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The incidence, clinical features and outcome of urinary tract infections in geriatric patients: A prospective longitudinal study

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ABSTRACT

Objectives: This study compares the incidence, clinical features, microbial profiles, and outcomes of urinary tract infections (UTIs) in patients aged 65 years and older versus those younger than 65 years.
Methods: A longitudinal cohort of 1,123 patients was divided into Group A (≥65 years, n = 560) and Group B (<65 years, n = 563) and followed for 2 years. The study analyzed UTI incidence, clinical features, microbial profiles, and outcomes, including recurrence and antibiotic resistance.
Results: Over 2 years, Group A had a significantly higher UTI incidence (38.0%) compared with Group B (12.8%) (P <0.0001). Complete recovery was less common in Group A (44.6%) than in Group B (70.83%), whereas recurrent UTIs and antibiotic resistance were more frequent in Group A (43.5% vs 22.2%, P <0.0001 and 11.7% vs 2.78%, P = 0.0017, respectively). *Escherichia coli* was the most prevalent pathogen in both groups, with *Klebsiella* and *Pseudomonas* species more common in recurrent UTIs, particularly in older patients. Risk factors for recurrent UTIs included advanced age, female sex, diabetes, immunosuppression, and renal stones.
Conclusions: These findings highlight the need for age-specific UTI prevention and management strategies that account for microbial resistance patterns and higher recurrence rates in older patients, addressing clinical and microbial challenges.

Introduction

Urinary tract infections (UTIs) are a significant health concern, particularly among older adult populations, constituting a substantial proportion of bacterial infections [1]. Although UTIs are prevalent across various age groups, their incidence escalates with age, affecting both sexes more equally due to anatomic and physiologic changes [2]. In older adults, the clinical presentation and outcomes of UTIs differ markedly from those in younger individuals, necessitating focused research to optimize management and improve patient outcomes [3–5].

In geriatric patients, UTIs can have profound clinical implications, potentially leading to detrimental outcomes if not promptly diagnosed and appropriately treated. The aging process is associated with numerous physiologic changes, such as decreased immune function, alterations in the genitourinary tract, and chronic conditions like diabetes and benign prostatic hyperplasia, which increase susceptibility to infections [6]. Epidemiologic data underscore the burden of UTIs in geriatric cohorts, highlighting not only the high incidence rates but also the associated risk factors predisposing older men and women to such infections. Cognitive impairment and functional disabilities, common in older adults, can further complicate the recognition and management of UTIs, often resulting in delayed treatment and worse outcomes [7,8].

The intricate interplay of physiologic changes, comorbidities, and health care complexities renders UTIs in older adults a multifaceted challenge, necessitating a comprehensive understanding of their clinical features and outcomes. Compared with younger cohorts, older patients experience more severe UTI outcomes, with higher rates of complications such as pyelonephritis, sepsis, and increased mortality. A significant number of geriatric patients experience recurrent UTIs, defined as two or more episodes within 6 months or three in a year, leading to increased morbidity, health care costs, and potential complications. Recurrent UTIs are particularly concerning in older individuals due to the cumulative impact on their health, quality of life, and the health care system [9,10].

The rise of antimicrobial resistance poses a significant challenge in treating UTIs, especially in older adult patients with frequent health care interactions and prior antibiotic use. Antimicrobial resistance complicates the management of UTIs, making standard treatments less effective and leading to prolonged illness and increased risk of severe outcomes. Older adult populations are more susceptible to infections by a broader range of pathogens, including multidrug-resistant organisms. This susceptibility is exacerbated by frequent hospitalizations, the use of invasive devices such as catheters, and the presence of multiple comor-

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bidities, which are more common in geriatric patients. Thus, identifying the specific etiological agents responsible for UTIs in this demographic is essential for tailoring appropriate antibiotic therapy [10,11].

Although previous studies have identified the higher frequency of UTIs and individual risk factors among older patients, there is a scarcity of longitudinal studies comparing the incidence, etiology, and outcomes across different age groups. This limitation hampers our understanding of the long-term implications and progression of UTIs in older adult patients. Furthermore, evolving patterns of antibiotic resistance among older adult patients with UTI remain inadequately explored, leading to gaps in the optimal management of these infections.

Therefore, the current longitudinal, prospective cohort study was designed to address critical gaps in understanding the incidence, clinical features, etiology, and outcomes of UTIs in older adults (65 years and older) compared with younger patients. This study also evaluates the impact of antimicrobial resistance on treatment efficacy, which is crucial for developing effective management strategies. Our primary research question is: How do the incidence, clinical features, etiology, and outcomes of UTIs in older adult patients differ from younger patients?

Understanding these differences is pivotal for clinicians to develop age-specific guidelines for diagnosing, treating, and preventing UTIs, thereby enhancing patient care and reducing the burden of this common infection in the aging population.

Patients and methods

Study design and setting

This longitudinal, prospective cohort study was conducted at Prince Sattam Bin Abdulaziz University Hospital, Kharj, KSA, from January 2021 to February 2024. The study enrolled older adult patients aged 65 years and older and those younger than 65 years, presenting to the hospital's outpatient clinics. Exclusion criteria included patients with active UTIs or indwelling urinary catheters at presentation, individuals with a history of renal transplant, and those who had received prophylactic antibiotics or immunosuppressive therapy within 5 days before presentation. Eligible patients provided written informed consent. Patients with indwelling urinary catheters were excluded because catheter-associated UTIs have distinct microbiologic profiles and risk factors, which would have confounded our findings. Similarly, patients with recent antibiotic use were excluded to avoid skewing the antibiotic resistance data.

Both age groups were followed prospectively for 2 years to monitor the incidence of UTIs. Baseline assessments included demographic data, medical history, and the presence of new-onset UTI symptoms. Patients who consented to join the study were scheduled for physical examinations and urine analysis appointments every 2 months. They were advised to report to the hospital immediately upon experiencing any symptoms suggestive of a UTI, such as dysuria, urgency, frequency, or lower abdominal discomfort, or if they observed a positive urine dipstick test result. The Acute Cystitis Symptom Score (ACSS) was used to assess UTI symptoms due to its robust psychometric properties and ease of administration. The ACSS includes 18 questions across four categories: "Typical" symptoms (six items), "Differential" diagnosis (four items), "Quality of Life" impact (three items), and "Additional" factors (five items, such as menstruation and pregnancy in women). The first three categories use a Likert scale (0-3) for symptom severity, whereas the last category requires binary "Yes/No" responses. Asymptomatic cases were defined by a low total score (less than 4), no individual symptom score exceeding 1, and no visible blood in the urine [12,13].

Laboratory investigations

Urine analysis was performed every 2 months, and urine cultures were performed every 2 months or upon any clinical suspicion of a UTI to identify causative pathogens. The frequency of urine cultures was consistent across both groups, and this protocol ensured comparability between older and younger patient groups. UTIs were initially diagnosed by a positive leukocyte esterase dipstick test (Nephurtest+leuco; Boehringer Mannheim, Germany) as previously described [14,15] or by positive urine microscopy of midstream samples showing ≥10 leukocytes/μl. In females with clinical findings suggesting UTI, urine microscopy was indicated even if the leukocyte esterase dipstick test was negative. Further investigations included:

a. Urine culture and sensitivity testing: Standard urine cultures were performed to identify the causative bacteria or pathogens responsible for UTIs. Quantitative bacterial colony counts were conducted to determine infection severity. Cystitis was identified by more than 1,000 colony-forming units/ml in clean-catch urine specimens, whereas pyelonephritis was diagnosed by detecting more than 10,000 colony-forming units/ml [16,17].
b. Biochemical assays, including urea, creatinine, urinary sodium, and uric acid measurements, were conducted at enrollment and during follow-up.

Imaging studies

Included ultrasounds, which were performed to assess kidney structure, identify abnormalities or obstructions, and evaluate for other disease conditions. Computed tomography scan and magnetic resonance imaging were utilized for selected patients to provide detailed anatomic and pathologic assessments.

Statistical data analysis

Descriptive statistics summarized the demographic characteristics of the study population, including age, sex distribution, and comorbidities. Continuous variables were presented as means ± SDs or medians with interquartile ranges, depending on their distribution. Categoric variables were summarized as frequencies and percentages. The incidence of UTIs was calculated as the number of new cases per 1,000 person-years for each cohort.

Chi-square tests were used to compare the incidence rates between the older and younger cohorts and between males and females within each group. For our study population, comprising patients with suspected UTIs, to ensure the ACSS's applicability in our specific study context, a preliminary pilot study was conducted with a subset of our target population. The ACSS demonstrated high internal consistency (Cronbach's alpha = 0.87) and test-retest reliability (r = 0.83, P <0.01) in our pilot cohort, reaffirming its reliability and validity for assessing UTI symptoms in our study population.

Microbiologic data were analyzed to identify the etiologic agents responsible for UTIs in both cohorts, with pathogen distribution compared using chi-square or Fisher's exact tests, depending on the expected cell counts. Antimicrobial resistance patterns were examined to assess trends over time and differences between age groups.

Outcomes of UTIs, including recurrence rates, antimicrobial resistance, and other complications, were analyzed descriptively and compared between the older and younger cohorts using appropriate statistical tests. Kaplan-Meier curves and log-rank tests were employed to compare the time to UTI development between cohorts and within sex subgroups. Cox proportional hazards regression analysis was used to identify independent predictors of UTI development, adjusting for potential confounders such as age, sex, comorbidities, and other relevant factors. Stratified analyses explored the impact of these variables on UTI incidence and outcomes within each cohort.

Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 27.0 (IBM Corp., Armonk, New York, USA).

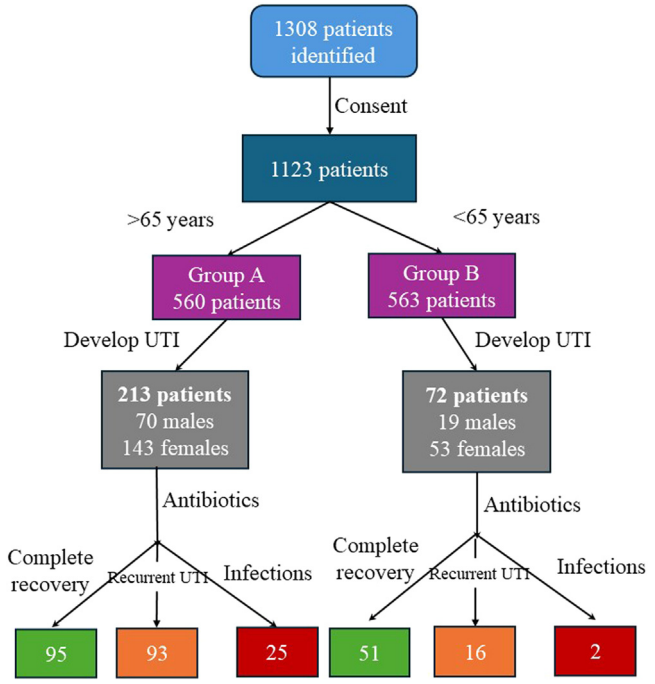

Figure 1. Flow of patients through the study. This flowchart illustrates the selection and progression of patients through the study. Out of 1,308 identified patients, 1,123 provided consent to participate. These patients were divided into two groups based on age: Group A (560 patients aged >65 years) and Group B (563 patients aged <65 years). In Group A, 213 patients (70 males and 143 females) developed UTIs. Among these, 95 patients completely recovered with antibiotic treatment, 93 experienced recurrent UTIs, and 25 developed additional infections. In Group B, 72 patients (19 males and 53 females) developed UTIs. Among these, 51 patients completely recovered with antibiotic treatment, 16 experienced recurrent UTIs, and two developed additional infections. The flowchart details the outcomes for each group, emphasizing the effectiveness of antibiotic treatment and the incidence of recurrent UTIs and other diseases. UTIs, urinary tract infections.

Results

This prospective cohort study investigated the incidence, risk factors, clinical features, and outcomes of UTIs in patients aged 65 years and older compared with those younger than 65 years, conducted from January 2021 to January 2024. A total of 1,308 patients were initially identified, and 1,123 consented to participate, representing an overall consent rate of 85.9%. The study population was divided into two age groups: Group A (560 patients aged 65 years or older) and Group B (563 patients younger than 65 years).

Patient demographics

The study included 1,123 patients: 560 in Group A and 563 in Group B. The mean ages were 69.12 ± 4.66 years for Group A and 39.08 ± 13.14 years for Group B (P <0.0001). Comorbidities such as diabetes, dyslipidemia, hypertension, autoimmune diseases, immunosuppression, neurologic diseases, chronic liver diseases, and gastrointestinal disorders were more common in Group A (69.46%) compared with Group B (19.36%) (Figure 1, Table S1).

Incidence of UTIs

In Group A, 213 out of 560 patients (38.0%) developed a UTI, with an incidence of 380.36 per 1,000 individuals over 2 years and an annual incidence rate of 190.18 per 1,000 person-years. Group A males had an incidence of 307.02 per 1,000 males over 2 years, whereas females had an incidence of 430.72 per 1,000 females over 2 years. In Group B, 72 out of 563 patients (12.8%) developed a UTI, with an incidence of 127.91 per 1,000 individuals over 2 years and an annual incidence rate of 63.96 per 1,000 person-years. The incidence rates for Group B males and females were 72.52 and 176.08 per 1,000 over 2 years, respectively (Figure 1).

These findings indicate a significantly higher incidence of UTIs in the older cohort compared with the younger cohort (χ^2 = 35.41, P <0.0001), suggesting age is a significant risk factor. Females had higher incidence rates than males in both age groups.

UTI outcomes

UTI outcomes were categorized into complete recovery, recurrent UTI, resistant infections, and asymptomatic bacteriuria. In Group A, 95 patients (44.6%) achieved complete recovery, whereas 33 (15.5%) had asymptomatic bacteriuria, all recovered completely. Recurrent UTI was observed in 93 patients (43.7%), with 24 developing cystitis and 10 developing pyelonephritis. In addition, 25 patients (11.7%) experienced resistant UTIs, with seven developing cystitis and four developing pyelonephritis.

In Group B, 51 patients (70.83%) recovered completely, including 12 with asymptomatic bacteriuria. Recurrent UTI was observed in 16 patients (22.2%), with four developing cystitis and two developing pyelonephritis. Resistance to antibiotics was noted in two patients (2.78%). Statistical analysis revealed significant differences between the two age groups regarding UTI outcomes. Older adult patients were less likely to recover entirely and more likely to experience recurrent UTIs and antibiotic-resistant infections than younger patients (Table 1, Figure 1). Group A (older adults, ≥65 years) experienced significantly earlier UTI recurrences compared with Group B (younger, <65 years). The log-rank test demonstrated a statistically significant difference in recurrence rates between the two groups (P <0.0001). Notably, the separation between the curves becomes evident within the first 6 months, with Group A showing a higher cumulative recurrence rate during this period. At 12 months, 33.5% of patients in Group A had experienced a recurrence compared with only 14.2% in Group B (P = 0.002). By the 24-month mark, the recurrence rate in Group A had increased to 43.5% compared with 22.2% in Group B (P <0.0001) (Figure S1).

Clinical features of enrolled patients with UTI

Table 1 outlines the UTI outcomes and clinical features in Group A (≥65 years) and Group B (<65 years). A significantly higher proportion of females in Group B (72.22%) developed UTI compared with Group A (52.58%) (χ^2 = 8.495, P = 0.0035). Group B patients had a significantly higher recovery rate (70.83%) compared with Group A (44.6%) (χ^2 = 12.291, P = 0.0005). Older patients showed a higher UTI recurrence rate (43.5%) compared with Group B (22.2%) (χ^2 = 26.69, P <0.0001). Resistance to UTI treatment was higher in Group A (11.7%) compared with Group B (2.78%) (χ^2 = 9.841, P = 0.0017).

Clinical manifestations varied significantly between the two age groups. Increased urination frequency and urgency were significantly more common in Group A (89.2% and 88.7%, respectively) compared with Group B (47.2% and 37.5%, respectively) (P <0.0001 for both symptoms). Dysuria was also more common in Group A (62%) compared with Group B (34.7%) (P <0.0001). Suprapubic and flank pain were more prevalent in Group A (55.4%) than in Group B (25%) (P <0.0001 and P = 0.0012, respectively). Hematuria, urinary incontinence, and disorientation were present in Group A but absent in Group B. Fever was more prevalent in Group B (40.3%) than in Group A (14.55%) (P <0.0001). Fatigue was more prevalent in older patients (81.2%) than in younger patients (P <0.0001). There was no significant difference in asymptomatic bacteriuria between the groups (15.49% in Group A vs 16.67% in Group B) (Table 1).

Table 1
UTI outcome and clinical features in Group A and B patients.

Variable	Group A (≥65) patients who developed UTI (n = 213)	Group B patients who developed UTI (<65) (n = 72)	χ^2 (Chi-square)	*P*-value
Females; n (%)	112 (52.58)	52 (72.22)	8.495	0.0035[a]
Males; n (%)	101 (47.42)	20 (38.46)		
UTI outcome				
Recovery; n (%)	95/213 (44.6)	51/72 (70.83)	12.291	0.0005[a]
Recurrence; n (%)	93/213 (43.5)	16/72 (22.2)	26.699	<0.0001[a]
Cystitis, n (%)	24/93 (25.8)	4/16 (25)		
Pyelonephritis; n (%)	10/93 (10.75%)	2/16 (12.5%)		
Resistance; n (%)	25/213 (11.7)	2/72 (2.78)	9.841	0.0017[a]
Cystitis; n (%)	7/25 (28%)	1/2 (50)		
Pyelonephritis; n (%)	4/25 (16%)	1/2 (50)		
Clinical manifestations				
Increased urination frequency; n (%)	190 (89.2)	34 (47.2)	56.371	<0.0001[a]
Urgency; n (%)	189 (88.7)	27 (37.5)	76.974	0.0001[a]
Dysuria; n (%)	132 (62.0%)	25 (34.7)	16.150	0.0001[a]
Suprapubic pain; n (%)	118 (55.4)	18 (25.0)	19.932	0.0001[a]
Flank pain; n (%)	39 (18.3)	2 (2.8)	10.540	0.0012[a]
Incontinence; n (%)	23 (10.8)	0 (0)	8.457	0.0036[a]
Fever; n (%)	31 (14.55)	29 (40.3)	21.424	<0.0001[a]
Fatigue; n (%)	173 (81.2)	18 (25.0)	76.946	<0.0001[a]
Disorientation; n (%)	27 (12.67)	0 (0)	10.082	0.0015
Asymptomatic bacteriuria; n (%)	33(15.49)	12 (16.67)	0.056	0.8133

UTI, urinary tract infection.

Table 1 presents a comparison of UTI outcomes and clinical features between Group A patients (≥65 years old) and Group B patients (<65 years old). The data includes the number and percentage of females and males in each group and various UTI outcomes, such as recovery, recurrence, cystitis, pyelonephritis, and resistance rates. In addition, the table highlights the clinical manifestations observed in both groups, such as increased urination frequency, urgency, dysuria, suprapubic pain, flank pain, incontinence, fever, fatigue, disorientation, and asymptomatic bacteriuria. Chi-square tests were used for categoric variables, and t-tests were used for continuous variables.

[a] Statistical significance is indicated by the chi-square (χ^2) values and corresponding *P*-values, with values marked by indicating a statistically significant difference between the groups.

Microbial profile and demographics according to UTI outcome

Table 2 summarizes the microbial profile, demographics, and comorbidities of older adults (≥65 years, Group A) and younger patients (<65 years, Group B) who developed UTIs. *Escherichia coli* was prevalent in both groups, with significant differences ($P = 0.024$). In Group A, patients with resolved UTIs had a higher prevalence of *E. coli* (42.12%) compared with those with recurrent (33.33%) or resistant UTIs (36%). In Group B, *E. coli* was most prevalent in resolved UTIs (52.94%). *Klebsiella* was more prevalent in recurrent UTIs in Group A (40.8%) than resolved (31.58%) or resistant UTIs (40%). In Group B, *Klebsiella* was most prevalent in resolved UTIs (21.57%) ($P = 0.044$). Significant differences in *Pseudomonas* were observed in both groups, with higher prevalence in recurrent UTIs (Group A: 21.51%, Group B: 37.5%) ($P = 0.041$).

A significantly higher proportion of females in Group B had resolved UTIs (41.18%, $P = 0.0209$). Diabetes mellitus was significantly higher in recurrent UTIs in both groups (Group A: 96.77%, Group B: 56.25%) ($P < 0.0001$). Dyslipidemia was frequent among patients with recurrent UTIs in both groups (Group A: 50.54%, Group B: 100%) ($P = 0.00073$). Obesity was highly prevalent in recurrent UTIs (Group A: 56.99%, Group B: 81.25%) ($P < 0.0001$). Prostatic disorders in males and vaginal infections in females were significantly higher in recurrent UTIs in both groups (Group A: 21.5%, Group B: 62.5%) ($P = 0.00003$).

Antibiotic resistance patterns

Antibiotic resistance tests revealed the highest resistance in Group A to cefixime (six patients), ceftazidime (four patients), nalidixic acid (four patients), amikacin (four patients), cotrimoxazole (three patients), and gentamicin (two patients). In Group B, resistance was observed to cefixime (two patients) and ceftazidime (one patient). Group A's lowest resistance was ceftriaxone, cefotaxime, and nitrofurantoin (one patient each). Both groups showed no resistance to levofloxacin (Figure 2).

Risk factors for UTI recurrence

Logistic regression analysis identified several significant factors associated with recurrent UTIs in older adult patients (Table 3). Older age (>65 years) was significantly associated with a higher risk of UTI recurrence, with each additional year increasing the likelihood by 14.18% (odds ratio: 1.1418, 95% confidence interval: 1.0981-1.1873, $P < 0.0001$). Females were over four times more likely to experience recurrent UTIs than males (odds ratio: 4.2871, 95% confidence interval: 2.3170-7.9323, $P = 0.0069$). Diabetes and higher body mass index significantly increased the risk of recurrent UTIs ($P < 0.0001$). Immunosuppression due to malignancies, autoimmune diseases, or drugs was significantly associated with UTI recurrence ($P = 0.0406$).

The presence of renal stones significantly increased the risk of recurrent UTIs ($P < 0.038$). Prostate disorders in males and gynecologic diseases in females were also significant risk factors for UTI recurrence, with *P*-values of <0.0001 and <0.0025, respectively. These findings highlight the multifactorial nature of UTI recurrence in older adult patients, emphasizing the importance of considering age, sex, comorbidities, and specific urogenital conditions in managing and preventing recurrent UTIs.

Discussion

This study provides comprehensive data on the incidence, clinical features, and outcomes of UTIs in older adult patients compared with younger individuals. The results indicate that the incidence of UTIs is substantially higher in patients aged 65 years and older compared with those younger than 65 years, aligning with previous studies [18–21] that underscore the increased susceptibility to UTIs with age. Older adults' heightened risk of UTIs may be attributed to physiologic changes, comorbidities, and increased health care interactions. These factors highlight the necessity for age-specific strategies in managing UTIs.

Table 2
Microbial profile, demographics, and comorbidities of the study groups according to the outcome of UTI.

Parameter	Group A (≥65) patients who developed UTI (n = 213)			Group B (<65) patients who developed UTI (n = 72)			Significance
UTI outcome	*Resolved UTI (n = 95)*	*Recurrent UTI (n = 93)*	*Resistant UTI (n = 25)*	*Resolved UTI (n = 51)*	*Recurrent UTI (n = 16)*	*Resistant UTI (n = 2)*	
Uropathogenic organism							
Escherichia coli; n (%)	40 (42.12)	31 (33.33)	9 (36)	27 (52.94)	***6 (37.5)***	1 (50)	X^2: 7.391 *P*: 0.024
Klebsiella; n (%)	30 (31.58)	38 (40.8)	10 (40)	11 (21.57)	***3 (18.75)***	1 (50)	X^2: 6.226 *P*: 0.044
Enterococcus; n (%) X^2: X^2:	9 (9.47)	6 (6.45) 2.01481 2.01481	2 (8)	5 (9.8)	1 (6.25)	0	X^2: 1.2063 *P*: 0.54
Pseudomonas; n (%)	6 (6.32)	20 (21.51)	6 (24)	3 (5.88)	6 (37.5)	1 (50)	X^2: 6.3570 *P*: 0.041[a]
Staphylococcus; n (%)	7 (7.37)	7 (7.53)	1 (4)	2 4.8%	0	0	X^2: 2.0148; *P* = 0.365
Mixed organisms; n (%)	4 (4.21)	7 (7.53)	2 (8)	6 (11.56)	0	0	X^2: 7.2; *P* = 0.0273[a]
Patients' characteristics							
Female; n (%)	35 (16.43)	56 (26.29)	21 (9.96)	27 (41.18)	10 (62.5)	2 (100)	X^2:7.729
Male; n (%)	48 (22.54)	44 (20.66)	9 (4.23)	24 (47.06)	6 (37.5)	0	*P* = 0.0209[a]
Diabetes n (%)	84 (88.4)	90 (96.77)	24(96)	38 (88.24)	16 (56.25)	2 (100)	X^2: 18.741 *P* = 0.000085[b]
Dyslipidemia n (%)	37 (38.95)	47 (50.54)	17 (68)	30 (58.8)	16 (100)	0	X^2: 14.4266 *P* = 0.00073[b]
Hypertension	42 (44.21)	42 (45.16)	11 (44)	32 (62.75)	13 (81.25)	0	X^2: 11.215 *P* = 0.003[b]
Obesity	29 (30.53)	53 (56.99)	21 (84)	28 (54.9)	13 (81.25)	2 (100)	X^2: 18.406 *P* <0.0001[b]
Immunosuppression	2 (2.11)	21 (22.58)	6 (24)	2 (3.92)	10 (62.5)	2 (100)	X^2: 0.7635 *P* = 0.682
Chronic liver disease	8 (8.42)	3 (3.22)	1 (4)	14 (27.45)	10 (62.5)	0	X^2: 2.7062 *P* = 0.258
Renal stones	7(7.37)	18 (19.35)	6 (24)	4 (7.84)	8 (11.76)	1(50)	X^2: 1.0474 *P* = 0.592
Gastrointestinal disorders	32 (33.68)	36 (38.7)	5 (20)	33 (64.7.)	13 (25.49)	2(100)	X^2: 5.8303 *P* = 0.054
Vaginal or cervical disease in females	4 (4.21)	20 (21.5)	12 (48)	21 (41.7)	10 (62.5)	2 (100)	X^2: 20.98 *P* = 0.00003[b]
Enlarged prostate in males	20 (31.58)	31 (33.33)	14 (16)	8 (15.69)	16 (100)	0	X^2: 6.4008 *P* = 0.0407[a]

UTIs, urinary tract infections.
This table presents the microbial profile, demographic characteristics, and comorbidities of Group A (≥65 years old) and Group B (<65 years old) patients who developed UTIs. The data is categorized based on the outcome of UTI: resolved, recurrent, or resistant. The table includes the distribution of uropathogenic organisms (*Escherichia coli, Klebsiella, Enterococcus, Pseudomonas, Staphylococcus*, and mixed organisms) among the groups, along with their respective chi-square (χ^2) values and *P*-values, indicating statistical significance where applicable. In addition, it details patients' characteristics (sex distribution) and comorbid conditions (diabetes, dyslipidemia, hypertension, obesity, immunosuppression, chronic liver disease, renal stones, gastrointestinal disorders, vaginal or cervical disease in females, and enlarged prostate in males). Statistically significant differences between the groups are highlighted with *P*-values, with values marked by [a] and [b] indicating significance levels.

Table 3
Logistic regression analysis of risk factors for recurrent UTIs in older adult patients.

Variable	Coefficient	Standard error	Wald	*P*	Odds ratio	95% Confidence interval
Age	0.10711	0.0093240	131.9561	<0.0001	1.1418	1.0981-1.1873
Sex	0.53446	0.19800	7.2861	0.0069	4.2871	2.3170-7.9323
Diabetes	0.12431	0.017063	53.0783	<0.0001	0.12431	0.017063
BMI	1.58094	0.13540	136.3342	<0.0001	1.58094	0.13540
Immunosuppression	0.19429	0.32511	3.3415	0.0406	1.2143	1.0094-1.4620
Hypertension	0.00033392	0.0027455	0.01479	0.8032	0.9937	0.9816-1.0060
Renal stones	0.56860	0.13189	6.5870	<0. 048	0.56860	0.13189
Prostate enlargement in males	0.077751	0.0047897	263.5118	<0.0001	1.1859	0.9245-1.5212
Gynecologic diseases in females	0.64035	0.183178	8.2603	<0.0025	.4054	1.3483-1.4650
Liver diseases	0.17048	0.12704	1.8007	0.1796	0.17048	0.12704
Gastrointestinal disorders	-0.0094388	0.0051051	3.4185	0.0645	0.9906	0.9807-1.0006

BMI, body mass index; UTIs, urinary tract infections.
This table presents a logistic regression analysis results identifying risk factors for recurrent UTIs in older adult patients. The variables analyzed include age, sex, diabetes, BMI, immunosuppression, hypertension, renal stones, prostate enlargement in males, gynecologic diseases in females, liver diseases, and gastrointestinal disorders. The table displays each variable's coefficient, standard error, Wald statistic, *P*-value, odds ratio, and 95% confidence interval. Statistically significant risk factors are indicated by *P*-values, with significant variables affecting the likelihood of recurrent UTIs highlighted accordingly.

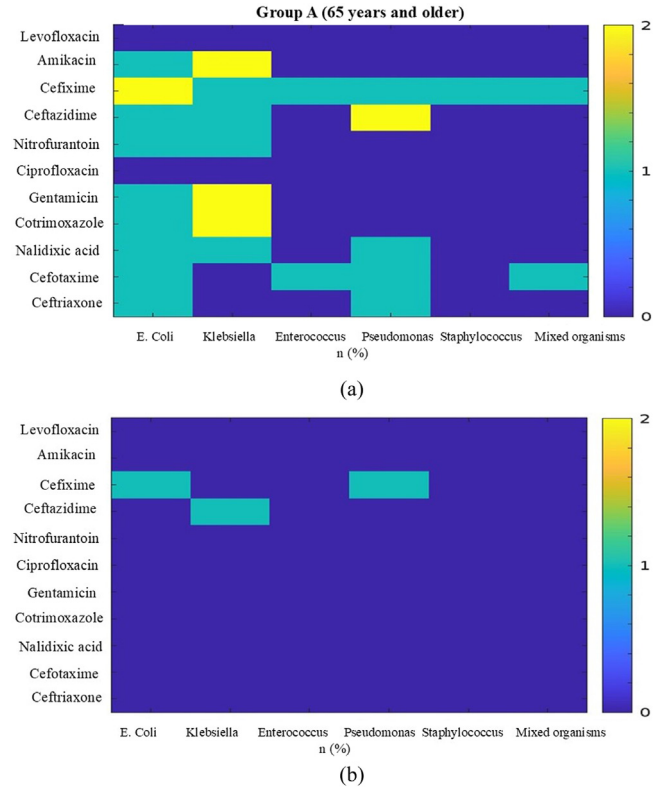

Figure 2. (a) Heatmap of antibiotic resistance patterns in uropathogenic bacteria in group A (patients aged ≥65 years). (b) Heatmap of antibiotic resistance patterns in uropathogenic bacteria in group B (patients aged <65 years).
The figure illustrates the percentage susceptibility of various bacterial isolates to different antibiotics among the two age groups: Group A (≥65 years) and Group B (<65 years). The bacterial isolates included *Escherichia coli, Klebsiella, Enterococcus, Pseudomonas, Staphylococcus*, and mixed organisms. The antibiotics tested were levofloxacin, amikacin, cefixime, ceftazidime, nitrofurantoin, ciprofloxacin, gentamicin, cotrimoxazole, nalidixic acid, cefotaxime, and ceftriaxone. This heatmap highlights significant differences in resistance percentages in the two study groups.

Our study also found a notably higher incidence of UTIs in females across both age groups, consistent with previous research [18,21–23]. Anatomic and hormonal differences likely contribute to the increased susceptibility of women to UTIs. In addition, older patients in the current study often present with atypical symptoms or less pronounced manifestations, such as urgency, suprapubic pain and flank pain, hematuria, urinary incontinence, and disorientation rather than the classic UTI symptoms seen in younger populations, which can lead to delays in diagnosis and initiation of appropriate treatment, increasing the risk of complications such as pyelonephritis and sepsis in the older cohort. Incorporating these insights into clinical practice can improve early recognition of UTIs in older adults, allowing prompt treatment and reducing the risk of recurrence, antibiotic resistance, and other complications.

The atypical presentations, including vague or nonspecific symptoms like fatigue or confusion, necessitate a high index of suspicion from clinicians. Diagnostic approaches must be tailored to this population, with careful consideration of underlying comorbidities such as diabetes, which may further obscure typical UTI symptoms. Routine screening for asymptomatic bacteriuria should also be considered in high-risk older adult patients, especially those with recurrent UTIs, to enable timely intervention.

Significant differences in UTI outcomes between the two age groups were observed. Older patients had a lower rate of complete recovery and experienced significantly earlier and more frequent UTI recurrences and antibiotic-resistant infections compared with younger patients. Furthermore, *E. coli* remains the predominant pathogen in older adults and younger patients, as observed in our study and corroborated by reports from Europe, Asia, and the Americas [24–27]. However, we found *Klebsiella* and *Pseudomonas* species to be more prevalent in recurrent UTIs in older adult patients. This trend has also been reported in studies from Southeast Asia and South America, where patients with recurrent UTI, particularly those with comorbidities like diabetes, showed higher resistance rates and increased prevalence of these organisms. These findings are concerning, given the global rise in antimicrobial resistance. Previous research [28–30] has shown that older adult patients are particularly vulnerable to antimicrobial resistance due to frequent antibiotic use and comorbid conditions necessitating repeated health care interventions. Routine screening for UTIs in older adults, especially those with comorbid conditions such as diabetes and immunosuppression, should be prioritized to enable early detection and timely intervention, preventing complications and improving patient outcomes.

The study observed the highest resistance rates with cefixime, ceftazidime, nalidixic acid, amikacin, cotrimoxazole, and gentamicin, with almost no resistance noted for levofloxacin and ciprofloxacin. However, antibiotic resistance patterns in UTIs exhibit significant variability across different populations, age groups, and geographic regions. These findings are consistent with reports from other regions, where older adult populations are also observed to have higher resistance rates, likely due to increased antibiotic exposure and frequent health care interactions. Compared with data from European and North American studies, our findings align with increasing resistance to commonly used antibiotics for UTI treatment, such as trimethoprim-sulfamethoxazole (TMP/SMX) and cephalosporins in older adults [28–31]. For example, a study from Southern Italy showed that the three most isolated pathogenic strains were *E. coli* (72.2%), *Klebsiella pneumoniae* (12.4%), and *Proteus* (9.0%), with high resistance rates to cephalosporins, ampicillin, and amoxicillin–clavulanic acid [32].

Furthermore, reports from Asia, specifically in older adult populations in China and Japan, highlight resistance patterns against amikacin and cefixime, mirroring our observations. In Asia, the prevalence and resistance patterns of UTIs among hospitalized urology patients highlight notable regional differences, underscoring the importance of localized antibiotic stewardship [29,33]. The higher incidence of antibiotic-resistant UTIs in older individuals necessitates continuous surveillance of resistance patterns and the development of targeted antibiotic stewardship programs and age-specific treatment guidelines to mitigate the spread of resistant pathogens. Tailoring antibiotic therapy based on local resistance patterns and individual patient profiles can enhance treatment efficacy and reduce recurrence risk.

Logistic regression analysis identified significant risk factors for recurrent UTIs in older individuals, including age, female sex, diabetes, higher body mass index, immunosuppression, renal stones, and prostate enlargement in males. These findings emphasize the multifactorial nature of UTI recurrence in older adults and support the need for comprehensive management approaches addressing these underlying risk factors, as suggested by other research groups [30]. Management of UTIs in older adult patients should adopt a holistic approach, addressing the infection and underlying risk factors such as diabetes, obesity, and immunosuppression with the engagement of multidisciplinary care teams, including primary care physicians, geriatricians, and infectious disease specialists to provide integrated care and improve patient outcomes.

The current study has several strengths, including its prospective cohort design, comprehensive follow-up, unique cohorts of different ethnic backgrounds, and robust data collection on clinical features, outcomes, and microbiologic profiles in patients aged 65 years and older and those younger than 65 years. However, limitations include potential selection bias due to the study being conducted at a single center and excluding patients with specific conditions such as renal transplants and recent antibiotic use. Future research should aim to include a more diverse patient population and explore the impact of various interventions on UTI prevention and management in older adult patients.

In conclusion, this study demonstrates that patients aged 65 years and older have a higher incidence of UTIs, significantly earlier and more frequent UTI recurrences, and antibiotic resistance than younger patients. Age- and sex-specific strategies are crucial for preventing and managing UTIs, focusing on addressing antibiotic resistance and recurrent infections in older adult patients. Implementing these strategies can enhance patient care and reduce the burden of UTIs in the aging population.

Declarations of competing interest

The authors have no competing interests to declare.

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Ethical consideration

The manuscript entitled: The Incidence, Clinical Features and Outcome of Urinary Tract Infections in Geriatric Patients: A Prospective Longitudinal Study has received approval from the University Institutional Review Board (IRB) and Ethical Committee. This approval encompasses the informed consent process, research proposal, study design, and data analysis methods employed in the study. IRB approval number: scBR-113/2021.

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Author contributions

Prof. Sanaa Kamal: Study design, conceptualization, data curation and validation statistical analysis, investigation, methodology, patients' recruitment, project administration, patient recruitment, resources, project supervision, manuscript writing, review & editing. Dr. Mohey Nagib and Mohammed Saad Al Qahtani contributed equally to patient recruitment, the study follow-up, and the article's drafting. Abdulmajeed Al Mazroua, Abdulaziz M. M. Alshamrani, and Abdallah S. A. Alayyaf contributed to patient recruitment, follow-up, acquisition of data, and data entry and interpretation. All authors reviewed the final manuscript, agreed to submit it for publication, and provided final approval of the version to be submitted.

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The study's funder had no role in study design, data collection, analysis, interpretation, or report writing.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijregi.2024.100469.

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