapılan ilk çalışma olması açısından önemli bir yere sahiptir.

Yöntem: Eylül 2024 – Nisan 2025 tarihleri arasında Şeki Rayon Merkez Hastanesi Mikrobiyoloji Laboratuvarı'na gönderilen toplam 85 idrar örneği incelenmiştir. Tüm örnekler koyun kan agarı ve EMB agarı üzerinde inkübe edilmiştir. Bakteri tanımlaması, Gram pozitif ve Gram negatif bakteriler için hazırlanmış test kitleri ile yarı otomatik sistem kullanılarak yapılmıştır. Antibiyotik duyarlılık testleri EUCAST standartlarına uygun olarak disk difüzyon yöntemi ile değerlendirilmiştir.

Bulgular: Seksen beş idrar örneğinin 42'sinde (%49.4) mikroorganizma üretilmiştir. En sık izole edilen patojen Escherichia coli (%47,6) olup, dört suş (%20) genişlemiş spektrumlu beta-laktamaz (ESBL) pozitif bulunmuştur; bunlardan biri ayrıca kinolon ve aminoglikozidlere direnç göstermiştir. Hafnia alvei suşlarının tamamı penisilin ve sefalosporinlere dirençli bulunmuştur. Klebsiella spp. suşlarının birinde (%16,7) ESBL pozitifliği, bir diğerinde (%16,7) ise aminoglikozid ve sefalosporin direnci saptanmıştır. Proteus spp. suşlarından birinde penisilin direnci belirlenmiştir. Raoultella spp. suşları penisilin ve sefalosporinlere dirençli olup, bunlardan biri ayrıca aminoglikozidlere karşı da direnç göstermiştir. Citrobacter spp. suşlarının her ikisi kinolonlara dirençli bulunmuştur. Gram pozitif bakterilerde ise antibiyotik direncine rastlanmamıştır.

Sonuç: Bulgular, Şeki bölgesinde İYE'nin kadınlarda daha sık görüldüğünü ve en yaygın izole edilen patojenin Escherichia coli olduğunu göstermektedir. Bazı suşlarda ESBL pozitifliği ve çeşitli antibiyotik gruplarına karşı direnç gözlenmiştir. Antibiyotik direncindeki artışın tedaviyi zorlaştırdığı dikkate alındığında, bölgede antibiyotik yönetiminin güçlendirilmesi ve düzenli antibiyogram testlerinin yapılması önerilmektedir. Bu sonuçların ampirik tedavi stratejilerinin optimize edilmesine ve akılcı antibiyotik kullanımına yönelik kararların şekillendirilmesine katkı sağlayacağı düşünülmektedir.

Anahtar kelimeler: Antibiyotik Direnci, Escherichia coli, ESBL İdrar Yolu Enfeksiyonu, Klebsiella spp.

INTRODUCTION

Urinary tract infections (UTIs) are among the most common bacterial infections worldwide and a major cause of morbidity in both women and men [4]. The leading uropathogens are Escherichia coli, Klebsiella spp., and, less frequently, Staphylococcus spp. Diagnosis relies on multiple approaches, with urine culture regarded as the gold standard in routine practice (1). Owing to anatomical factors—most notably a shorter urethra and its proximity to the anus—UTIs occur more frequently in women than in men (2). Additional contributors such as suboptimal hygiene, fecal contamination, sexual activity, and related behavioral or environmental exposures further increase susceptibility in women (3). Although initially limited to the lower tract, infections can ascend to involve the bladder, ureters, and kidneys; opportunistic and sexually transmitted organisms may also occasionally affect the urinary tract.

From a population perspective, UTIs constitute a substantial global health burden. Recent estimates suggest >400 million cases annually, with a ~60% increase between 1990 and 2019, and considerable mortality and disability-adjusted life years lost [4]. UTIs are prevalent in both outpatient and inpatient settings; when undertreated or inadequately treated, they can lead to serious complications, including pyelonephritis. In clinical workflows, standard urine culture (SUC) remains widely used; national surveys indicate that outpatient urine cultures are obtained in a high proportion of women presenting with typical UTI symptoms (e.g., dysuria, urgency, frequency) (5).

Antimicrobial resistance (AMR) threatens effective empiric management. In Gram-negative bacilli, β-lactam resistance is driven

largely by β-lactamase production and is now a prominent concern in both community and hospital settings (6). The dissemination of β-lactamase–producing organisms beyond hospitals—spanning human, animal, and environmental interfaces—has emerged as a growing One Health challenge with uncertain downstream consequences (7). These trends complicate empiric selection, prolong illness, and may increase complication rates and length of stay.

Against this background, we conducted a single-center, laboratory-based study in the Sheki (Azerbaijan) region to characterize the species distribution of culture-confirmed UTI pathogens, their antibiotic susceptibility profiles, and key resistance mechanisms. Particular emphasis is placed on the prevalence of extended-spectrum β-lactamase (ESBL)–producing strains and susceptibility to commonly used antibiotic classes. In this study aimed to characterize the etiologic spectrum of culture-confirmed urinary tract infections in the Sheki region and to describe species-specific antibiotic susceptibility under EUCAST criteria, with particular focus on the prevalence of ESBL-producing Enterobacterales and implications for empiric therapy and local stewardship.

MATERIAL AND METHODS

This study has been conducted in the Microbiology Laboratory of Sheki State Hospital (Azerbaijan) and covered specimens received between September 2024 and April 2025. A total of 85 urine specimens submitted for routine diagnostic testing were processed; duplicate isolates from the same patient episode and contaminated/mixed cultures (per laboratory policy) were excluded. Specimens were plated onto sheep blood agar and eosin methylene blue (EMB) agar and incubated aerobically at 37 °C for 24–48 h. After incubation, isolated colonies were selected for work-up. Preliminary screening has been performed by semi-automated methods as available, and definitive species-level identification used commercial API biochemical panels (API 20E for Gram-negative bacilli and API Staph for Gram-positive cocci), following the manufacturer's instructions. Antimicrobial susceptibility testing has been performed by disk diffusion and interpreted according to EUCAST clinical breakpoints current during the study period; quality control employed appropriate reference strains in accordance with laboratory standard operating procedures. All data were collected retrospectively from the laboratory information system, de-identified before analysis, and handled in compliance with institutional requirements and applicable regulations on patient confidentiality.

RESULTS

Across the study period, 85 urine specimens were processed; 42 yielded significant growth (49.4% positivity). The organism distribution among culture-positive specimens is summarized in Table 1 and visualized in Figure 1.

The full species breakdown is provided in Table 1. Escherichia coli is the most frequent uropathogen (20/42; 47.6%). Other Enterobacterales included Klebsiella spp. (6/42; 14.3%), Hafnia alvei (5/42; 11.9%), Raoultella spp. (2/42; 4.8%), Citrobacter spp. (2/42; 4.8%), Proteus spp. (2/42; 4.8%), and Serratia spp. (1/42; 2.4%). Non-fermenting Gram-negative bacteria were less common (Acinetobacter spp. 1/42; 2.4%). Gram-positive isolates consisted of Staphylococcus saprophyticus (1/42; 2.4%) and Staphylococcus aureus (1/42; 2.4%), Escherichia coli is the most frequent uropathogen (20/42; 47.6%). Other Enterobacterales included Klebsiella spp. (6/42; 14.3%), Hafnia alvei (5/42; 11.9%), Raoultella spp. (2/42; 4.8%), Citrobacter spp. (2/42; 4.8%), Proteus spp. (2/42; 4.8%), and Serratia spp. (1/42; 2.4%). Non-fermenting Gram-negative bacteria were less common (Acinetobacter spp. 1/42; 2.4%). In addition, Candida spp. was detected in 1/42

(2.4%) of the culture-positive samples." (Table 1). E. coli infections occurred predominantly in women (mean age 37.8 years), with affected men being older on average (58.3 years). Klebsiella spp. infections spanned a wide age range, including very young patients (as young as 2 years) and older adults; among adult cases, the mean age is 52.6 years. Further descriptive breakdowns by sex and age strata are provided in Table 1 and Figure 2. Table 1. Etiologic distribution of uropathogens isolated from urine cultures of patients with urinary tract infection at Sheki Central Hospital.

Table 1. Distribution of urinary pathogens

Organism group	Organism*	Isolates, n	%
Gram-positive bacteria	S.saprophyticus	1	2.4
	Staphylococcus aureus	1	2.4
Gram-negative bacteria — Enterobacterales	E. coli	20	47.6
Enterobacterales	Klebsiella spp.	6	14.3
Enterobacterales	Hafnia alvei	5	11.9
Enterobacterales	Raoultella spp.	2	4.8
Enterobacterales	Citrobacter spp.	2	4.8
Enterobacterales	Proteus spp.	2	4.8
Enterobacterales	Serratia spp.	1	2.4
Yeasts	Candida spp	1	2.4
Non-fermenting	Acinetobacter spp.	1	2.4
	Total	**42**	**100.0**

Among E. coli isolates, extended-spectrum β-lactamase (ESBL) production has been observed in 4/20 (20.0%). A subset of E. coli also exhibited fluoroquinolone and aminoglycoside resistance (Table 2). For Klebsiella spp., ESBL production is identified, accompanied by aminoglycoside and cephalosporin resistance phenotypes (Table 2). Hafnia alvei isolates (5/5) showed concordant resistance to penicillins and cephalosporins. Raoultella spp. isolates (2/2) demonstrated penicillin and cephalosporin resistance; 1/2 also showed aminoglycoside resistance. Citrobacter spp. isolates (2/2) were quinolone-resistant. For Proteus mirabilis (2 isolates), penicillin resistance has been documented in one isolate. Among Gram-positive isolates (S. aureus and S. saprophyticus), no notable resistance has been identified in this series. Aggregate species-specific susceptibility profiles are presented in Table 2; ESBL proportions are shown in Figure 2. For Klebsiella spp., ESBL production is identified alongside aminoglycoside and cephalosporin resistance phenotypes.

Table 2. Summary antimicrobial susceptibility matrix for major uropathogens

Antibiotic	E. coli S/R	Klebsiella spp. S/R	Hafnia alvei S/R	Proteus spp. S/R
Ampicillin	9/11	0/6	0/5	2/1
Amoxicillin-clavulanate	18/2	5/1	0/5	2/1
Ceftriaxone	14/6	3/3	3/2	2/0
Cefuroxime	14/6	3/3	3/2	2/0
Cefotaxime	14/6	3/3	3/2	2/0
Ceftazidime	18/2	4/2	4/1	2/0
Aminoglycosides	18/2	5/1	4/0	2/0
Carbapenems	20/0	6/0	5/0	2/0
Levofloxacin	18/2	6/0	3/3	2/0
Ciprofloxacin	20/2	6/0	3/ 3	2/0

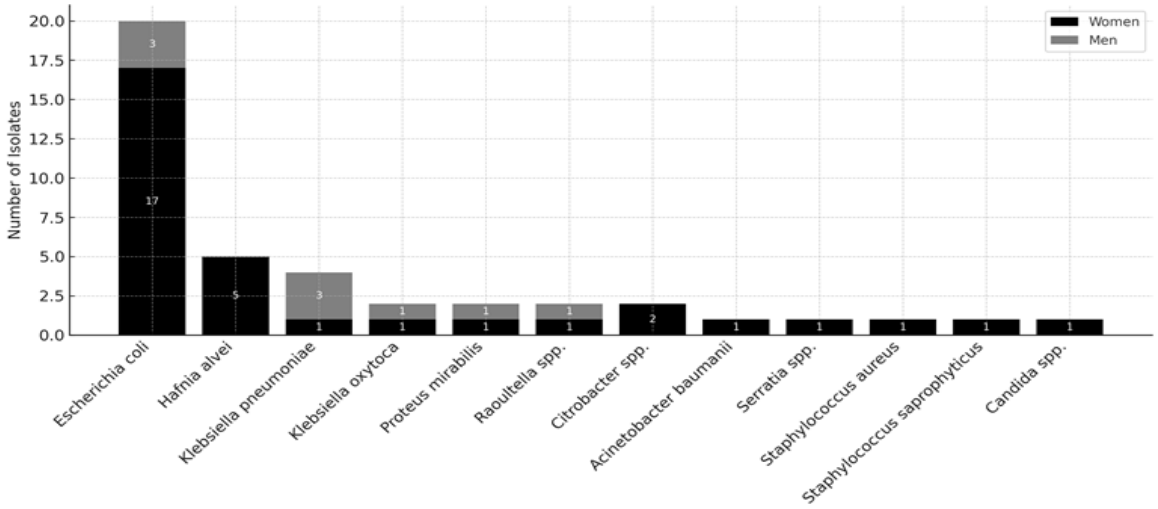

Figure 1. Sex-specific distribution of bacterial and yeast isolates

E. coli infections occurred predominantly in women (mean age 37.8 years), with affected men being older on average (58.3 years). Klebsiella spp. infections spanned a wide age range, including very young patients (as young as 2 years) and older adults; among adult cases, the mean age is 52.6 years. Further descriptive breakdowns by sex and age strata are provided in Figure 2.

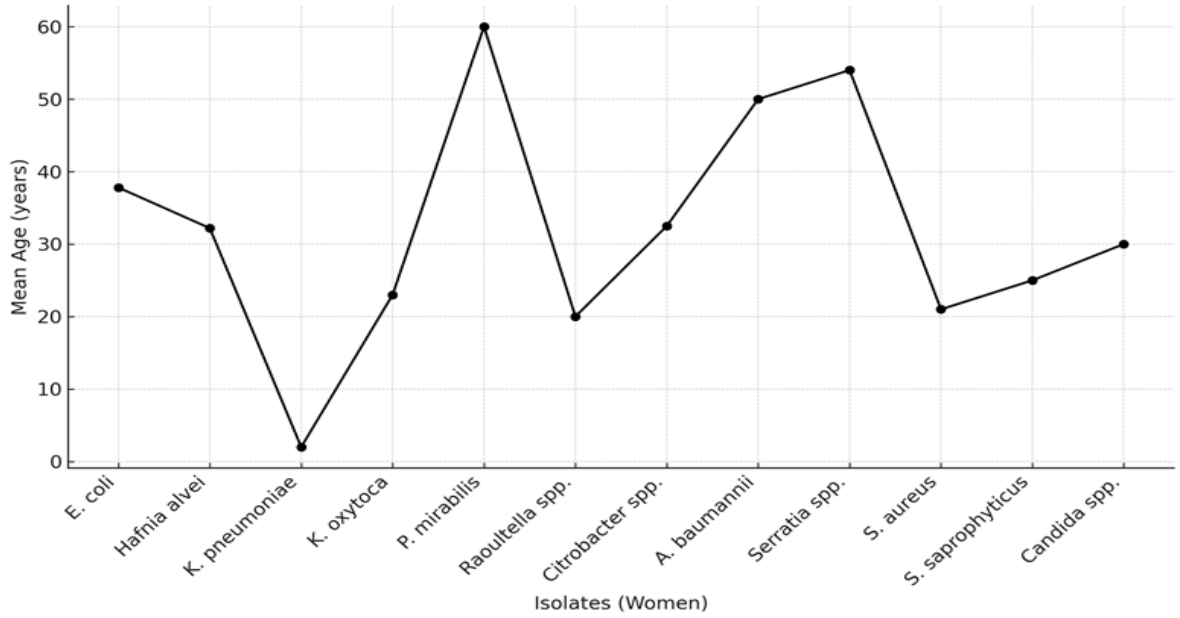

Figure 2. Mean age of female patients according to infecting organism

DISCUSSION

This single-center, laboratory-based study delineates the current etiologic spectrum of culture-confirmed urinary tract infections (UTIs) in the Sheki region and summarizes species-specific susceptibility patterns under EUCAST interpretation. The distribution is dominated by Escherichia coli, with additional contributions from Klebsiella spp., Hafnia alvei, Raoultella spp., Citrobacter spp., and Proteus mirabilis; Gram-positive isolates are infrequent and have not shown notable resistance within the tested panel. ESBL production has been observed among E. coli isolates, and non-susceptibility to selected fluoroquinolones and aminoglycosides is documented in parts of the Enterobacterales panel. Taken together, these data support empiric regimens prioritizing narrow-spectrum oral agents for uncomplicated cystitis (e.g., nitrofurantoin and fosfomycin) and caution against routine

first-line use of fluoroquinolones or broad-spectrum β-lactams unless clearly indicated.

Our organism distribution is consistent with international and regional reports in which E. coli remains the leading uropathogen, particularly among women, with Klebsiella spp. as the second most frequent agent (8–11). The ESBL rate in E. coli observed here aligns with ranges reported in comparable settings and mirrors the upward pressure on β-lactam resistance and fluoroquinolone non-susceptibility described across multi-year cohorts (8,12–14). The identification of H. alvei and Raoultella—albeit at low frequencies—has been increasingly recognized in clinical microbiology series and may carry distinctive resistance phenotypes, including cephalosporin and aminoglycoside non-susceptibility in subsets (8,13). Epidemiologic patterns in our cohort—higher prevalence in women and age-linked variation across organisms—are likewise consistent with prior evidence from reviews and regional datasets (9–13).

In routine care, these findings argue for empiric therapy anchored to current local susceptibility data. For uncomplicated UTIs, nitrofurantoin or fosfomycin remain appropriate first-line options where active, while fluoroquinolones and broad-spectrum β-lactams should be reserved in view of resistance trends and ecological impact. Rapid incorporation of culture–susceptibility feedback into treatment, short, guideline-concordant courses in primary care, and evidence-based protocols for pregnancy and complicated presentations are recommended. Regular updates to a center-specific antibiogram (at least annually) and inter-facility data sharing will further strengthen empiric decision-making and antimicrobial stewardship.

Strengths include standardized laboratory procedures (API identification; EUCAST disk diffusion), explicit exclusion of duplicates/contaminants, and a complete, species-level summary of susceptibility patterns. Several limitations merit consideration. First, the single-center and retrospective design limits generalizability. Second, sample size is modest, and some taxa (e.g., Raoultella, P. mirabilis) were represented by very few isolates, constraining precision. Third, the analysis is descriptive (no hypothesis testing or adjusted models); therefore, apparent group differences should be interpreted cautiously and not as causal. Finally, broader clinical covariates (e.g., prior antibiotic exposure, comorbidities, catheterization) were not systematically captured, precluding risk-factor inference.

Antimicrobial resistance (AMR) remains a global health threat associated with substantial morbidity and mortality (15–17). Our regional snapshot is congruent with worldwide concerns about increasing ESBL-producing Enterobacterales and fluoroquinolone resistance, underscoring the need for robust AMR surveillance and stewardship interventions across care levels.

Future research should involve larger, prospective, multi-center cohorts with systematic clinical metadata and multivariable analyses to identify predictors of resistance (e.g., ESBL phenotypes) and to validate risk-stratified empiric algorithms. Regular antibiogram updates and integration with national/regional AMR platforms will improve external validity and facilitate benchmarking.

In our setting, the distribution of uropathogens and their susceptibility profiles support narrow-spectrum empiric therapy for uncomplicated UTIs (notably nitrofurantoin and fosfomycin) and selective, limited use of fluoroquinolones and broad-spectrum β-lactams given resistance and ecological considerations. Strengthening culture-guided care, adhering to evidence-based protocols in special populations, and sustaining annual antibiogram updates with multi-center collaboration will likely improve the accuracy of empiric choices and patient outcomes.

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The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript.

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