



## Research Article

# Antibiotic Resistance of *Escherichia coli* in Pediatric Urinary Tract Infections: A Literature Review

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## Abstract

Antimicrobial resistance represents one of the most serious global public health threats, and in pediatric care, it poses a growing challenge in the treatment of urinary tract infections (UTIs), where *Escherichia coli* is the most frequently identified pathogen. This literature review aimed to analyze recent scientific evidence on the antibiotic resistance patterns of *E. coli* in pediatric UTIs, in order to identify trends that may guide clinical practice and prevention strategies. A structured bibliographic search was conducted in three databases—PubMed, SciELO, and Google Scholar—covering the period between 2019 and 2024. A total of 23 studies were selected, including original articles and narrative reviews, that met the following inclusion criteria: population under 18 years of age, microbiologically confirmed diagnosis, and full-text availability. The reviewed literature revealed a high prevalence of resistance to commonly used antibiotics in clinical practice, such as ampicillin and trimethoprim-sulfamethoxazole, with significant geographic variation. In contrast, carbapenems such as meropenem and imipenem exhibited low resistance rates, positioning them as effective therapeutic options for complicated clinical cases. Moreover, multidrug-resistant strains were reported in several countries, increasing the complexity of empirical treatment approaches. These findings underscore the urgent need to strengthen microbiological surveillance systems, regularly update pediatric clinical guidelines, and promote the rational use of antimicrobials. The review also highlights the importance of generating local evidence in Latin America, given the limited number of regional studies, to better inform empirical therapy and improve clinical outcomes in pediatric populations affected by urinary tract infections caused by antibiotic-resistant *Escherichia coli*.

## Keywords

Antibiotic Resistance, Urinary Tract Infection, Pediatrics, *Escherichia coli*

## 1. Introduction

Urinary tract infections (UTIs) are among the most common bacterial diseases in the pediatric population and represent a significant cause of medical consultation and hospitalization. It is estimated that between 8% and 10% of girls and

between 2% and 3% of boys will experience at least one episode of symptomatic UTI before the age of seven [1]. Most of these infections are caused by Gram-negative bacteria, with *Escherichia coli* being the primary etiological agent, identified

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in more than 80% of cases [2].

In recent decades, the effectiveness of conventional antimicrobial treatments has been compromised due to the progressive increase in resistant bacterial strains. This situation has substantially altered the therapeutic approach to UTIs, requiring a more rational antibiotic selection based on local susceptibility profiles. Several factors have contributed to this issue, including the indiscriminate use of antibiotics, self-medication, limited access to microbiological testing, and inadequate epidemiological surveillance, particularly in developing countries [3].

The mechanism by which uropathogenic microorganisms infect the urinary tract varies according to the age of the pediatric patient. In neonates, the hematogenous route is more common, making early diagnosis more challenging and increasing the risk of systemic complications. In contrast, in older children, the ascending route is the most common. In this case, bacteria, equipped with fimbriae, adhere to the urinary epithelium, facilitating colonization and the development of infection. The child's age, the mechanism of infection, and the presence of bacterial virulence factors significantly influence the clinical presentation and prognosis of urinary tract infections [4].

Bacterial resistance to beta-lactams can arise through various mechanisms, including the production of efflux pumps, modification or decreased expression of porins, alterations in penicillin-binding proteins, and the production of beta-lactamases—enzymes capable of inactivating the antibiotic. Horizontal gene transfer has played a fundamental role in the dissemination of resistance, particularly through mobile genetic elements, facilitating the emergence of multidrug-resistant bacterial strains, such as those producing extended-spectrum beta-lactamases or carbapenemases [5].

Long-term antibiotic prophylaxis has been a common approach for preventing recurrent urinary tract infections in children. However, despite this practice, its ability to prevent long-term renal complications has not been demonstrated [6]. Moreover, its prolonged use is not only ineffective but also entails considerable risks, such as the development of bacterial resistance.

The timely initiation of appropriate antibiotic therapy is essential to improve the prognosis of infections caused by multidrug-resistant bacteria, as delays in treatment may worsen the patient's condition [7, 8]. The selection of empirical antibiotics should be guided by local guidelines, as antimicrobial

susceptibility patterns vary significantly across regions [9].

In this context, understanding current antibiotic resistance patterns of *Escherichia coli* in pediatric urinary tract infections is a priority, given its high prevalence and potential clinical impact. The present study aims to analyze the most recent scientific evidence published between 2019 and 2024 in order to identify relevant trends that may guide empirical management and contribute to the development of more effective prevention and control strategies.

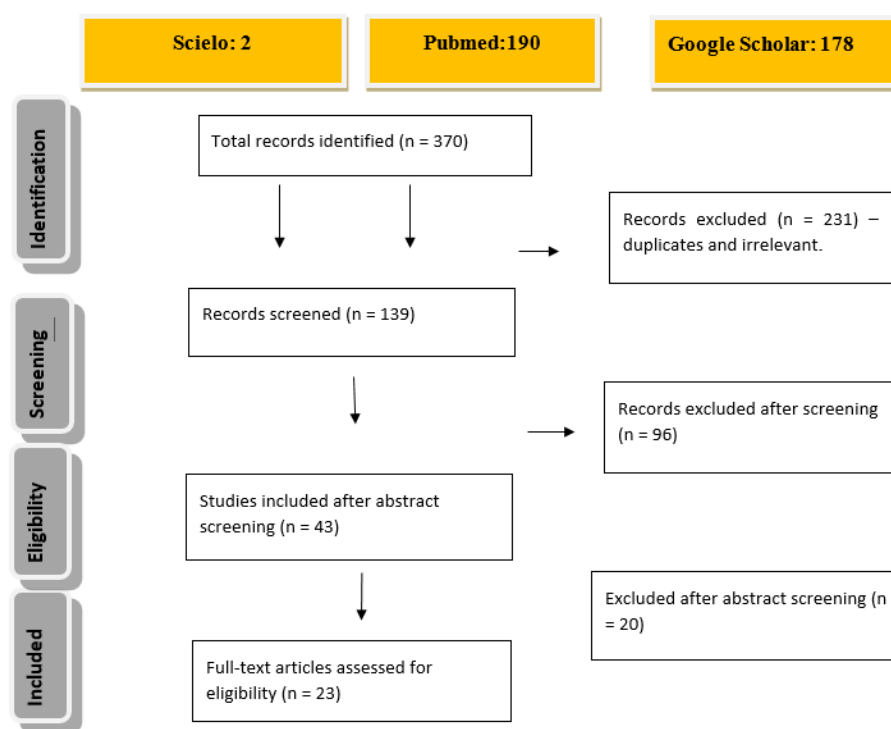
In Latin America, particularly in Nicaragua, the scarcity of updated local studies limits healthcare professionals' ability to make evidence-based decisions grounded in contextual data. Therefore, this review seeks to provide region-specific epidemiological information to support the adaptation of therapeutic guidelines to the microbiological and resistance patterns of each setting.

## 2. Materials and Methods

This study was conducted with the aim of synthesizing recent scientific evidence on antimicrobial resistance of *Escherichia coli* in urinary tract infections in the pediatric population. To ensure rigor and transparency in the process, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines were used as a reference, providing a structured framework for the identification, selection, and analysis of scientific studies.

The search was carried out in three recognized databases: PubMed, SciELO, and Google Scholar, selected for their relevance in the biomedical field and their access to up-to-date scientific literature. Original articles, systematic reviews, and meta-analyses published between 2019 and 2024 were included, in English or Spanish, available in full text, and addressing urinary tract infections confirmed to be caused by *Escherichia coli* in patients under 18 years of age. Duplicate articles, studies conducted in adult populations, unrelated publications, those with low methodological quality, and undergraduate theses were excluded.

To define the search strategy, MeSH terms such as “Urinary Tract Infections,” “*Escherichia coli*,” “Drug Resistance, Bacterial,” and “Pediatrics” were used, combined with free-text terms such as “antibiotic susceptibility,” “pediatric UTI,” and “uropathogens in children.” Boolean operators AND and OR were applied to optimize the precision and scope of the results.



Source: Authors' own elaboration.

**Figure 1.** PRISMA flow diagram for a literature review on antimicrobial resistance of *Escherichia coli* in urinary tract infections in pediatric patients.

### 3. Results and Discussion

Through the literature review, a total of 22 publications on bacterial resistance of *Escherichia coli* in urinary tract infections in pediatric patients were included.

**Table 1.** Studies on antibiotic resistance of *Escherichia coli* in pediatric urinary tract infections (2019-2024).

| Author and Year              | Country     | Title                                                                                                                                                                           | Sample                                             | Summary of findings                                                                                                                                                                                                                                                                                                                                       |
|------------------------------|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| K. Vazouras et al. 2019 [10] | Greece      | "Antibiotic treatment and antimicrobial resistance in children with urinary tract infections".                                                                                  | 230 patients under 17 years hospitalized with UTI. | <i>E. coli</i> showed high resistance to: Ampicillin 42%, Trimethoprim-sulfamethoxazole 26.5%, Ampicillin/sulbactam 19.3%, Cephalothin (2nd gen) 28.8%, Piperacillin/tazobactam 12.1%                                                                                                                                                                     |
| Suh et al (2019) [11]        | South Korea | "Febrile urinary tract infection in children: changes in epidemiology, etiology, and antibiotic resistance patterns over a decade".                                             | 359 children under 19 years with febrile UTI.      | High resistance rates were observed for penicillins, cephalosporins, and ciprofloxacin. Piperacillin-tazobactam remains effective. Higher recurrence in vesicoureteral reflux                                                                                                                                                                             |
| Lu Keshi et al (2019) [12]   | China       | "Analysis of drug resistance of extended-spectrum beta-lactamases-producing <i>Escherichia coli</i> and <i>Klebsiella pneumoniae</i> in children with urinary tract infection". | 698 children with positive urine cultures          | Resistance exceeding 98% was observed for first- to third-generation cephalosporins and aztreonam. In contrast, carbapenems such as meropenem and imipenem showed resistance rates ranging from 0.24% to 5.45%, making them the most effective antibiotics for treating infections caused by extended-spectrum beta-lactamase (ESBL)-producing organisms. |

| Author and Year                                                                                                          | Country      | Title                                                                                                                                             | Sample                                                                                                                 | Summary of findings                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|--------------------------------------------------------------------------------------------------------------------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Vázquez-Pérez Alvaro, Alonso-Acero Laura, Fernando Baquero-Artigao, Manuela de Pablos Gómez y Cristina Calvo (2021) [13] | Spain        | Community-acquired UTI: etiology, resistance, and patient profile in a tertiary care hospital                                                     | A sample of 169 unique patients at La Paz Hospital.                                                                    | Caution is recommended in the use of cephalosporins, and combinations with $\beta$ -lactamase inhibitors should be considered for appropriate treatment.<br><br>Sensitivity to amoxicillin-clavulanate was high in children without uropathy (87%) but lower in patients with uropathy (64.2%). Therefore, amoxicillin-clavulanate was recommended for patients without uropathy, while combination therapy (amoxicillin-clavulanate plus gentamicin or amikacin) was suggested for those with uropathy. |
| Escandell Rico Francisco Miguel & Pérez Fernández Lucia (2022) [1]                                                       | Spain        | Urinary tract infections: etiology and antimicrobial susceptibility                                                                               | 388 uropathogens.                                                                                                      | This study shows that fosfomycin and amoxicillin-clavulanate generally effective. However, fosfomycin is recommended as the preferred option due to its advantages in dosing, side-effect profile, and clinical outcomes.                                                                                                                                                                                                                                                                                |
| Mendieta-Tello et al. (2023) [2]                                                                                         | Ecuador      | Retrospective analysis of microbiological profile and antimicrobial resistance in pediatric urinary tract infections in public hospitals in Quito | 445 urine cultures from patients aged 1 month to 15 years, collected from three public hospitals in the city of Quito. | Resistance was primarily observed to ampicillin, amoxicillin, ampicillin-sulbactam, trimethoprim-sulfamethoxazole, and first- through fourth-generation cephalosporins.                                                                                                                                                                                                                                                                                                                                  |
| Samanci S y Pinarbaş (2023) [14]                                                                                         | Turkey       | Microbial etiology and antibiotic resistance in urinary tract infections in children; view from an area where antibiotics are overused".          | 4,064 positive urine cultures from children under 18 years of age in a hospital.                                       | Common resistance patterns were observed for ampicillin (69.8%), amoxicillin-clavulanate (59.7%), and cefixime (51.3%), while sensitivity was noted to amikacin, meropenem, nitrofurantoin, and ciprofloxacin.                                                                                                                                                                                                                                                                                           |
| Heshmat H, Meheissen M, Farid A y Hamza E (2023) [15]                                                                    | Egypt        | "Bacteremia and antimicrobial resistance pattern of uropathogens causing febrile urinary tract infection in a Pediatric University Hospital".     | 103 patients with microbiologically confirmed UTIs in Alexandria.                                                      | Higher resistance was identified to ampicillin (75%), cefuroxime and cefotaxime (62.7%), ciprofloxacin (60.8%), and ceftazidime (58.8%). Greater susceptibility was observed to fosfomycin, levofloxacin, meropenem, and tetracycline.                                                                                                                                                                                                                                                                   |
| Alsubaie et al. (2023) [16]                                                                                              | Saudi Arabia | "Antibiotic resistance patterns of pediatric community-acquired urinary tract infections in a tertiary care center in Jeddah".                    | Pediatric patients aged 0 to 14 years with 510 culture-confirmed UTIs were included.                                   | Resistance was observed to ampicillin (71.2%), cefazolin (56.5%), co-trimoxazole (52.5%), cefuroxime (37.8%), ceftriaxone (34.5%), ciprofloxacin (35.3%), and amoxicillin-clavulanate (30.9%), while amikacin (0.4%) and imipenem (0%) showed very low resistance rates.                                                                                                                                                                                                                                 |
| Fakhri-Demeshghieh et al. (2024) [17]                                                                                    | Iran         | "Antibiotic Resistance of Uropathogenic Escherichia coli (UPEC) among Iranian Pediatrics: A Systematic Review and Meta-Analysis".                 | Meta-analysis including 19 studies on antibiotic resistance of Escherichia coli.                                       | The highest prevalence of antibiotic resistance was observed for doxycycline (59%), followed by ticarcillin-clavulanate (57%), cefazolin (54%), cefuroxime (53%), and amoxicillin-clavulanate (52%). In contrast, the lowest resistance rates were found for colistin (0%), meropenem (1%), and imipenem (2%), suggesting that these antibiotics may represent more effective treatment options for E. coli urinary tract infections in Iranian children.                                                |
| Zhang K, Xiang C, Zhang Y, Chao M                                                                                        | China        | "A retrospective study of uropathogen and its                                                                                                     | 458 patients with positive cultures.                                                                                   | High resistance was observed to ampicillin (93.39%), cefazolin (76.03%), ceftriaxone                                                                                                                                                                                                                                                                                                                                                                                                                     |

| Author and Year                                                                                                                             | Country  | Title                                                                                                                                                                                           | Sample                                                                                              | Summary of findings                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------------------------------------------------------------------------------------------------------------------------------------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (2024) [18]                                                                                                                                 |          | antibiotic resistance among children with urinary tract infection from a single center in China".                                                                                               |                                                                                                     | (73.55%), trimethoprim-sulfamethoxazole (63.64%), and aztreonam (64.46%). However, high susceptibility was noted to amikacin, ertapenem, nitrofurantoin, and imipenem. Multidrug resistance (MDR) was reported in 80.44% of complicated UTIs and 77.05% of uncomplicated cases.                                                                                                                                                                                                                                                                                                |
| Abdikarin Ahmed Mohamed, Yavuz Bastug, Cem Senol, Mohamed Muktar Kassim, Abdissalam Abdullahi Yusuf & Abdikarim Hussein Mohamed (2024) [19] | Somalia  | "Antimicrobial resistance pattern and uropathogens distribution in children visiting a referral hospital in Mogadishu. Somalia".                                                                | 840 urine cultures, of which 148 were positive for <i>Escherichia coli</i> .                        | Most cephalosporins showed high resistance rates (83%) against the pathogens, as did trimethoprim-sulfamethoxazole (79.7%). Carbapenem resistance ranged from 6.8% to 14.6%, and an alarmingly high prevalence of multidrug-resistant (MDR) uropathogens (27%) was observed.                                                                                                                                                                                                                                                                                                   |
| Roza E et al (2024) [20]                                                                                                                    | Tanzania | "Bacterial aetiology, antimicrobial susceptibility patterns, and factors associated with urinary tract infection among under-five children at primary health facility, North-Western Tanzania". | 106 urine cultures from febrile children under five years of age                                    | The study reported higher resistance to ampicillin (81.1%), gentamicin (32.4%), and trimethoprim-sulfamethoxazole (37.8%), and greater susceptibility to cefepime (97.3%), piperacillin-tazobactam (95.5%), nitrofurantoin (96.2%), and meropenem (100% in some strains). Multidrug resistance (MDR) was identified in 33.0% of isolates, predominantly <i>S. aureus</i> (31.4%), <i>E. coli</i> (20.0%), and <i>Klebsiella</i> spp. (20.0%). Additionally, the combination of ampicillin, gentamicin, and trimethoprim-sulfamethoxazole showed a high MDR rate exceeding 50%. |
| He, Xin-Tian et al (2024) [21]                                                                                                              | China    | "The risk factors, antimicrobial resistance patterns, and outcomes associated with extended-spectrum $\beta$ -lactamases-Producing pathogens in pediatric urinary tract infection".             | 288 positive cultures for <i>E. coli</i> in children under 18 years of age in a hospital in Taiwan. | Analyses revealed high resistance to ampicillin (67.6%-85.5%). A significant increase in resistance to gentamicin, ciprofloxacin, cefazolin, and third-generation cephalosporins was observed during the study period. In contrast, resistance to amikacin was minimal, and no resistance to imipenem was detected.                                                                                                                                                                                                                                                            |
| Oliva FA (2024) [22]                                                                                                                        | Cuba     | Bacterial resistance and detection of $\beta$ -lactamases in hospitalized children with urinary tract infections                                                                                | 342 urine cultures, of which 260 were positive for <i>E. coli</i> , in a hospital in Cuba.          | The study showed resistance to aminopenicillins and third-generation cephalosporins (34.2%), and susceptibility to carbapenems, aminoglycosides, and fosfomycin.                                                                                                                                                                                                                                                                                                                                                                                                               |

Source: Authors' own elaboration.

The main findings of this literature review reveal consistent patterns of antimicrobial resistance of *Escherichia coli* in pediatric urinary tract infections. Although resistance rates vary across regions, most studies agree on an alarming decline in the effectiveness of commonly used antibiotics for empirical treatment, such as ampicillin, amoxicillin-clavulanate, and trimethoprim-sulfamethoxazole. This situation compromises the safety of initial management, particularly in settings with limited access to microbiological testing.

Several studies conducted in Asia, Africa, and Latin America report concerning levels of resistance to cephalosporins of

different generations, suggesting possible overuse of this antibiotic group and the emergence of extended-spectrum beta-lactamase (ESBL)-producing strains. In regions such as China, Iran, and Somalia, particularly high resistance rates to third-generation cephalosporins and aztreonam have been identified, reinforcing the need to limit their empirical use.

In contrast, antibiotics such as meropenem, imipenem, amikacin, fosfomycin, and nitrofurantoin maintain high susceptibility profiles in most of the studies reviewed. Their effectiveness against multidrug-resistant strains positions them as key therapeutic options for managing complicated cases. However,

their use should be reserved for justified situations, as the selective pressure induced by their indiscriminate use may reduce their effectiveness in the short term.

The detection of multidrug-resistant (MDR) strains in several countries adds another layer of complexity to the treatment of these infections. Studies from China, Turkey, and Tanzania report MDR rates exceeding 70% in patients with complicated UTIs, highlighting a growing and concerning trend. This situation is associated with an increased risk of complications, prolonged hospital stays, and higher healthcare costs.

Finally, this review highlights the limited availability of recent studies in Latin America. This lack of local data hinders the development of clinical guidelines adapted to real resistance patterns and exposes pediatric patients to less effective empirical treatments. Therefore, this study not only systematizes international evidence but also underscores the urgent need to generate local epidemiological data to improve clinical decision-making and strengthen therapeutic safety in the region.

This review has several limitations. The included studies showed heterogeneity in methodology, sample size, and antimicrobial susceptibility testing, which may affect direct comparisons among regions. In addition, publication bias may have influenced the availability of reported resistance patterns. Another limitation is the limited number of studies from Latin America, particularly Nicaragua, restricting regional representativeness of the findings.

In Nicaragua and other Latin American countries, strengthening microbiological surveillance systems and promoting antimicrobial stewardship programs are essential to improve empirical treatment strategies in pediatric urinary tract infections. Updating local clinical guidelines based on regional resistance patterns may contribute to better therapeutic outcomes and help reduce the spread of multidrug-resistant strains.

## 4. Conclusions

This review demonstrates that *Escherichia coli* exhibits significant resistance to antibiotics commonly used in pediatric urinary tract infections, compromising the effectiveness of standard empirical treatment.

The findings support the need to revise current therapeutic regimens and limit the empirical use of antimicrobials without microbiological support. Given the limited regional data available in pediatric populations, it is essential to promote local studies that guide clinical decisions based on real and updated evidence. Strengthening pediatric microbiological surveillance and promoting the rational use of antibiotics are urgent actions to contain the spread of multidrug-resistant strains and improve clinical outcomes in childhood.

## Abbreviations

UTI      Urinary Tract Infection

MDR      Multidrug Resistance  
ESBL      Extended-Spectrum Beta-Lactamase  
PRISMA   Preferred Reporting Items for Systematic  
              Reviews and Meta-Analyses  
UPEC      Uropathogenic *Escherichia coli*

## Author Contributions

**Samantha Lucia Sandigo Rosales:** Conceptualization, Formal Analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing

**Sheila Karina Valdivia Quiroz:** Supervision, Validation, Writing – review & editing

**Francisco Jose Mayorga Marin:** Methodology, Resources, Supervision, Validation

## Conflicts of Interest

The authors declare no conflicts of interest.

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