

EVALUATION OF ANTIBIOTIC SUSCEPTIBILITY PATTERNS AND PRESCRIPTION PRACTICES IN URINARY TRACT INFECTIONS FROM A RATIONAL DRUG USE PERSPECTIVE

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Akılci İlaç Kullanımı Perspektifinden İdrar Yolu Enfeksiyonlarında Antibiyotik Duyarlılık Profillerinin ve Reçete Uygulamalarının Değerlendirilmesi

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ABSTRACT

Objective: This study aimed to evaluate the distribution of uropathogens, their antibiotic susceptibility patterns, and the appropriateness of antibiotic prescriptions in hospitalized patients with urinary tract infections (UTIs) within the framework of rational drug use (RDU).

Material and Methods: This retrospective descriptive study included 1,097 inpatients diagnosed with UTIs at Yozgat City Hospital between January and December 2023. Microbiological culture results and antibiotic susceptibility profiles were analyzed. Additionally, prescriptions of 378 randomly selected patients were evaluated for compliance with antibiogram results. Statistical analyses were performed using SPSS 23.0.

Results: A total of 34 microorganisms were identified, with *Escherichia coli* (36.95%), *Klebsiella pneumoniae* (16.88%), and *Pseudomonas aeruginosa* (9.22%) being the most common. High resistance rates were observed for clindamycin (96.3%), cefoxitin (96.2%), and ampicillin (78.7%). Notably, resistance to commonly used broad-spectrum antibiotics such as ciprofloxacin and ceftriaxone was also high (56.8%). Amikacin (83.7%) and meropenem (62.6%) showed higher susceptibility. Among prescriptions, meropenem (22.8%) was the most frequently used antibiotic. Antibiogram compatibility was 65.2% for *E. coli* and 32.1% for other microorganisms.

Conclusion: A substantial proportion of empirical antibiotic treatments were not aligned with susceptibility results. These findings highlight the urgent need for integrating antibiogram data into clinical decision-making and strengthening antimicrobial stewardship programs to promote rational antibiotic use.

Keywords: Urinary Tract Infections; Antibiotic Resistance; Rational Drug Use; Antibiogram; Prescription Appropriateness

Öz

Amaç: Bu çalışma, rasyonel ilaç kullanımı (RDU) çerçevesinde, idrar yolu enfeksiyonu (İYE) tanısı konmuş yatan hastalarda idrar yolu patojenlerinin dağılımını, antibiyotik duyarlılık profillerini ve antibiyotik reçetelerinin uygunluğunu değerlendirmeyi amaçlamıştır.

Gereç ve Yöntemler: Bu retrospektif tanımlayıcı çalışmaya, Ocak-Aralık 2023 tarihleri arasında Yozgat Şehir Hastanesi'nde İYE tanısı konulan 1.097 yatan hastası dahil edilmiştir. Mikrobiyolojik kültür sonuçları ve antibiyotik duyarlılık profilleri analiz edilmiştir. Ayrıca, rastgele seçilen 378 hastanın reçeteleri, antibiyogram sonuçlarına uygunluk açısından değerlendirilmiştir. İstatistiksel analizler SPSS 23.0 kullanılarak yapılmıştır.

Bulgular: Toplam 34 mikroorganizma tanımlanmıştır; bunların en yaygın olanları *Escherichia coli* (%36,95), *Klebsiella pneumoniae* (%16,88) ve *Pseudomonas aeruginosa* (%9,22) idi. Klindamisin (%96,3), sefoksitin (%96,2) ve ampisilin (%78,7) için yüksek direnç oranları gözlemlendi. Özellikle, siprofloksasin ve seftriakson gibi yaygın olarak kullanılan geniş spektrumlu antibiyotiklere karşı direnç de yüksekti (%56,8). Amikasin (%83,7) ve meropenem (%62,6) daha yüksek duyarlılık gösterdi. Reçeteler arasında meropenem (%22,8) en sık kullanılan antibiyotikti. *E. coli* için %65,2, diğer mikroorganizmalar için %32,1 idi.

Sonuç: Ampirik antibiyotik tedavilerinin önemli bir kısmı duyarlılık sonuçlarıyla uyumlu değildi. Bu bulgular, antibiyogram verilerinin klinik karar verme sürecine entegre edilmesinin ve rasyonel antibiyotik kullanımını teşvik etmek için antimikrobiyal yönetim programlarının güçlendirilmesinin acil ihtiyacını vurgulamaktadır.

Anahtar Kelimeler: İdrar Yolu Enfeksiyonları; Antibiyotik Direnci; Akılci İlaç Kullanımı; Antibiyogram; Reçete Uygunluğu

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INTRODUCTION

Urinary tract infections (UTIs) are among the most frequently encountered bacterial infections worldwide, occurring in both community-acquired and hospital-acquired settings, and represent a significant public health concern (1,2). These infections, encountered at all levels of clinical practice, are more prevalent particularly among women, older adults, immunocompromised patients, and individuals undergoing invasive procedures such as catheterization (3,4). UTIs not only reduce individuals' quality of life but also lead to systemic problems such as loss of workforce productivity, increased healthcare expenditures, and difficulties in accessing treatment (5). The most common pathogen in the etiology of UTIs is *Escherichia coli* (*E. coli*), followed by microorganisms such as *Klebsiella pneumoniae*, *Proteus mirabilis*, *Enterococcus faecalis* and *Staphylococcus saprophyticus* (6). However, in recent years, the widespread, unnecessary and empirical use of antibiotics has led these pathogens to develop resistance to many agents, particularly broad-spectrum antibiotics (7). This situation reduces the effectiveness of treatment in both outpatients and inpatients, increases the risk of complications, and necessitates the use of more expensive or invasive treatment options (4,8). The World Health Organisation (WHO) has identified Rational Drug Use (RDU) as a global priority in the fight against antimicrobial resistance. The rational use of antibiotics means treatment with the right antibiotic, at the right time, in the right dose, and for the right duration. In this context, supporting empirical treatments with antibiotic susceptibility testing and developing individualised treatment plans based on resistance profiles not only enhances clinical success but also prevents the development of resistance. Antibiotic resistance leads not only to individual treatment failures but also to the spread of resistant strains within the general population and makes infections more deadly. For example, the increasing resistance to commonly used broad-spectrum agents such as ciprofloxacin, ceftriaxone and piperacillin/

tazobactam is leading to the earlier and more frequent use of 'last-resort' antibiotics such as carbapenems; this, in turn, contributes to the spread of carbapenem resistance and a gradual reduction in treatment options (9).

In this context, the aim of this study is to determine the antibiotic susceptibility profiles of microorganisms isolated from patients hospitalised at Yozgat City Hospital and diagnosed with UTI, and to assess the compliance of the antibiotics prescribed to these patients with the principles of RDU. It is anticipated that the data obtained will contribute to the identification of hospital-based resistance profiles, facilitate the review and updating of regional antibiotic usage policies, and enable the restructuring of empirical treatment protocols with a more rational approach. Furthermore, the study aims to guide clinicians in making evidence-based decisions regarding antibiotic selection; to lay the groundwork for future multicentre research; and to contribute to the creation of national antibiotic resistance maps.

MATERIAL AND METHODS

This study was approved by the Clinical Research Ethics Committee of Yozgat Bozok University on 9 May 2024 (ref. no: E-86495228-2024-05-50) and was conducted using a retrospective and descriptive research design. The study population consisted of patients who were hospitalized at Yozgat City Hospital between 1 January 2023 and 31 December 2023 and were clinically diagnosed with UTI and had positive urine culture results recorded in the hospital database.

Microbiological data from a total of 1,097 patients with documented microbial growth in urine cultures and available antibiotic susceptibility test results were included in the study. To evaluate the consistency between prescribed treatments and antibiogram results, prescription data from 378 patients were analyzed. These patients were selected using a simple random sampling method from the study population. Antibiotic prescriptions were considered appropriate if

the prescribed antibiotic was reported as “susceptible” according to the available antibiotic susceptibility test results in the hospital records.

All microbiological and prescription data were obtained retrospectively from the hospital information system. Due to the retrospective nature of the study, diagnostic and laboratory procedures were not standardized by the researchers but were based on routine clinical practice. Patient confidentiality was strictly maintained, and no identifiable personal data were recorded.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics version 23.0. Descriptive statistics, including frequency, percentage, and mean values, were used to summarize demographic characteristics, distribution of microorganisms, antibiotic resistance patterns,

ward distribution, and prescription data. Due to the descriptive nature of the study, no inferential statistical analysis was performed.

RESULTS

In this study, data from a total of 1,097 patients who were hospitalized at Yozgat City Hospital in 2023 and diagnosed with UTI were retrospectively analyzed. Of the patients, 51.05% were male and 48.95% were female. The age distribution showed that the majority of cases were concentrated in older age groups. Specifically, 43.03% of patients were aged 75 years and above, while 30.81% were between 61 and 75 years of age. In the pediatric population, the highest proportion was observed in the 0-5 years age group (7.11%). Detailed demographic characteristics are presented in Table 1.

Table 1. Demographic characteristics of patients with urinary tract infection (UTI) included in the study (n = 1,097)

		N	%
Gender	Male	560	51.05
	Female	537	48.95
	Total	1097	100
Age groups	0-5 years	78	7.11
	6-12 years	52	4.74
	19-25 years	8	0.73
	26-35 years	9	0.82
	36-45 years	20	1.82
	46-60 years	120	10.94
	61-75 years	338	30.81
	75+ years	472	43.03
	Total	1097	100

A total of 1,097 microorganisms were isolated from urine cultures, comprising 34 different species. *Escherichia coli* (36.95%) was the most frequently isolated pathogen, followed by *Klebsiella pneumoniae* (16.88%) and *Pseudomonas aeruginosa*

(9.22%). Among fungal pathogens, *Candida albicans* was identified in 8.58% of cases. Among Gram-positive bacteria, *Enterococcus faecalis* (5.93%) and *Enterococcus faecium* (4.74%) were the most

commonly detected species. A group of 22 other microorganisms each accounted for less than 1%, representing a combined proportion of 7.48%. The distribution of microorganisms is shown in Table 2.

Table 2. Distribution of microorganisms isolated from urine cultures of patients with urinary tract infection (n = 1,097)

Microorganism name	N	%
<i>Escherichia coli</i> (<i>E. coli</i>)	405	36.95
<i>Klebsiella pneumoniae</i> ssp. <i>Pneumoniae</i>	185	16.88
<i>Pseudomonas aeruginosa</i>	101	9.22
<i>Candida albicans</i>	94	8.58
<i>Enterococcus faecalis</i>	65	5.93
<i>Enterococcus faecium</i>	52	4.74
<i>Acinetobacter baumannii</i>	34	3.1
<i>Proteus mirabilis</i>	23	2.1
<i>Candida tropicalis</i>	17	1.55
<i>Enterobacter cloacae</i> complex	14	1.28
<i>Enterobacter aerogenes</i>	13	1.19
<i>Candida glabrata</i>	11	1
Others	82	7.48

Antibiotic susceptibility analysis demonstrated considerable variability among different agents. High resistance rates were observed for clindamycin (96.3%), ceftioxin (96.2%), and benzylpenicillin (90%). Ampicillin (78.7%) and cefuroxime (69.9%) also showed high resistance rates. Among commonly used broad-spectrum antibiotics, resistance rates were 56.8% for ciprofloxacin and 53.5% for piperacillin/tazobactam. In contrast, higher susceptibility rates were observed

for certain antibiotics. Amikacin showed the highest susceptibility rate (83.7%), followed by nitrofurantoin (63.4%) and meropenem (62.6%). For Gram-positive bacteria, high susceptibility rates were observed for linezolid (98.7%), vancomycin (95.1%), and teicoplanin (93.2%). Among antifungal agents, fluconazole (97.5%), voriconazole (97.6%), and micafungin (95.9%) demonstrated high effectiveness. Detailed antibiotic susceptibility profiles are presented in Table 3.

Table 3. Antibiotic susceptibility and resistance profiles of microorganisms isolated from urine cultures

Antibiotic/Agent	Resistance (%)	Intermediate susceptibility (%)	Susceptibility (%)
Clindamycin	96.3	-	3.7
Ceftioxin	96.2	-	3.8
Benzylpenicillin	90.0	-	10.0
Ampicillin	78.7	-	21.3
Cefuroxime	69.9	-	30.1

Table 3. Continued

Levofloxacin	58.1	12.9	29
Ciprofloxacin	56.8	16.7	26.5
Piperacillin/Tazobactam	53.5	14.1	32.4
Amoxicillin-clavulanic acid	64.4		35.6
Tetracycline	48.4	51.6	-
Ceftazidime	48.5	10.4	41.1
Trimethoprim / Sulfamethoxazole	40	17.7	42.3
Meropenem	32.9	4.5	62.6
Amikacin	15.7	0.6	83.7
Nitrofurantoin	36.6	-	63.4
Vancomycin	2.3	2.6	95.1
Teicoplanin	5.4	1.4	93.2
Linezolid	0.3	1.0	98.7
Tigecycline	2.9	1.2	95.9
Fluconazole	1.2	1.3	97.5
Voriconazole	1.0	1.4	97.6
Micafungin	2.1	2.0	95.9

Regarding ward distribution, 61.4% of patients (n=641) (6.7%). The distribution of patients by hospital units is were treated in intensive care units, followed by illustrated in Figure 1. medical wards (14.2%) and infectious diseases wards

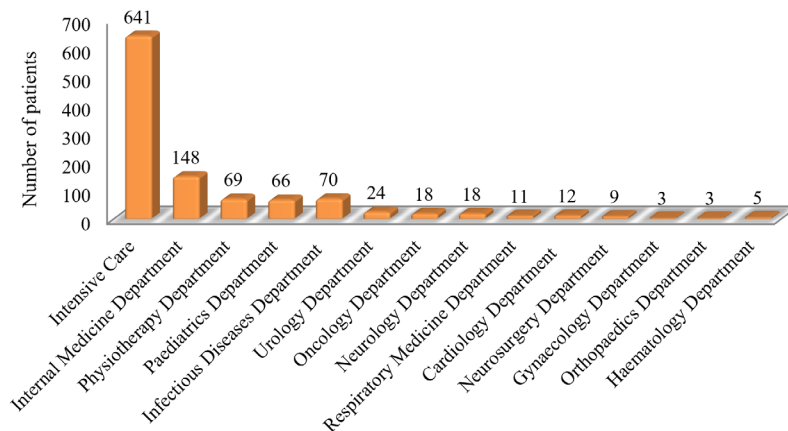


Figure 1. Distribution of patients with urinary tract infection by hospital units

Among the 378 prescriptions analyzed, meropenem (22.8%), ceftriaxone (19.3%), and piperacillin/tazobactam (16.1%) were the most frequently prescribed antibiotics. Other broad-spectrum

antibiotics, including ciprofloxacin, cefepime, and ampicillin/sulbactam, were also used at varying rates. The distribution of prescribed antibiotics is shown in Figure 2.

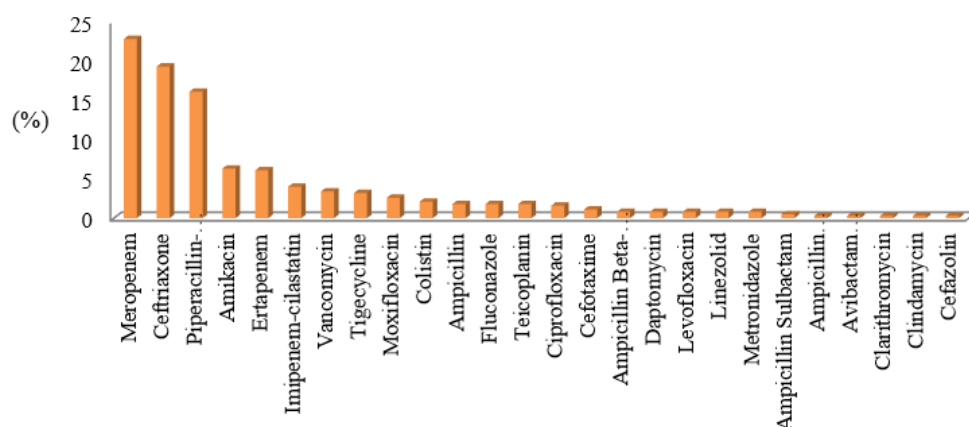


Figure 2. Distribution of antibiotics prescribed for the treatment of urinary tract infection (n = 378)

Evaluation of prescription appropriateness based on antibiotic susceptibility results showed that 65.2% of prescriptions for *Escherichia coli* isolates were compatible with antibiogram findings. In contrast,

this rate was 32.1% for other microorganisms. The distribution of prescription appropriateness is presented in Figure 3.

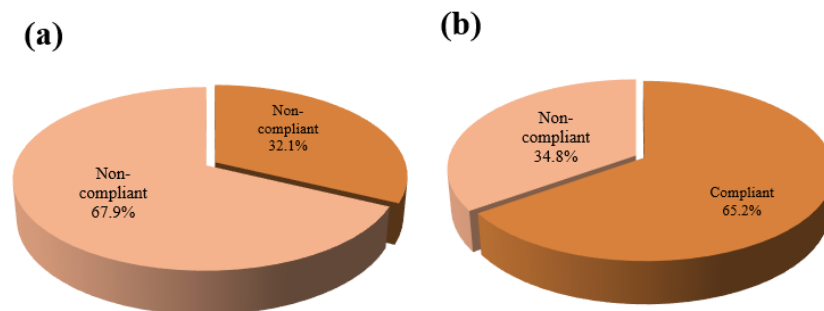


Figure 3. (a) The extent to which drugs prescribed for the treatment of different microbial strains other than *E. coli* are consistent with the results of antibiotic susceptibility testing; (b) The extent to which drugs prescribed for the treatment of *E. coli* strains are consistent with the results of antibiotic susceptibility testing

DISCUSSION

UTIs remain a leading cause of morbidity in both community and hospital settings and constitute one of the most frequent indications for antibiotic prescriptions worldwide (10). The escalating antimicrobial resistance among uropathogens represents a major clinical challenge, complicating empirical therapy and increasing the risk of therapeutic failure (11). In this context, systematic monitoring of local resistance trends and critical evaluation of prescribing practices are indispensable for implementing effective antimicrobial stewardship programs, which are essential components of RDU. The present retrospective study analyzed microbiological culture results, resistance profiles, and prescription data of 1,097 inpatients diagnosed with UTIs at Yozgat City Hospital, providing a comprehensive overview of pathogen distribution, resistance patterns, and treatment appropriateness, while also evaluating the findings in the context of RDU.

Our analysis revealed a nearly equal gender distribution, with 51.05% of patients being male and 48.95% female. This diverges from widely reported data indicating higher UTI prevalence in women (12,13). For example, Davoudi-Kiakalayeh et al. (2017) reported 65.37% of UTI cases occurring in women (14). The higher proportion of male inpatients in our study likely reflects the inpatient-only cohort, the predominance of men in intensive care units, and the increased incidence of prostate hypertrophy and catheterization among males. This finding underscores the need to consider patient population characteristics when interpreting epidemiological data and tailoring infection control strategies.

Age-stratified analysis indicated that 73.8% of patients were aged ≥ 61 years. This aligns with established evidence linking advanced age to immunosenescence, a higher burden of comorbidities, and increased exposure to invasive procedures, all of which predispose older adults to UTIs (15). In pediatric

patients, the 0-5-year age group accounted for 7.11% of cases, highlighting the clinical significance of UTIs in early childhood. Factors such as anatomical differences, immature immune defenses, and suboptimal hygiene practices contribute to increased susceptibility in this population (16,17). Collectively, these findings emphasize that both pediatric and geriatric populations constitute high-risk groups requiring vigilant monitoring and early intervention.

Analysis of healthcare-associated infections (HAIs) revealed that 61.4% of UTIs occurred in intensive care units (ICUs), consistent with prior reports identifying ICUs as high-risk environments due to frequent use of invasive devices, poor hand hygiene, prolonged hospitalization, malnutrition, and broad-spectrum antibiotic exposure (18). Our findings highlight the critical need for stringent infection control measures and judicious antibiotic use in ICUs. Empirical therapy initiated without susceptibility data may accelerate resistance development, reinforcing the importance of integrating rapid diagnostic testing into treatment protocols.

Microbiological profiling revealed that *Escherichia coli* (36.95%) was the predominant pathogen, followed by *Klebsiella pneumoniae* (16.88%) and *Pseudomonas aeruginosa* (9.22%), in line with both community- and hospital-acquired UTI literature (19,20). Notably, *Candida* species accounted for 11.4% of isolates, underscoring the significance of fungal pathogens in hospitalized and critically ill patients. Given the prevalence of non-albicans *Candida* strains and their propensity for antifungal resistance, early recognition and management of fungal UTIs are essential to prevent treatment failure (21-23).

Resistance profiling revealed alarming rates for commonly prescribed antibiotics, including clindamycin (96.3%), cefoxitin (96.2%), benzylpenicillin (90%), and ampicillin (78.7%). These findings underscore the urgent need to revise empirical treatment algorithms based on contemporary resistance patterns rather

than relying solely on clinical intuition. Olcay et al. (2025) similarly reported high resistance in *E. coli* strains from community-acquired UTIs, reinforcing the necessity for evidence-based empirical therapy (24). In contrast, agents such as meropenem (62.6% susceptibility), amikacin (83.7%), nitrofurantoin (63.4%), linezolid (98.7%), and vancomycin (95.1%) demonstrated substantial efficacy, consistent with Keskin et al. (2021) and Mareş et al. (2024), highlighting their continued clinical utility (25,26). Comparisons with previous studies reveal a notable divergence in resistance rates: Mareş et al. (2024) reported resistance of *E. coli* to amoxicillin-clavulanic acid, trimethoprim-sulfamethoxazole, and levofloxacin at 33.1%, 32.41%, and 32.06%, respectively, whereas our inpatient cohort exhibited higher rates of 64.4%, 40%, and 58.1% (26). This discrepancy likely reflects the higher prevalence of multidrug-resistant strains in hospitalized patients and emphasizes the necessity of continuous local surveillance to guide empiric therapy and inform antibiotic stewardship programs.

Prescription analysis revealed that the most commonly used antibiotics were meropenem (22.8%), ceftriaxone (19.3%), and piperacillin/tazobactam (16.1%). However, resistance rates for these agents were 32.9%, 56.8%, and 53.5%, respectively, suggesting a decline in the efficacy of frequently used antibiotics and a potential contribution to the propagation of antimicrobial resistance. Previous studies have similarly highlighted rising resistance rates among common UTI pathogens, underscoring the importance of tailoring empirical therapy to local susceptibility patterns (27,28).

When the appropriateness of antibiotic prescriptions was compared to susceptibility results, 65.2% of *E. coli* isolates and only 32.11% of other microorganisms were treated appropriately. This discrepancy indicates that microbiological data are not consistently integrated into empirical treatment decisions, representing a critical gap in RDU practices. Inappropriate prescribing practices contribute to resistance development and reduced treatment efficacy, particularly in hospital-acquired UTIs (27,29,30). Ultimately, a substantial

proportion of empirical antibiotic treatments were not aligned with susceptibility results. These findings highlight the urgent need for integrating antibiogram data into clinical decision-making and strengthening antimicrobial stewardship programs to promote rational antibiotic use.

Study Limitations

The primary limitation of this study is its single-center design, which restricts generalizability to other geographical regions. Nevertheless, the findings provide valuable insights into local resistance patterns and can inform the development of region-specific clinical guidelines, thereby contributing significantly to the rational use of antibiotics and supporting the development of targeted antimicrobial stewardship strategies.

Future perspectives: Further prospective and multicenter studies incorporating standardized diagnostic criteria and advanced statistical analyses are needed to validate these findings, optimize empirical therapy, and support the development of evidence-based treatment guidelines that promote rational drug use.

CONCLUSION

In light of these findings, the critical importance of prudent antibiotic use in the management of UTIs is underscored. Empirical treatment protocols should be guided not only by clinical experience but also by current microbiological data and regional resistance patterns to enhance therapeutic efficacy and mitigate the development of antimicrobial resistance. Prioritizing low-resistance agents, reserving broad-spectrum antibiotics for cases with clear indications, and adhering to evidence-based clinical guidelines are essential strategies to improve treatment outcomes. Furthermore, reinforcing resistance surveillance programs at both local and national levels, providing continuous education for clinicians, and integrating laboratory-based recommendations into empirical

therapy are recommended as key measures to promote rational antibiotic use. These strategies, combined with the adoption of standardized diagnostic criteria in future prospective and multicenter studies, will support the development of robust, evidence-based treatment guidelines and contribute to a sustainable approach in combating antimicrobial resistance.

Use of Artificial Intelligence: This paper was prepared without the use of artificial intelligence (AI) tools.

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Conflict of Interest: The authors declare no conflicts of interest related to this study.

Ethical Approval: This study was approved by the Clinical Research Ethics Committee of Yozgat Bozok University on 9 May 2024 (ref. no: E-86495228-2024-05-50).

Author Contributions

Protocol/project development: SŞ, TK, MŞ

Data collection and management: SŞ, TK, MŞ

Data analysis: SŞ, TK, MŞ

Manuscript writing/editing: SŞ, TK, MŞ

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