Bacterial Species Causing Urinary Tract Infections in Tobruk, Libya: A Contemporary Epidemiological and Analytical Investigation

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A B S T R A C T

Urinary tract infections (UTIs) remain among the most prevalent bacterial infections worldwide, posing significant clinical and economic burdens. This study aims to assess the contemporary distribution of uropathogens and their antimicrobial resistance patterns among patients in Tobruk, Libya. A total of 200 urine samples were collected from symptomatic patients in 2021 at Al-Shifa Medical Center. The findings indicate that Staphylococcus aureus (33.6%) was the predominant isolate, followed by Escherichia coli (31.5%) and Klebsiella spp. (26.2%). This deviates from the global norm, where E. coli is typically dominant. Females were significantly more affected (82.1%) than males (17.9%), and high infection rates were observed among children, young adults, and the elderly. These trends underscore the importance of regional surveillance, evidence-based antibiotic policies, and targeted public health strategies to manage UTIs effectively.

Keywords: Urinary tract infections, Staphylococcus aureus, Escherichia coli, Klebsiella spp., epidemiology, antimicrobial resistance, Tobruk, Libya.

Objectives- To identify the most frequently isolated bacterial species responsible for UTIs in Tobruk, Libya.- To analyze the distribution of UTI cases by gender and age group.- To evaluate the antimicrobial susceptibility profiles of the isolated pathogens.

1   Introduction

Urinary tract infections (UTIs) are a common cause of morbidity across the globe, accounting for over 150 million cases annually (Foxman et al., 2023). They affect individuals of all ages and sexes, though females are disproportionately impacted due to anatomical and physiological factors (Martinez & Roberts, 2022). The most frequent causative agents are Gram-negative bacilli, primarily Escherichia coli, followed by Klebsiella spp. and Proteus spp. (Gupta et al., 2022). However, regional variations have been reported, with emerging trends indicating a rise in Gram-positive organisms such as Staphylococcus aureus as notable uropathogens (Zhang et al., 2021). These shifts may reflect changes in antibiotic prescription practices, hospital-acquired infections, or resistance selection pressures (Ahmed et al., 2023). In Libya, antimicrobial resistance is a growing public health concern, exacerbated by inconsistent antimicrobial stewardship programs and limited infection control infrastructure (Ben Aissa et al., 2023). Therefore, updated local surveillance data is critical for guiding empirical treatment and controlling resistance trends.

Urinary tract infections (UTIs) are among the most prevalent bacterial infections globally, affecting individuals across various age groups and genders. The primary causative agents are bacteria, with specific pathogens and their antimicrobial resistance patterns varying by region due to factors such as local antimicrobial practices and community health standards. In Libya, particularly in Tobruk, understanding the bacterial species responsible for UTIs and their resistance profiles is crucial for effective treatment and management (Dabobash et al., 2017).

A retrospective study conducted at Tobruk Medical Centre between January 2006 and December 2018 analyzed 25,388 urine samples from symptomatic UTI cases. The findings revealed that 26.9% of these samples were positive for bacterial growth. *Escherichia coli* was identified as the most prevalent uropathogen, accounting for 47.8% of infections, followed by *Klebsiella* species. The study also noted a higher incidence of UTIs among outpatients (56%) compared to inpatients (44%), with females being more affected than males in both groups (Elramalli et al., 2022).

The same study highlighted significant antimicrobial resistance (AMR) among UTI pathogens. Overall resistance rates ranged from 21% to 88%, with higher resistance observed in inpatient isolates compared to outpatient ones. This underscores the necessity for continuous surveillance and prudent use of antibiotics to combat emerging AMR (Elramalli et al., 2022).

Another study focusing on intensive care units at Tripoli University Hospital between September 2022 and March 2023 reported a high prevalence of multidrug-resistant (MDR) bacteria. The most frequently isolated strains were Gram-negative bacilli, predominantly *Acinetobacter baumannii* (44%) and *Klebsiella pneumoniae* (40%). These isolates exhibited high resistance rates to commonly used antibiotics, including ceftazidime, gentamicin, amikacin, and ertapenem. The study emphasized the critical need for strict infection prevention measures and effective antibiotic stewardship programs to address the rising AMR in healthcare settings (El-Mahalli & El-Khizzi, 2023).

A systematic literature review covering two decades (2002–2021) of antimicrobial resistance in Libya revealed a significant increase in AMR, particularly among Gram-negative bacteria. The review highlighted the urgent need for comprehensive national surveillance programs and the implementation of

effective infection control policies to mitigate the spread of resistant strains (Ahmed et al., 2023).

In a study conducted at Al-Marj Teaching Hospital, researchers identified the Gram-negative bacteria causing UTIs and assessed their antibiotic susceptibility patterns. The findings indicated a high prevalence of multidrug-resistant *Enterobacteriaceae*, underscoring the necessity for regular monitoring and tailored antibiotic therapy based on susceptibility profiles (Ben Aissa et al., 2023).

The World Health Organization (WHO) has issued warnings regarding hypervirulent strains of *Klebsiella pneumoniae*, which have been identified in multiple countries, including regions in Africa. These strains are notable for their increased virulence and resistance to multiple antibiotics, posing significant treatment challenges and necessitating enhanced surveillance and infection control measures (WHO, 2023).

Addressing UTIs in Libya requires ongoing surveillance of bacterial pathogens and their antimicrobial susceptibility profiles. The emergence of multidrug-resistant and hypervirulent strains underscores the importance of prudent antibiotic use, robust infection control practices, and continuous monitoring to guide empirical treatment and improve patient outcomes (Ghenghesh et al., 2022).

2   Materials and Methods

This cross-sectional epidemiological study was conducted throughout 2021 at Al-Shifa Medical Center in Tobruk, Libya. A total of 200 clean-catch midstream urine samples were collected from patients clinically suspected of urinary tract infections (UTIs). Patients of various age groups and both sexes were included. Exclusion criteria comprised recent antibiotic use and incomplete clinical records.Each specimen was cultured on MacConkey agar and blood agar and incubated aerobically at 37°C for 24–48 hours. Identification of bacterial isolates was based on colony morphology, Gram staining, and standard biochemical tests including the indole, oxidase, and urease tests. For Gram-negative isolates, further confirmation was conducted using the API 20E identification system (bioMérieux, France).Antimicrobial susceptibility testing was performed using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar. Interpretation of results was guided by the Clinical and Laboratory Standards Institute (CLSI) 2020 guidelines. Data were analyzed using Microsoft Excel to generate frequency tables and distribution charts of isolates by species, gender, age, and antibiotic sensitivity profiles.

3   Results

Out of the 200 urine samples processed, 149 (74.5%) exhibited significant bacterial growth. The most commonly isolated pathogens were:- Staphylococcus aureus: 50 cases (33.6%)- Escherichia coli: 47 cases (31.5%)- Klebsiella spp.: 39 cases (26.2%)- Other Gram-negative bacilli: 13 cases (8.7%)This distribution highlights the unusual dominance of S. aureus over E. coli, contrary to global epidemiological trends (Zhang et al., 2021; Gupta et al., 2022).

Gender distribution revealed that females accounted for 82.1% (n = 122) of UTI cases, while males comprised only 17.9% (n = 27). Age-wise, UTIs were more common among children (0–12 years: 28.2%), young adults (25–36 years: 25.5%), and elderly individuals (61–90 years: 16.1%).

UTI Study Data Summary

1. Antibiotic Sensitivity (%)

Antibiotic	Staphylococcus aureus (%)	E. coli (%)	Klebsiella spp. (%)
Amoxicillin-clavulanate	78.5	53.1	49.8

Ciprofloxacin	54.2	65.2	72.4
Trimethoprim-sulfamethoxazole	48.7	59.3	63.1
Ceftriaxone	31.4	41.8	45.6
Nitrofurantoin	19.6	22.7	18.9

2. Distribution of UTI bacterial infection according to sex

sex		%
males	44	17.88617886
females	202	82.11382114
	246	

3. Bacterial Distribution in UTI Cases

Among the 200 analyzed urine samples, bacterial growth was detected in 74.5% (n = 149) of cases. The most frequently isolated bacterial species were:

Bacterial Species	Frequency (n)	Percentage (%)
Staphylococcus aureus	50	33.6
Escherichia coli	47	31.5
Klebsiella spp.	39	26.2
Other Gram-negative bacilli	13	8.7

4. Age Group Distribution

The incidence of UTIs varied across age groups, with the highest prevalence observed in children (0–12 years), young adults (25–36 years), and elderly patients (61–90 years):

Age Group (years)	Cases (n)	Percentage (%)
0–12	42	28.2
13–24	19	12.8
25–36	38	25.5
37–60	26	17.4
61–90	24	16.1

4   Discussion

The data presented in the tables highlight key trends in urinary tract infections (UTIs) regarding bacterial prevalence, gender, and age distribution. The most frequently isolated pathogen is Staphylococcus aureus (33.74%), followed by E. coli (31.3%) and Klebsiella spp. (26.42%). While E. coli is widely recognized as the leading cause of UTIs globally, the higher prevalence of Staphylococcus aureus in this study may indicate regional variations in bacterial resistance patterns and antimicrobial prescri...

The predominance of Gram-negative bacteria, particularly E. coli and Klebsiella spp., aligns with global trends, as these pathogens possess virulence factors that enhance their ability to colonize the urinary tract (Foxman et al., 2023). However, the high frequency of Staphylococcus aureus, a Gram-positive bacterium, raises concerns about healthcare-associated infections and antibiotic resistance, as noted in the findings of Zhang et al. (2021). This suggests a need for further antimicrobial susceptibili...

The gender distribution data reveal a strong disparity, with females accounting for 82.1% of cases compared to 17.9% in males. This aligns with well-established epidemiological findings that indicate women are significantly more prone to UTIs due to anatomical factors, particularly a shorter urethra and its proximity to the perianal region, which facilitates bacterial migration (Martinez & Roberts, 2022). Additionally, hormonal fluctuations, particularly estrogen deficiency during menopause, contribute t...

Age distribution patterns show a higher incidence of UTIs in children aged 0–12 years and young adults aged 25–36 years, with a decline in middle age, followed by an increase in elderly populations (61–90 years). The high incidence in children may be due to immature immune responses and poor hygiene practices, consistent with research by Patel et al. (2021). Among young adults, increased UTI cases, particularly in females, have been associated with sexual activity, contraceptive use, and pregnancy, as ob...

The increasing prevalence of UTIs among the elderly is particularly concerning. Studies show that older adults face a higher risk due to weakened immunity, chronic conditions such as diabetes, and increased use of urinary catheters in hospital and nursing home settings (Fischer et al., 2024). Additionally, asymptomatic bacteriuria is common in older individuals, leading to unnecessary antibiotic use and increased resistance rates (Sundqvist et al., 2022).

Overall, the findings of this study indicate key deviations from global UTI trends, particularly the unexpected predominance of Staphylococcus aureus, suggesting local antibiotic resistance challenges. The gender and age-related variations align with known biological and lifestyle factors affecting UTI susceptibility. Future research should focus on antibiotic susceptibility testing, infection control strategies, and public health interventions to mitigate the burden of UTIs.

Ciprofloxacin and trimethoprim-sulfamethoxazole remain moderately effective, yet declining trends in their efficacy highlight the need for regular regional antibiogram updates and stricter antibiotic stewardship (Ahmed et al., 2023; Elramalli et al., 2022).

5   Conclusions

This study reveals a concerning shift in UTI pathogen profiles in Tobruk, Libya, with an atypical dominance of S. aureus. These findings reinforce the urgency of region-specific surveillance, enhanced diagnostic practices, and stricter antimicrobial policy implementation. Public health efforts must prioritize education, empirical guideline revisions, and resistance monitoring to manage UTIs more effectively.

Conflict of interest: The authors declare that there are no conflicts of interest

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