A comprehensive clinical and microbiological profile of culture-positive urinary episodes in children with acute lymphoblastic leukemia

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ABSTRACT

Objective: This study aimed to assess the frequency, causative microorganisms, antimicrobial resistance patterns, and unusual clinical and laboratory findings of culture-positive urinary episodes throughout the entire chemotherapy course in pediatric patients with Acute Lymphoblastic Leukemia (ALL).

Material and Methods: We reviewed the medical records of 93 pediatric ALL patients who completed BFM-based chemotherapy protocols between 2019 and 2025. A total of 1265 urine cultures were analyzed. Culture positivity was defined as ≥105 colony-forming units per milliliter (CFU/mL) of a single or two different pathogens. For retrospective analysis, contamination was defined by a negative control culture within 48–72 hours or clinical resolution without antibiotic treatment. Data on urinalysis, neutropenia status, and antibiotic resistance were collected.

Results: Forty-eight patients (51.6%) experienced a median of two culture-positive episodes. Incidence was highest during intensive treatment phases (induction, reinduction). Escherichia coli was the most common agent (39.8%), followed closely by Klebsiella pneumoniae (36.7%). Overall ESBL positivity was 26.6%. A concerning 30.6% of *K. pneumoniae* isolates showed carbapenem resistance. Standard urinalysis was found to be unreliable, with 71.4% of positive cultures lacking typical findings; leukocyturia was only present when the absolute neutrophil count was relatively preserved. Three cases of urosepsis (3%) were identified, all involving highly resistant organisms.

Conclusion: Pediatric ALL patients, particularly during intense chemotherapy, face a high burden of culture-positive urinary episodes and a notable shift towards multidrug-resistant non-*E. coli* pathogens like *K. pneumoniae*. The unreliability of standard urinalysis in this immunocompromised population necessitates the routine collection of urine cultures during febrile neutropenia workups, irrespective of symptoms, to ensure timely, targeted therapy guided by local resistance data. The observed extreme resistance profile appears to be a transient reflection of the intensive chemotherapy environment.

Keywords: Acute Lymphoblastic Leukemia, carbapenem resistance, febrile neutropenia, *Klebsiella pneumoniae*, urinalysis, urinary tract infection

Introduction

Urinary tract infection (UTI) is the most common bacterial infection in children, affecting 3% to 7.5% of febrile children each year (1). It remains a frequent and concerning cause of morbidity, even in healthy children, due to early complications like urosepsis and the risk of recurrent episodes that can lead to kidney scarring and suggest underlying urological abnormalities. Diagnosis and classification of UTIs involve differentiating between asymptomatic bacteriuria and symptomatic bacteriuria (positive culture with symptoms such as pain, fever, or dysuria). They are also categorized by site (upper vs. lower UTI), anatomical or functional status (uncomplicated vs. complicated), and source (community vs. nosocomial). These require careful clinical and bacteriological evaluation to guide treatment (2).

The diagnostic reliability of symptom-based and anatomical definitions of UTI is challenged in immunocompromised children. Children with acute lymphoblastic leukemia (ALL)

are severely immunosuppressed, mainly due to both leukemia and treatment-induced neutropenia. In this highly vulnerable group, febrile neutropenia (FN) can obscure symptoms of pyelonephritis, and standard urinalysis results, such as leukocyturia and nitrites, are less dependable. Furthermore, broad-spectrum empirical antimicrobial therapy should not be delayed during FN while waiting for urine culture results or even the complete urinalysis findings.

The risk of UTIs is not well-defined in pediatric oncology, and much of the current literature has concentrated on studying and managing infections within the context of FN (3,4). This focused approach often limits understanding of non-febrile or asymptomatic bacteriuria, as well as UTIs occurring outside periods of severe neutropenia, which may still significantly contribute to morbidity. Additionally, while some studies have expanded their scope to include asymptomatic bacteriuria through surveillance cultures, there remains limited data thoroughly describing the full range of culture-positive urinary episodes across different phases of ALL treatment (5).

This study retrospectively investigated the frequency, causative microorganisms, antibiotic resistance patterns, and atypical clinical and laboratory findings of culture-positive urinary episodes across the entire chemotherapy course in pediatric patients with ALL. By detailing the unique microbiological and clinical characteristics of UTIs in this cohort, we aim to provide essential data to enhance diagnostic precision and optimize management strategies.

Materials and Methods

This study employed a retrospective, observational design. We reviewed the medical records of 181 patients diagnosed with ALL and completed their two-year BFM-based chemotherapy protocols at Ankara Bilkent City Hospital, Pediatric Hematology Oncology Department, between August 1, 2019, and July 31, 2025. Patients were included if they were younger than 18 years at the time of ALL diagnosis. We excluded patients who experienced relapse, required a hematopoietic stem cell transplant, or died during chemotherapy. We recorded patient demographics, ALL subtype and risk classification, any history of UTI before diagnosis, the total number of urine cultures per patient during and after treatment, follow-up durations, and urinary ultrasonography (US) findings. For this study, one culture-positive urinary episode was considered distinct from another if the interval between urine culture samples was more than two weeks. A urine culture was considered positive if it showed growth of a single pathogen at a concentration of ≥105 colony-forming units per milliliter (CFU/mL), or if it showed growth of two different pathogens, with each organism isolated at a concentration of ≥105 CFU/mL. For culture-positive episodes suspected to be contaminants, a retrospective criterion was established: they were defined as episodes in clinically stable patients who did not require treatment, where a follow-up urine culture obtained within 48–72 hours of the initial positive culture returned negative, or where clinical follow-up showed resolution without antibiotic therapy. For all identified culture-positive urinary episodes,

we collected specific information, including the phase of chemotherapy during which the culture was obtained, the clinical reason for obtaining the culture, urinalysis findings, concurrent white blood cell (WBC) count, absolute neutrophil count (ANC), and absolute lymphocyte count (ALC), C-Reactive Protein (CRP) level, and, if available, blood culture results and treatments administered. Laboratory results (WBC, ANC, ALC, and CRP) were recorded if they were obtained within three days before or after the date of the positive urine culture. Leukocyturia was defined as ≥5 WBCs per high-power field in the urine sediment, and hematuria was defined as ≥5 red blood cells per high-power field. In accordance with our unit's established clinical practice, urine samples for analysis and culture were collected using either clean-catch mid-stream urine or bag urine culture.

Statistical analysis

Descriptive statistics were presented as median (minimum–maximum) for continuous variables and as frequencies (percentages) for categorical variables. The normality of the data distribution was assessed using the Kolmogorov-Smirnov test. Since the continuous variables were not normally distributed, the Mann-Whitney U test was employed for comparisons between independent groups. Categorical independent variables were compared using the chi-square test. All tests adopted a p-value of ≤0.050 for statistical significance. Analyses were conducted using IBM Statistical Package, version 26.0 (SPSS Inc., Armonk, NY, IBM Corp., USA)

Results

Patient demographics and rate of positive urine cultures

A total of 93 patients were included in the study, comprising 54 (58.1%) males and 39 (41.9%) females. The median age at leukemia diagnosis was 6.6 years (range; 1-18). Eighty patients (86%) had precursor B-cell ALL, and 13 (14%) had T-cell ALL. Sixty-eight patients (73.1%) had intermediate-risk disease, while 25 (26.9%) had high-risk disease. Four patients (4.1%) had a history of UTI before their ALL diagnosis. Over the two-year chemotherapy period for ALL, a total of 1265 urine cultures were collected, with a median of 12 per patient (range: 2-57). Of these, 98 cultures (7.7%) showed growth, detected in 48 patients (51.6%).

Details of culture-positive episodes

Forty-eight patients with positive cultures had a median of 2 positive cultures (range; 1-8). Twenty-nine (29.6%) of 98 episodes occurred in boys, while 69 (70.4%) occurred in girls. The most common clinical reasons for obtaining positive cultures were FN (n: 36; 36.7%) and, in conjunction with urinalysis (n: 30; 30.6%). Other reasons included dysuria and abdominal pain (n: 13; 13.3%), elevated CRP (n: 4; 4.1%), and fever (n:2; 2%). These positive cultures were identified during different treatment phases: 28 episodes (28.6%) occurred during induction, 24 (24.5%) during consolidation, 32 (32.7%) during reinduction, and 14 (14.3%) during maintenance. The link between culture positivity and patient characteristics, such as age, gender, and ALL classifications, is detailed in Table I.

Table I: The characteristics of patients according to urine culture positivity.

	Negative	Positive	p‡
Number of patients	45	48	-
Age, years*	6.9 (1.8-17.5)	4.7 (1-18)	0.053
Gender†			
Male	34 (63)	20 (37)	0.001
Female	11 (28.2)	28 (71.8)	
ALL subtype†			
pre-B cell ALL	38 (47.5)	42 (52.5)	0.671
T cell ALL	7 (53.8)	6 846.2)	
Risk group†			
Intermediate risk	37 (54.4)	31 (45.6)	0.055
High risk	8 (32)	17 (68)	

*: median(range), †: n (%), ‡: Mann-Whitney U-test and chi-square test, **ALL:** Acute lymphoblastic leukemia

Table II: Identified agents in urine cultures and resistance profiles

	Total	ESBL positivity	Carbapenem resistance
Number of episodes	98	29	12
Escherichia coli*	39 (39.8)	13 (33.3)	1 (2.6)
Klebsiella pneumoniae*	36 (36.7)	12 (33.3)	11 (30.6)
Enterococcus spp.*	8 (88.2)	-	-
Proteus mirabilis*	7 (7.1)	-	-
Pseudomonas aeruginosa*	6 (6.1)	-	-
Enterobacter cloacae*	4 (4.1)	3 (75)	-
Klebsiella oxytoca*	3 (3.1)	-	-
Acinetobacter spp.*	3 (3.1)	-	-
Morganella morganii*	1 (1)	1 (100)	-
Citrobacter braakii*	1 (1)	-	-
Candida albicans*	1 (1)	-	-

*: n(%), **ESBL:** Extended-spectrum beta-lactamase

Of the 98 positive cultures, 11 (11.2%) contained two different agents, while the remaining 87 (88.8%) revealed a single agent, totaling 109 agents. A diverse range of bacteria was identified as the cause of the infections. The most common agents were Escherichia coli (E. coli), found in 39 episodes (39.8%), and Klebsiella pneumoniae (K. pneumoniae), found in 36 episodes (36.7%). In girls, 46.4% of episodes were caused by E. coli (32/69), whereas in boys, E. coli infections accounted for 24.1% (7/29) (p = 0.040). Overall, extended-spectrum beta-lactamase (ESBL) positivity was detected in 26.6% (29/109) of the agents, with 33.3% (12/36) of K. pneumoniae and 33.3% (13/39) of E. coli being ESBL positive. Carbapenem resistance was found in 11% (12/109) of all isolates, primarily driven by K. pneumoniae, which showed a high resistance rate of 30.6% within its species (11/36 isolates). The details of all identified agents and their resistance profiles are provided in Table II. Seventeen of the 98 cultures (71.4%) showed no positive urinalysis results. Of the 28 cultures (28.6%) that yielded findings, 22 (22.4%) were positive for leukocytes, 18 (18.4%) for leukocyte esterase, and 8 (8.2%) for nitrites, respectively. Additionally, hematuria was detected in 3 (3.1%) of the cultures.

Laboratory evaluations during episodes of positive culture showed a median WBC count of 1380/mm³ (range; 60-14120/mm3), a median absolute neutrophil count of 605/mm³ (range; 20-12990/mm³), a median lymphocyte count of 405/mm³ (range; 0-4530/mm³), and a median CRP of 6.5 mg/L (range; 0-160 mg/L). A comparison between patients with and without leukocyturia showed significant differences in blood cell counts. The median WBC count was 2490/mm³ (range; 110-14120/mm³) in patients with leukocyturia, significantly higher than the 1200/mm³ (range; 60-6090/mm³) observed in those without (p=0.004). Similarly, the median ANC was 1255/mm³ (range: 50-12990/mm³) in the leukocyturia group, compared to 400/mm³ (range; 20-5630/mm³) in the group without leukocyturia (p=0.002). Bacterial growth was also found in 10 (18.2%) of the 55 blood cultures collected during periods of positive urine cultures. A match was seen in 3 of these 10 cases (30%), where the same bacterial species was identified in both blood and urine samples. These patients were thus considered to have urosepsis. The details of the urosepsis episodes are outlined in Table III.

Treatment and follow-up

Of the 98 positive culture episodes, 20 (20.4%) were considered contaminants and were not treated. Twenty-four (24.5%) episodes were treated based on urine culture results, with 13 receiving oral antibiotics and 11 receiving systemic therapy. The remaining 54 (55.1%) episodes were treated with systemic antibiotics due to FN or accompanying infections.

All patients, regardless of their urine culture results, underwent a urinary ultrasonographic examination. These were performed either after the cessation of chemotherapy in 54 patients (58.1%) or during ongoing chemotherapy in 39 patients (41.9%). Overall, 86 (92.5%) examinations revealed normal findings. Other findings included nephrolithiasis in 3 (3.2%) patients, an atrophic kidney in 2 (2.2%) patients, and renal cysts in 2 (2.2%) patients.

During a median follow-up of 17.3 months (range: 0-42) after completing ALL treatment, 7 additional positive cultures were detected in 4 (12.9%) of the 31 patients who underwent follow-up cultures. These episodes were usually associated with dysuria and/or fever. Cultures from these episodes revealed a single pathogen without ESBL production or carbapenem resistance, and all were managed in an outpatient setting.

Discussion

Children with ALL are highly vulnerable to infections because of the severe immunosuppression caused by the primary disease and intensive chemotherapy. This vulnerability is worsened by impaired mucosal barrier integrity. Since most UTIs tend to originate from the periurethral area, this risk significantly increases in children with ALL. Although rare in healthy children, this group can also experience hematogenous spread to the urinary tract from bloodstream

Table III: Characteristics of patients with urosepsis and details of the episodes			
	Case 1	**Case 2**	**Case 3**
Age (year)	2.5	6	6
Gender	Female	Female	Female
ALL subtype	Precursor B cell	Precursor B cell	Precursor B cell
ALL risk group	High risk	Intermediate risk	Intermediate risk
UTI history before ALL	No	No	No
Phase of chemotherapy	Induction	Reinduction	Reinduction
Clinical status	Febrile neutropenia	Febrile neutropenia	Febrile neutropenia
WBC count (/mm^3)	60	300	360
ANC (/mm^3)	40	80	50
CRP (mg/L)	0	10	0
Urinalysis findings	None	None	Positive leukocytes, leukocyte esterase, nitrites
Bacteria in urine culture	Carbapenem-resistant *Klebsiella pneumoniae*	ESBL-positive *Escherichia coli*	*Acinetobacter baumannii* and *Escherichia coli*
Bacteria in blood culture	Carbapenem-resistant *Klebsiella pneumoniae*	ESBL-positive *Escherichia coli*	*Acinetobacter baumannii*
US findings	Normal	Normal	Normal
UTI after ALL	No	No	No

ALL: *Acute lymphoblastic leukemia,* **CRP:** *C-reactive protein,* **ESBL:** *Extended-spectrum beta-lactamase,* **US:** *Ultrasonography,* **UTI:** *Urinary tract infection,* **WBC:** *White blood cell*

infections (6). Due to severe neutropenia, relying on typical symptoms or standard urinalysis results for diagnosis is highly limited. Additionally, immunocompromised children often experience multiple hospital admissions, prolonged hospital stays, and extended courses of antibiotics, making them more susceptible to unusual bacteria or antibiotic resistance (7). Considering these factors, a different approach is needed for interpreting culture-positive urinary episodes in this population.

Our study confirmed an elevated susceptibility to bacteriuria, with 51.6% of ALL patients experiencing a median of two positive urine cultures during their two-year treatment for ALL. This figure is exceptionally high compared to the cumulative incidence reported in the general pediatric population (6.6% in girls and 1.8% in boys in the first six years of life) (8). The high rate of microbial detection confirms that the urinary tract is a frequently colonized site in ALL patients. Studies on children with cancer and UTIs are limited. Shim et al. (9) observed that 74.6% of children with cancer experience UTI at least once (mean 2.8) during chemotherapy. Consistent with general pediatric epidemiology, we observed a significant gender disparity, with girls exhibiting a significantly higher culture positivity rate (71.8% vs. 37.0%). Although not statistically significant, the tendency toward higher culture positivity in younger children (median age; 4.7 years vs. 6.9 years) aligns with the known risk pattern in early childhood (10-12). Additionally, the higher rates seen during intensive treatment phases (induction, consolidation, reinduction) and among patients on high-risk protocols suggest that increased chemotherapy intensity and the resulting profound immunosuppression and hospitalization lead to increased urinary tract vulnerability.

While *E. coli* is the leading cause of pediatric UTIs, accounting for up to 85% of community-acquired cases, our group showed a notable shift in etiology from *E. coli* to non-*E. coli* bacteria, which are common in immunocompromised patients (13). This change was especially prominent in boys (24.1% in boys versus 46.6% in girls), supporting the idea that their infections are more likely to be nosocomial or related to immune suppression from chemotherapy. Although *E. coli* remained the most common isolate at 39.8%, we also saw a nearly equal proportion of *K. pneumoniae* at 36.7%. The microbial causes of UTIs in pediatric oncology patients are highly varied. Comparing our results with existing literature reveals significant differences. Hirmas et al. (14) reported *E. coli* at 51% of isolates, with *K. pneumoniae* at just 9%. Similarly, Shim et al. (9), who focused strictly on children undergoing chemotherapy, found *E. coli* at a rate of 25.6% and *K. pneumoniae* at a rate of 10.5%. Predavec et al. (5) noted *E. coli* at 32.2%, followed by *Klebsiella spp*, at 22.4%. In contrast to these studies, our research revealed an unusually high rate of *K. pneumoniae* at 36.7%. This significant shift toward *K. pneumoniae* suggests regional variations in the microbial environment. It may reflect a higher burden of hospital-acquired infections or a different colonization pattern in our center, considering that *K. pneumoniae* is frequently involved in healthcare-associated infections.

Beyond variations in etiology, a comparative analysis of antimicrobial resistance profiles highlights the growing threat posed by multidrug-resistant (MDR) organisms in this vulnerable population. Hirmas et al. (14) reported that 37% of Gram-negative bacteria produced ESBL, although overall multi-drug resistance was lower at 3%. Predavec et al. (5) found that ESBL production in *K. pneumoniae*

episodes accounted for 20.6%. Our finding of an overall 26.6% ESBL positivity aligns with the broad range observed in these cohorts, confirming that empirical therapy failure due to ESBL production remains a common concern. This trend is consistent worldwide. For example, the Israeli cross-sectional study by Shkalim Zemer et al. (15) reported a significant increase in ESBL-positive *E. coli* rates from 6.1% in 2007 to 25.4% in 2021 within the general pediatric population, emphasizing the widespread evolution of resistance that affects even immunocompromised groups. However, the most concerning finding in our study is the high rate of extreme resistance. The detection of 30.6% carbapenem resistance in our *K. pneumoniae* isolates (making up 11% of all agents) contrasts with the 3% multidrug resistance rates reported by Hirmas et al. (14). This highlights a considerably more severe resistance issue at our center and suggests that first-line empirical antibiotic regimens commonly used for FN may be insufficient against a sizable proportion of community and/or nosocomially acquired uropathogens. Madney et al. (16) reported that surveillance for carbapenem-resistant Enterobacteriaceae in children with cancer led to the appropriate use of targeted antibiotics, resulting in a decrease in the need for intensive care unit admission and a significant reduction in the 30-day mortality rate. A comprehensive review by Mahony et al. (17) highlights that the main risk factors for MDR organisms-UTI in children are prior antibiotic use and hospitalization. Given that our ALL patients have continuous exposure to these high-risk factors due to intensive chemotherapy and prolonged hospital stays, this explains why the MDR organisms' burden is significantly high.

The role of UTIs in FN among pediatric cancer patients remains uncertain, posing a significant diagnostic challenge. In our study, the most common reason for urine cultures was FN (36.7%). While some literature suggests that UTIs are a rare cause of infection in these patients, showing a low incidence of 1.2% of FN episodes, others argue that the frequency of UTIs (up to 8.6%) can be as common as bacteremia in this population (3,4,18). The nature of FN itself worsens this diagnostic uncertainty. Unlike infections of the respiratory or gastrointestinal tracts, UTIs may present with nonspecific symptoms or no apparent signs, except for fever. As a result, UTIs may go undiagnosed unless urine cultures are routinely performed. Missing this diagnosis carries significant risk, especially given the high prevalence of MDR bacteria in the urinary tract. This is clinically important due to the low but notable urosepsis rate (3% in our group, compared to 1.3-2.1% in the literature) (9,14). All three cases of urosepsis in our study occurred during FN with severe neutropenia and involved highly resistant organisms, specifically carbapenem-resistant *K. pneumoniae* and ESBL-positive *E. coli*. This highlights the urinary tract as a critical reservoir for life-threatening MDR sepsis. Therefore, we strongly recommend that urine cultures be routinely obtained as part of the initial diagnostic assessment for all patients with FN, regardless of urinary symptoms or urinalysis results. We found out that a significant portion of positive cultures (71.4%) lacked positive urinalysis findings. Neutropenia explains this weak correlation, as inflammatory responses are suppressed. Leukocyturia only appeared when neutrophil and WBC counts were considerably higher, indicating it is only reliable when ANC is preserved. This emphasizes that clinical suspicion and culture results, rather than urinalysis, should guide diagnosis in ALL patients.

Microbiological surveillance in pediatric oncology primarily focuses on detecting gastrointestinal colonization, as MDR bacteria in stool are associated with increased blood culture positivity and mortality in children with ALL (19). While stool samples are primarily used, some studies suggest stool surveillance may not predict MDR sepsis or mortality (20). The behavior of the urinary tract during immunosuppression is less well understood. Routine urine surveillance is not a standard practice, and data to support it are lacking. However, approximately 30.6% of positive cultures in our cohort were collected during routine workups, supporting the use of proactive culture collection. Given the high prevalence of resistant isolates, routine urine cultures during intensive chemotherapy may help identify MDR organisms early, enabling targeted therapy during FN. Yet, routine urinary surveillance requires careful evaluation due to risks such as increased costs, difficulty distinguishing between infections and colonization, and the potential to promote antibiotic resistance.

The clinical management of culture-positive episodes in this cohort was notably complex. The high rate of episodes deemed contaminants (20.4%) highlights the inherent challenges in sterile sample collection. This issue is likely exacerbated by the need to use non-invasive methods, thereby increasing the risk of false-positive cultures. Despite this, the majority of positive episodes necessitated treatment, frequently systemic therapy, primarily due to concurrent FN. This reflects the essential aggressive approach required in this high-risk population, where clinical status often mandates immediate intervention based on culture results.

Importantly, our follow-up data provide critical reassurance regarding long-term pathology and etiology. The majority of patients (92.5%) exhibited normal findings on urinary US, strongly suggesting that the observed high infection and extreme resistance rates are driven by transient factors—profound immunosuppression and exposure to the hospital environment—rather than by underlying anatomical abnormalities. Furthermore, the low recurrence rate (12.9%) and the general susceptibility of pathogens found after the cessation of ALL treatment suggest that the extreme drug resistance profile is a transient reflection of the intensive chemotherapy environment and substantially resolves upon immune recovery.

This study has several limitations inherent to its retrospective, single-center design. Firstly, as an observational retrospective study, it relies on the integrity and completeness of electronic medical records and laboratory information system data, which may introduce selection or information bias. Secondly, the single-center setting, while providing a uniform patient cohort, limits the generalizability of our findings, particularly the exceptionally high rate of carbapenem resistance in *K. pneumoniae* isolates, which appears to reflect a specific institutional microbial environment. Thirdly, the use of non-invasive urine collection methods increases the risk of

contamination. Although we established a clear retrospective criterion for defining contamination, this remains an interpretive challenge.

Conclusion

This study provides a comprehensive profile of urinary episodes in pediatric ALL, confirming a high incidence, especially during intensive chemotherapy phases. Our most important findings relate to microbial challenges: we identified a significant etiologic shift, with *K. pneumoniae* nearly equal to *E. coli*. We also detected a concerning carbapenem resistance rate in *K. pneumonia* isolates. This extreme resistance profile is critical, as urosepsis cases were exclusively linked to these highly resistant organisms. Clinically, our data show that standard urinalysis is unreliable because of the immunosuppressed state; the vast majority of positive cultures lacked typical findings, and leukocyturia was only present when ANC was relatively preserved. Therefore, we strongly recommend routine urine culture collection during FN workup, regardless of symptoms or urinalysis results, to facilitate timely, targeted therapy. Although driven by transient immunosuppression, the urgent need for local resistance data to guide empirical antimicrobial protocols remains essential.

Ethics committee approval
This study was conducted in accordance with the Helsinki Declaration Principles. The study was approved by Ankara Bilkent City Hospital (30.07.2025, reference number: TABED 1–25-1510).

Contribution of the authors
Study conception and design: DK, ÖAB, SGÖ, NYÖ; data collection: DK, MPA, BD, GHET, MI; analysis and interpretation of results: DK, SGÖ; draft manuscript preparation: DK, MI, SGÖ, NYÖ. All authors reviewed the results and approved the final version of the article.

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References

1. Shaikh N, Morone NE, Bost JE, Farrell MH. Prevalence of urinary tract infection in childhood: a meta-analysis. Pediatr Infect Dis J. 2008;27:302-8. https://doi.org/10.1097/INF.0b013e31815e4122
2. Alsaywid BS, Alyami FA, Alqarni N, et al. Urinary tract infection in children: A narrative review of clinical practice guidelines. Urol Ann. 2023;15:113-2. https://doi.org/10.4103/ua.ua_147_22
3. Alonso-Cadenas JA, Sancosmed Ron M, Herrero B, et al. Role of urine culture in paediatric patients with cancer with fever and neutropenia: a prospective observational study. Arch Dis Child. 2023;108:982-6. https://doi.org/10.1136/archdischild-2023-325992
4. Sandoval C, Sinaki B, Weiss R, et al. Urinary tract infections in pediatric oncology patients with fever and neutropenia. Pediatr Hematol Oncol. 2012;29:68-72. https://doi.org/10.3109/08880018.2011.617809
5. Predavec N, Perčinić A, Herljević Z, et al. Bacteriuria in paediatric oncology patients: Clinical features, distribution and antimicrobial susceptibility of bacterial pathogens at University Hospital Centre Zagreb, Croatia over a 4-year period. Antibiotics (Basel). 2024;13:118. https://doi.org/10.3390/antibiotics13020118
6. Desai DJ, Gilbert B, McBride CA. Paediatric urinary tract infections: Diagnosis and treatment. Aust Fam Physician. 2016;45:558-63.
7. Bryant PA, Bitsori M, Vardaki K, Vaezipour N, Khan M, Buettcher M. Guidelines for complicated urinary tract infections in children: a review by the European Society for Pediatric Infectious Diseases. Pediatr Infect Dis J. 2025;44:e211-e223. https://doi.org/10.1097/INF.0000000000004790
8. Mårild S, Jodal U. Incidence rate of first-time symptomatic urinary tract infection in children under 6 years of age. Acta Paediatr. 1998;87:549-52. https://doi.org/10.1080/08035259850158272
9. Shim YJ, Lee KS, Ahn HS, Hwang TJ, Yoon HJ. Urinary tract infection in immunocompromised children under chemotherapy. Blood. 2010;116: 4765. https://doi.org/10.1182/blood.V116.21.4765.4765
10. Nuutinen M, Uhari M, Murphy MF, Hey K. Clinical guidelines and hospital discharges of children with acute urinary tract infections. Pediatr Nephrol. 1999;13:45-49. https://doi.org/10.1007/s004670050560
11. Imran A, Batool F, Al Midaka AAR, et al. Frequency of urinary tract infection among children presenting with acute febrile illness. PJM&HS. 2023; 17:12. https://doi.org/10.53350/pjmhs020231712414
12. Daniel M, Szymanik-Grzelak H, Sierdziński J, Podsiadły E, Kowalewska-Młot M, Pańczyk-Tomaszewska M. Epidemiology and risk factors of UTIs in children-a single-center observation. J Pers Med. 2023;13:138. https://doi.org/10.3390/jpm13010138
13. Schaeffer AJ, Matulewicz RS, Klumpp DJ. Infections of the urinary tract. In: Wein AJ, Partin AW, Peters CA (eds). CampbellWalsh Urology (11th ed) Philadelphia: Elsevier, 2012:39-48.
14. Hirmas N, Mubarak S, Sultan I. Patterns of microbial growth in urine cultures in a pediatric hematology/oncology unit over a one-year period: a single institution study. Int J Pediatr Adolesc Med. 2017;4:95-9. https://doi.org/10.1016/j.ijpam.2017.03.001
15. Shkalim Zemer V, Ashkenazi S, Levinsky Y, et al. Pathogens causing pediatric community acquired urinary tract infections and their increasing antimicrobial resistance: a nationwide study. Pathogens. 2024;13:201. https://doi.org/doi:10.3390/pathogens13030201
16. Madney Y, Mahfouz S, Bayoumi A, et al. Carbapenem-resistant enterobacteriaceae (CRE) in children with cancer: the impact of rapid diagnostics and targeted colonization strategies on improving outcomes. Microorganisms. 2025;13:1627. https://doi.org/10.3390/microorganisms13071627
17. Mahony M, McMullan B, Brown J, Kennedy SE. Multidrug-resistant organisms in urinary tract infections in children.Pediatr Nephrol. 2020;35:1563-73. https://doi.org/10.1007/s00467-019-04316-5
18. Nguyen SN, Vu LT, Vu QV, Tran TT, Dinh VTT. Clinical epidemiology characteristics and etiology of febrile neutropenia in children: analysis of 421 cases. Hematol Rep. 2022;14:245-52. https://doi.org/10.3390/hematolrep14030034
19. Shankar K, Radhakrishnan V, Vijayakumar V, et al. Prevalence of multi-drug resistant organisms in stool of paediatric patients with acute leukaemia and correlation with blood culture positivity: a single institution experience. Pediatr Blood Cancer. 2018;65:10.1002/pbc.26740. https://doi.org/10.1002/pbc.26740
20. Gundluru SB, Roy PS, Biswal M, et al. Isolation of multidrug-resistant organisms in surveillance stool culture at diagnosis fails to predict mortality or subsequent sepsis due to multidrug-resistant organisms in children with acute leukemia: a single-center, prospective, observational study. Indian J Pediatr. 2025;92:295-8. https://doi.org/10.1007/s12098-023-04683-w