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Prevalence and Antimicrobial Resistance Patterns of *Escherichia Coli* in Pediatric Urinary Tract Infections in Karbala, Iraq: A Four-Year Retrospective Study

Hussein Abd Ali Mohammed Sadeq Al Her[1]*, Ekhlas Abdulameer Hameed Alazzawi[1], Muntdhar Mohammed Cani[1]

[1]Department of Clinical Laboratory Science, College of Pharmacy, Kerbala university, Karbala, Iraq

***Corresponding Author**

***Hussein Abd Ali Mohammed Sadeq Al Her:** hussein.abdali@uokerbala.edu.iq

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Abstract

One of the primary microorganisms responsible for urinary tract infections (UTIs) is Uropathogenic *Escherichia coli* (UPEC). Recent years have shown an increase in the prevalence of multidrug-resistant bacteria and UPEC with high antibiotic resistance, which could make treatment more challenging. The study intended to determine the prevalence and antibiotic resistance pattern of E. coli from suspected pediatric urinary tract infections in Karbela, Iraq. A retrospective cross-sectional study was conducted at Department of Microbiology Laboratory at Karbala Teaching Hospital for Children, Iraq, from August 2023 to February 2024.Data for antimicrobial susceptibility test results collect from 409 pediatric patients among 2020 to 2023. Data were analyzed using excel software. The result show females had a higher prevalence of UTIs compared to males across all study years. The prevalence of UPEC isolates varied seasonally, with peaks occurring in different months for different years. Overall, resistance rates to many antibiotics were high, particularly Nalidixic acid, Ciprofloxacin, Levofloxacin, and Ceftriaxone. While some antibiotics showed slight variations in resistance between males and females. Amikacin and Nitrofurantoin demonstrated higher effectiveness against UPEC. The proportion of UPEC isolates varied by age group, with the 1–5-year age group showing the highest prevalence. The present study concluded high prevalence of UPEC with Multidrug-resistant (MDR) isolated from urinary tract infection in Karbala city, Iraq.

أنماط انتشار ومقاومة مضادات الميكروبات لبكتيريا الإشريكية القولونية في التهابات المسالك البولية عند الأطفال في كربلاء، العراق: دراسة استرجاعية لمدة أربع سنوات.

حسين عبد علي محمد صادق، اخلاص عبد الأمير حميد، منتظر محمد كاني

الخلاصة

أحد الكائنات الحية الدقيقة الأساسية المسؤولة عن التهابات المسالك البولية هي الإشريشية القولونية المسببة للأخماج البولية .أظهرت السنوات الأخيرة زيادة في انتشار سلالات البكتيريا المقاومة للمضادات المتعددة و UPEC مع مقاومة عالية للمضادات الحيوية، مما قد يجعل العلاج أكثر صعوبة. تهدف الدراسة إلى تحديد انتشار ونمط مقاومة المضادات الحيوية للإشريشية القولونية من التهابات المسالك البولية المشتبه بها عند الأطفال في كربلاء بالعراق. أجريت دراسة مقطعية بأثر رجعي في مختبر الأحياء المجهرية / مستشفى كربلاء التعليمي للأطفال بالعراق، من أغسطس 2023 إلى فبراير 2024. تم جمع بيانات نتائج اختبار حساسية مضادات الميكروبات من 409 مريض أطفال بين عامي 2020 و2023. تم تحليل البيانات باستخدام برنامجExcel . تظهر النتيجة أن الإناث لديهن انتشار أعلى لالتهابات المسالك البولية مقارنة بالذكور في جميع سنوات الدراسة. تباين انتشار عزلات UPEC موسميًا، مع حدوث الذروة في أشهر مختلفة لسنوات مختلفة. بشكل عام، كانت معدلات المقاومة للعديد من المضادات الحيوية مرتفعة، وخاصة حمض الناليديكسيك، والسيبروفلوكساسين، والليفوفلوكساسين، والسيفترياكسون. في حين أظهرت بعض المضادات الحيوية اختلافات طفيفة في المقاومة بين الذكور والإناث. أظهر أميكاسين ونتروفورانتوين فعالية أعلى ضد UPEC تباينت نسبة عزلات UPEC حسب الفئة العمرية، حيث أظهرت الفئة العمرية من 1 إلى 5 سنوات أعلى معدل انتشار. وخلصت الدراسة الحالية إلى ارتفاع معدل انتشار UPEC مع البكتيريا المقاومة للأدوية المتعددة (MDR) المعزولة من عدوى المسالك البولية في مدينة كربلاء بالعراق.

1. Introduction

Children frequently experience urinary tract infections (UTIs). Up to 7% of children will have had a UTI by when they are 19 years old (Delbet *et al.*, 2017). UTI prevalence may be influenced by a variety of variables, including age, sexes, immunosuppression, and urological equipment (Iqbal *et al*., 2010). Pediatric UTI in many instances, remain under-diagnosed because of the absence of specific symptoms and signs, particularly in infants and young children (Desai *et al*., 2016). The various regions and populations studied showed significant differences in the epidemiology, species distribution, and susceptibility patterns of uropathogen) Behzadi *et al*., 2021 (. *Escherichia coli* is the primary cause behind UTIs, and the patient's own feces serve as a reservoir for the pathogen (Nielsen *et al*., 2014).Numerous virulence factors, particularly those related to long-term survival in the urinary tract, are carried by Uropathogenic Escherichia coli (UPEC). However, little research has been done on their frequency or function among UPEC that causes pediatric UTIs (Ramos *et al*., 2011). Antimicrobial resistance and widespread antibiotic usage appear to be significantly correlated, according to the available data. Thus, prescribing and using antibiotics appropriately can lessen the disease burden of UTIs, which in turn will reduce the difficulties and expenses associated with them(Foxman, 2010). This study aimed to determine the prevalence of UPEC isolated from pediatric patients and analyze the antimicrobial susceptibility patterns (AST) results of these isolates to evaluate their multidrug resistance (MDR) in Karbala City, Iraq

2. Patients and Methodology

A retrospective cross-sectional study was conducted over a six-month period from August 2023 to February 2024. Data were collected from the medical records of patients referred to the Microbiology Laboratory of Karbala Teaching Hospital for Children, Iraq. A total of 409 urine samples data results confirmed to contain UPEC were obtained from patients of all ages and both sexes diagnosed with suspected urinary tract infections (UTIs) among 2020 and 2023. Patients were categorized into four age groups: under 1 year, 1 to 5 years, 6 to 10 years, and 11 to 16 years. Collected Antimicrobial susceptibility testing result was performed on locally available antibiotics using the disk diffusion method according to Clinical Laboratory Standards Institute (CLSI) guidelines as routine work. The following antibiotics were included in the susceptibility testing of the isolate samples; ampicillin (10 µg), gentamicin (10 µg), ciprofloxacin (5 µg), nitrofurantoin (300 µg), nalidixic acid (30 µg), cefixime (5 µg), ceftriaxone (30 µg), cefotaxime (30 µg), ceftazidime (30 µg), trimethoprim-sulfamethoxazole (TMP-SMX) (5/250 µg), amikacin (30 µg), levofloxacin (5 µg), Chloramphenicol (30µg) and amoxicillin-clavulanic acid. Data Analysis by Microsoft Excel 2016 was used for the statistical analysis of our results.

3. Results

A total of 409 urine samples result from AST were collected from suspected UTI patients. The sex and age group distribution of patients from whom the urine samples were collected is shown in Fig.1., which the data appears to be a count of the number of patients suspected with UTI by sex and year. The ratio of female: male ,1.76 :1, 2.10:1 ,2.12:1 and 2.56:1 for 2020 to 2023 respectively with rang 2.17:1 for four years. Females had a higher number of UTIs than males across all four years. 2023 had the highest number of UPEC diagnoses (139) and 2020 had the lowest (83).

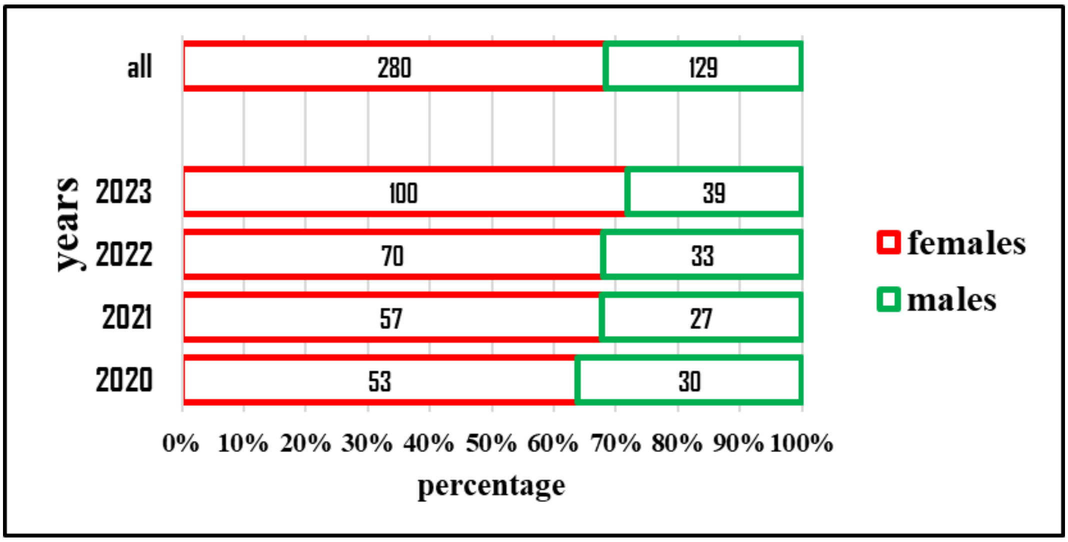

Figure1: Gender Distribution of Study Participants Across Years 2020 To 2023. The horizontal bar graph displays the number and percentage of female (red bars) and male (green bars) participants per year and in total (top row). Females consistently outnumbered males in each year, with the highest participation recorded in 2023. The total number of participants across all years was 409, comprising 280 females and 129 males.

The Table1 show age group <1 year proportion of isolates UPEC decreased over the years, from 34% in 2020 to 12% in 2023 ,1-5 years group had the highest overall percentage, with a peak in 2021 (42%), 6 –10 years percentage increased steadily, reaching 37% in 2023 and 11-16-year group maintained a relatively stable proportion, with a slight increase in 2023.

Table1: Prevalence of UPEC Isolates Among Age Group Pediatric Patients Through the Four Years.

AGE GROUP	**2020 % (N)**	**2021 % (N)**	**2022 % (N)**	**2023 % (N)**	**TOTAL % (N)**
< 1	34 (28)	19 (16)	19 (19)	12 (16)	19 (79)
1--5	23 (19)	42 (35)	35 (36)	29 (40)	32 (130)
6--10	25 (21)	26 (22)	29 (30)	37 (52)	31 (125)
11--16	18 (15)	13 (11)	17 (18)	22 (31)	18 (75)
TOTAL	100 (83)	100 (84)	100 (103)	100(139)	100 (409)

The Table2 show group under 1-year higher proportion of UPEC isolates in males (59%). Group 1-5 years and 6-10 years show significantly higher proportion in females (78% and 82% respectively)11-16 years females continue to have a higher proportion, but the gap narrows, (60% female vs. 40% male). Overall, the females account for the majority of UPEC isolates (68%). These trends indicate a higher prevalence of UTIs in females, particularly in the 1–10-year age groups, aligning with known anatomical and physiological susceptibilities.

Table2: Prevalence of UPEC Isolates According Sex and Age Group

Sex	**Age group**				
	< 1	**1 - 5**	**6 - 10**	**11 - 16**	**Total**
Female	41 (32)	78 (101)	82 (102)	60 (45)	68 (280)
Male	59 (47)	98 (29)	18 (23)	40 (30)	32 (129)
Total	100 (79)	100 (130)	100 (125)	100 (75)	100 (409)

Table3 presents the monthly prevalence of UPEC isolates. In 2020, peak distributions were observed in February 44% and December 31%. Conversely, 2022 exhibited high distributions in January39% and September 37%, with no cases recorded in July and August. The year 2022 also saw peak distributions in July 42% and December 44%. In contrast, 2023 demonstrated the highest prevalence in August 59%, maintaining a relatively consistent distribution throughout the year, except for December. Overall, 2023 exhibited a more consistent monthly spread of UPEC isolates compared to the previous years.

Table3: Monthly Prevalence of UPEC Isolates with Percentages and Frequency Over Four Years

Year	Jan % (N)	Feb % (N)	Mar % (N)	Apr % (N)	May % (N)	Jun % (N)	Jul % (N)	Aug % (N)	Sep % (N)	Oct % (N)	Nov % (N)	Dec % (N)	TOTAL % (N)
2020	15 (6)	44 (20)	20 (7)	25 (8)	10 (4)	19 (7)	8 (2)	13 (4)	17 (5)	15 (4)	15 (4)	31 (12)	20 (83)
2021	39 (16)	11 (5)	23 (8)	16 (5)	27 (11)	22 (8)	0 (0)	0 (0)	37 (11)	19 (5)	18 (5)	26 (10)	21 (84)
2022	12 (5)	18 (8)	26 (9)	25 (8)	20 (8)	33 (12)	42 (10)	28 (9)	17 (5)	19 (5)	26 (7)	44 (17)	25 (103)
2023	34 (14)	27 (12)	31 (11)	34 (11)	44 (18)	25 (9)	50 (12)	59 (19)	30 (9)	47 (13)	41 (11)	0 (0)	34 (139)
TOTAL	10 (41)	100 (45)	100 (35)	100 (32)	100 (41)	100 (36)	100 (24)	100 (32)	100 (30)	100 (27)	100 (27)	100 (39)	100 (409)

Fig.2 presents antibiotic effectiveness against UPEC for all four years. Amikacin, Nitrofurantoin, and Chloramphenicol demonstrated high efficacy. Ciprofloxacin, Gentamicin, and Levofloxacin exhibited moderate effectiveness. Nalidixic acid, Trimethoprim-Sulfamethoxazole, Cefixime, Ceftriaxone, Ceftazidime, Cefotaxime, Ampicillin, and Amoxicillin-Clavulanate showed low effectiveness. The data indicates that Amikacin, Nitrofurantoin, and Chloramphenicol are the most effective antibiotics against UPEC in this study population.

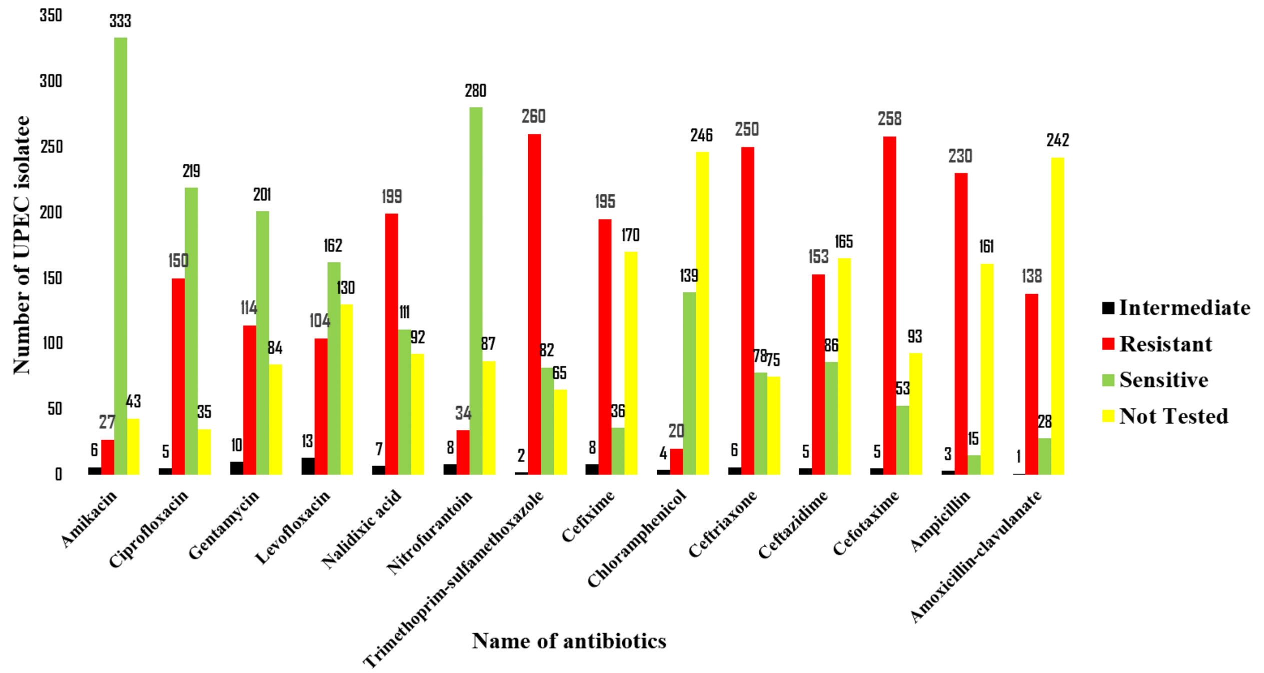

Figure2: Antibiotic Susceptibility Profiles of Uropathogenic *Escherichia Coli* (UPEC) Isolates Against 14 Antibiotics

The bar graph illustrates the number of UPEC isolates classified as sensitive (green), resistant (red), intermediate (black), or not tested (yellow) for each antibiotic. Amikacin showed the highest sensitivity (n = 333), whereas resistance was notably high for cefotaxime (n = 258) and ampicillin (n = 230). Variability in resistance and sensitivity patterns highlights the importance of local antibiograms in guiding effective treatment strategies.

Table4 provided data outlines the antibiotic resistance patterns of UPEC isolated from urine samples for four years (2020-2023). The data is categorized by antibiotic, year, and resistance pattern (R: resistant, S: sensitive, I: intermediate, NT: not tested). The analysis data show highly effective antibiotics: Amikacin, and Nitrofurantoin, moderately effective: Ciprofloxacin, Gentamycin, Levofloxacin and low effectiveness: Nalidixic Acid, Trimethoprim-Sulfamethoxazole, Cefixime, Chloramphenicol, Ceftriaxone, Ceftazidime, Cefotaxime, Ampicillin, and Amoxicillin-Clavulanate.

Table4: Antimicrobial Sensitivity Test Results for Isolated UPEC From Urine Within Four Years

Antibiotics	**Pattern**	**2020 % (n)**	**2021 % (n)**	**2022 % (n)**	**2023 % (n)**	**TOTAL % (n)**
Amikacin	**I**	**1 (1)**	**1 (1)**	**1 (1)**	**2 (3)**	**1 (6)**
	R	**10 (8)**	**1 (1)**	**11 (11)**	**5 (7)**	**7 (27)**
	S	**85 (71)**	**62 (52)**	**84 (87)**	**89 (123)**	**81 (333)**
	NT	**4 (3)**	**36 (30)**	**4 (4)**	**4 (6)**	**11 (43)**
Ciprofloxacin	**I**	**2 (2)**	**0 (0)**	**1 (1)**	**1 (2)**	**1 (5)**
	R	**31 (26)**	**40 (34)**	**42 (43)**	**34 (47)**	**37 (150)**
	S	**57 (47)**	**60 (50)**	**55 (57)**	**47 (65)**	**54 (219)**
	NT	**10 (8)**	**0 (0)**	**2 (2)**	**18 (25)**	**9 (35)**
Gentamycin	**I**	**0 (0)**	**1 (1)**	**1 (1)**	**6 (8)**	**2 (10)**
	R	**40 (33)**	**11 (9)**	**11 (9)**	**18 (25)**	**28 (114)**
	S	**57 (47)**	**32 (27)**	**32 (27)**	**53 (74)**	**49 (201)**
	NT	**3 (3)**	**56 (47)**	**56 (47)**	**23 (32)**	**21 (84)**
Levofloxacin	**I**	**2 (2)**	**0 (0)**	**1 (1)**	**7 (10)**	**3 (13)**
	R	**15 (12)**	**17 (14)**	**35 (36)**	**30 (42)**	**25 (104)**
	S	**35 (29)**	**27 (23)**	**48 (50)**	**43 (60)**	**40 (162)**
	NT	**48 (40)**	**56 (47)**	**16 (16)**	**20 (27)**	**32 (130)**
Nalidixic acid	**I**	**1 (1)**	**1 (1)**	**0 (0)**	**4 (5)**	**2 (7)**
	R	**39 (32)**	**24(20)**	**65 (67)**	**57 (80)**	**49 (199)**
	S	**30 (25)**	**15(13)**	**28 (29)**	**32 (44)**	**27 (111)**
	NT	**30 (25)**	**50(50)**	**6 (7)**	**7 (10)**	**22 (92)**
Nitrofurantoin	**I**	**2 (2)**	**2 (2)**	**1 (1)**	**2 (3)**	**2 (8)**
	R	**17 (14)**	**7 (6)**	**2 (2)**	**9 (12)**	**8 (34)**
	S	**59 (49)**	**58 (49)**	**89 (92)**	**65 (90)**	**69 (280)**
	NT	**22 (18)**	**33 (27)**	**8 (8)**	**24 (34)**	**21 (87)**
Trimethoprim-sulfamethoxazole	**I**	**0 (0)**	**1 (1)**	**0 (0)**	**1 (1)**	**0 (2)**
	R	**40 (33)**	**64 (54)**	**77 (79)**	**68 (94)**	**64 (260)**
	S	**22 (18)**	**22 (18)**	**20 (21)**	**18 (25)**	**20 (82)**
	NT	**39 (32)**	**13 (11)**	**3 (3)**	**14 (19)**	**16 (65)**
Cefixime	**I**	**0 (0)**	**0 (0)**	**1 (1)**	**5 (7)**	**2 (8)**
	R	**0 (0)**	**12 (10)**	**83 (86)**	**71 (99)**	**48 (195)**
	S	**0 (0)**	**4 (3)**	**10 (10)**	**17 (23)**	**9 (36)**
	NT	**100 (83)**	**85 (71)**	**6 (6)**	**7 (10)**	**41 (170)**
Chloramphenicol	**I**	**0 (0)**	**0 (0)**	**0 (0)**	**3 (4)**	**1 (4)**
	R	**4 (3)**	**1 (1)**	**8 (8)**	**6 (8)**	**5 (20)**
	S	**2 (2)**	**7 (6)**	**64 (66)**	**46 (65)**	**34 (139)**
	NT	**94 (78)**	**92 (77)**	**28 (29)**	**45 (62)**	**60 (246)**
Ceftriaxone	**I**	**1 (1)**	**2 (2)**	**0 (0)**	**2 (3)**	**2 (6)**
	R	**53 (44)**	**50 (42)**	**81 (84)**	**58 (80)**	**61 (250)**
	S	**17 (14)**	**19 (16)**	**15 (16)**	**23 (32)**	**19 (78)**

	NT	**29 (24)**	**29 (24)**	**2 (3)**	**17 (24)**	**18 (75)**
Ceftazidime	**I**	**0 (0)**	**5 (4)**	**1 (1)**	**0 (0)**	**1 (5)**
	R	**13 (11)**	**25 (21)**	**60 (62)**	**42 (59)**	**37 (153)**
	S	**0 (0)**	**11 (9)**	**30 (31)**	**33 (46)**	**21 (86)**
	NT	**86 (72)**	**59 (50)**	**9 (9)**	**25 (34)**	**41 (165)**
Cefotaxime	**I**	**0 (0)**	**2 (2)**	**0 (0)**	**2 (3)**	**1 (5)**
	R	**58 (48)**	**62 (52)**	**82 (85)**	**53 (73)**	**63 (258)**
	S	**11 (9)**	**10 (8)**	**15 (15)**	**15 (21)**	**13 (53)**
	NT	**31 (26)**	**26 (22)**	**3 (3)**	**30 (42)**	**23 (93)**
Ampicillin	**I**	**0 (0)**	**0 (0)**	**0 (0)**	**2 (3)**	**1 (3)**
	R	**0 (0)**	**31 (26)**	**84 (87)**	**84 (117)**	**56 (230)**
	S	**0 (0)**	**5 (4)**	**4 (4)**	**5 (7)**	**4 (15)**
	NT	**100 (83)**	**64 (54)**	**12 (12)**	**9 (12)**	**39 (161)**
Amoxicillin-clavulanate	**I**	**0 (0)**	**0 (0)**	**0 (0)**	**1 (1)**	**0 (1)**
	R	**15 (12)**	**87 (73)**	**27 (28)**	**18 (25)**	**34 (138)**
	S	**0 (0)**	**3 (3)**	**11 (11)**	**10 (14)**	**7 (28)**
	NT	**85 (71)**	**10 (8)**	**62 (64)**	**71 (99)**	**59 (242)**
R: Resistant, S: Sensitive, I: Intermediate, NT: Not Tested, n: number of UPEC						

The Table5 provides information on antibiotic susceptibility tested with UPEC isolated. Data presented in the table, detailing the number and percentage of UPEC isolated from urine samples, be analyzed to compare resistance patterns between males and females for various antibiotics. Most antibiotics show higher sensitivity in females, indicating better efficacy. Males generally exhibit higher resistance across several antibiotics

Table5: Antimicrobial Sensitivity Test Results for Isolated UPEC From Urine Based on Sexes

Antibiotics	**Pattern**	**Female % (n)**	**Male % (n)**	**Total**
Amikacin	**I**	**2 (6)**	**0 (0)**	**1 (6)**
	R	**5 (13)**	**11 (14)**	**7 (27)**
	S	**81 (227)**	**82 (106)**	**81 (333)**
	NT	**12 (34)**	**7 (9)**	**11 (43)**
Ciprofloxacin	**I**	**1 (3)**	**2 (2)**	**1 (5)**
	R	**34 (94)**	**43 (56)**	**37 (150)**
	S	**56 (158)**	**47 (61)**	**54 (219)**
	NT	**9 (25)**	**8 (10)**	**9 (35)**
Gentamycin	**I**	**2 (6)**	**3 (4)**	**2 (10)**
	R	**26 (72)**	**33 (42)**	**28 (114)**
	S	**51 (143)**	**45 (58)**	**49 (201)**
	NT	**21 (59)**	**19 (25)**	**21 (84)**
Levofloxacin	**I**	**3 (8)**	**4 (5)**	**3 (13)**
	R	**25 (71)**	**25 (33)**	**25 (104)**
	S	**45 (125)**	**29 (37)**	**40 (162)**
	NT	**27 (76)**	**42 (54)**	**32 (130)**
Nalidixic acid	**I**	**2 (6)**	**1 (1)**	**2 (7)**
	R	**46 (128)**	**55 (71)**	**49 (199)**
	S	**30 (85)**	**20 (26)**	**27 (111)**
	NT	**22 (61)**	**24 (31)**	**22 (92)**

Nitrofurantoin	**I**	**2 (5)**	**2 (3)**	**2 (8)**
	R	**6 (18)**	**12 (16)**	**8 (34)**
	S	**74 (207)**	**57 (73)**	**68 (280)**
	NT	**18 (50)**	**29 (37)**	**21 (87)**
Trimethoprim-sulfamethoxazole	**I**	**0 (1)**	**1 (1)**	**0 (2)**
	R	**65 (181)**	**61 (79)**	**64 (260)**
	S	**21 (58)**	**19 (24)**	**20 (82)**
	NT	**14 (40)**	**19 (25)**	**16 (65)**
Cefixime	**I**	**2 (5)**	**2 (3)**	**2 (8)**
	R	**48 (135)**	**47 (60)**	**48 (195)**
	S	**10 (27)**	**7 (9)**	**9 (36)**
	NT	**40 (113)**	**44 (57)**	**42 (170)**
Chloramphenicol	**I**	**1 (2)**	**2 (2)**	**1 (4)**
	R	**4 (12)**	**6 (8)**	**5 (20)**
	S	**35 (98)**	**32 (41)**	**34 (139)**
	NT	**60 (168)**	**60 (78)**	**60 (246)**
Ceftriaxone	**I**	**1 (3)**	**2 (3)**	**2 (6)**
	R	**61 (170)**	**62 (80)**	**61 (250)**
	S	**21 (60)**	**14 (18)**	**19 (78)**
	NT	**17 (47)**	**22 (28)**	**18 (75)**
Ceftazidime	**I**	**1 (3)**	**2 (2)**	**1 (5)**
	R	**35 (97)**	**43 (56)**	**38 (153)**
	S	**24 (66)**	**15 (20)**	**21 (86)**
	NT	**41 (114)**	**40 (51)**	**40 (165)**
Cefotaxime	**I**	**1 (3)**	**2 (2)**	**1 (5)**
	R	**62 (174)**	**65 (84)**	**63 (258)**
	S	**15 (41)**	**9 (12)**	**13 (53)**
	NT	**22 (62)**	**24 (31)**	**23 (93)**
Ampicillin	**I**	**0 (1)**	**2 (2)**	**1 (3)**
	R	**57 (159)**	**55 (71)**	**56 (230)**
	S	**4 (11)**	**3 (4)**	**4 (15)**
	NT	**39 (109)**	**40 (52)**	**39 (161)**
Amoxicillin-clavulanate	**I**	**0 (0)**	**1 (1)**	**0 (1)**
	R	**31 (88)**	**38 (50)**	**34 (138)**
	S	**8 (22)**	**5 (6)**	**7 (28)**
	NT	**61 (170)**	**56 (72)**	**59 (242)**
R: Resistant, S: Sensitive, I: Intermediate, NT: Not Tested, n: number of UPEC				

Table6 present data compare antibiotic resistance patterns across different age groups. Older age groups generally show higher sensitivity. Infants (<1 year) often exhibit higher resistance levels. Nitrofurantoin and Amikacin show higher effectiveness across age groups. Trimethoprim-Sulfamethoxazole, Cefixime, Ceftriaxone, and Ampicillin show high resistance across all ages.

Table6: Antimicrobial Sensitivity Test Results for Isolated UPEC From Urine Based on Age Group

Antibiotics	Pattern	Age group				
		< 1 % (n)	1 – 5 % (n)	6 – 10 % (n)	11 – 16 % (n)	Total % (n)
Amikacin	I	0 (0)	0(0)	0 (0)	0 (0)	0(0)
	R	13 (10)	5 (7)	4 (5)	7 (5)	7 (27)
	S	78 (62)	78 (101)	84 (105)	87 (65)	81 (333)
	NT	9 (7)	16 (21)	9 (11)	5 (4)	11 (43)
Ciprofloxacin	I	1 (1)	1 (1)	2 (3)	0 (0)	1 (5)
	R	47 (37)	32 (41)	39 (49)	31 (23)	37 (150)
	S	44 (25)	55 (73)	52 (65)	61 (46)	53(219)
	NT	8(6)	12 (15)	6 (8)	8 (6)	9 (35)
Gentamycin	I	4 (3)	2 (2)	4 (5)	0 (0)	2 (10)
	R	37 (29)	22 (29)	26 (33)	31 (23)	28 (114)
	S	44 (35)	47 (61)	53 (66)	52 (39)	49 (201)
	NT	15 (12)	29 (38)	17(21)	17(13)	21 (84)
Levofloxacin	I	6 (5)	2 (3)	2 (3)	3 (2)	3 (13)
	R	22 (17)	24 (31)	31 (39)	22 (17)	25 (104)
	S	19 (15)	40 (52)	45 (56)	52 (39)	40 (162)
	NT	53 (42)	34 (44)	22 (27)	23 (17)	32 (130)
Nalidixic acid	I	3 (2)	1 (1)	2 (3)	1 (1)	2 (7)
	R	51 (41)	45 (59)	51 (64)	47 (35)	49 (199)
	S	23 (18)	24 (31)	30 (37)	33 (25)	27 (111)
	NT	23 (18)	30 (39)	17 (21)	19 (14)	22 (92)
Nitrofurantoin	I	0 (0)	2 (2)	4 (5)	1 (1)	2 (8)
	R	13 (10)	5 (6)	7 (9)	12 (9)	8 (34)
	S	62 (49)	66 (86)	76 (95)	67 (50)	68 (280)
	NT	25 (20)	27 (36)	12 (16)	20 (15)	21 (87)
Trimethoprim-sulfamethoxazole	I	1 (1)	0 (0)	1 (1)	0 (0)	0.5 (2)
	R	62 (49)	65 (85)	70 (87)	52 (39)	63.5(260)
	S	14 (11)	19 (24)	18 (23)	32 (24)	20 (82)
	NT	23 (18)	16 (21)	11 (14)	16 (12)	16 (65)
Cefixime	I	1 (1)	3 (4)	2 (3)	0 (0)	2 (8)
	R	41 (32)	48 (63)	48 (60)	54(40)	47 (195)
	S	0 (0)	9 (11)	12 (15)	13 (10)	9 (36)
	NT	58 (46)	40 (52)	38 (47)	33 (25)	42 (170)
Chloramphenicol	I	1 (1)	0 (0)	2 (2)	1 (1)	1 (4)
	R	6 (5)	2 (3)	7 (9)	4 (3)	5 (20)
	S	25 (20)	35 (46)	38 (48)	33 (25)	34 (139)
	NT	67 (53)	63 (81)	53 (66)	62 (46)	60 (246)
Ceftriaxone	I	1 (1)	1 (1)	2 (3)	1 (1)	2 (6)
	R	72 (57)	60 (78)	59 (74)	55 (41)	61 (250)
	S	9 (7)	16 (21)	25 (31)	25 (19)	19 (78)
	NT	18 (14)	23 (30)	14 (17)	19 (14)	18 (75)
Ceftazidime	I	0 (0)	1 (1)	1 (1)	4 (3)	1 (5)
	R	46 (36)	32 (42)	41 (51)	33 (24)	37 (153)
	S	5 (4)	19 (25)	28 (35)	29 (22)	21 (86)
	NT	49 (39)	48 (62)	30 (38)	34 (26)	41 (165)
Cefotaxime	I	1 (1)	1 (1)	2 (3)	0 (0)	1 (5)

	R	**72 (57)**	**62 (81)**	**64 (79)**	**55 (41)**	**63 (258)**
	S	**3 (2)**	**9 (12)**	**19 (24)**	**20 (15)**	**13 (53)**
	NT	**24 (19)**	**28 (36)**	**15 (19)**	**25 (19)**	**23 (93)**
Ampicillin	**I**	**1 (1)**	**1 (1)**	**1 (1)**	**0 (0)**	**1 (3)**
	R	**43 (34)**	**55 (71)**	**65 (81)**	**59 (44)**	**56 (230)**
	S	**1 (1)**	**3 (4)**	**3 (4)**	**8 (6)**	**4 (15)**
	NT	**55 (43)**	**41 (54)**	**31 (39)**	**33 (25)**	**39 (161)**
Amoxicillin-clavulanate	**I**	**0 (0)**	**0 (0)**	**0 (0)**	**1 (1)**	**0 (1)**
	R	**38 (30)**	**38 (30)**	**26 (33)**	**33 (25)**	**34 (138)**
	S	**4 (3)**	**4 (3)**	**10 (12)**	**9 (7)**	**7 (28)**
	NT	**58 (46)**	**58 (46)**	**64 (80)**	**56 (42)**	**59 (242)**

Table6 shows the resistance pattern of MDR of UPEC. Among 409 isolates, 96% of isolates were found resistant to at least one antibiotic, and % 80 was found resistant at least to 3 or more classes of antibiotics, thus classified as MDR

Table 6: Isolated UPEC From Urine with Determine MDR According Antimicrobial Sensitivity Test

Number of antibiotics resistant	2020 UPEC isolate % (N)	2021 UPEC isolate % (N)	2022 UPEC isolate % (N)	2023 UPEC isolate % (N)	Total % (N)
0	**7 (6)**	**2 (2)**	**1 (1)**	**5 (7)**	**4 (16)**
1	**16.5 (14)**	**11.5 (9)**	**1 (1)**	**4 (6)**	**7.25 (30)**
2	**13.5 (12)**	**11.5(9)**	**4 (4)**	**7 (10)**	**9 (35)**
3	**16 (13)**	**15.5 (13)**	**1 (1)**	**11.5 (17)**	**11 (44)**
4	**16 (13)**	**11.5 (9)**	**11 (11)**	**13.5 (19)**	**13 (52)**
5	**16 (13)**	**14 (12)**	**11.5 (12)**	**9 (12)**	**12 (49)**
6	**6 (5)**	**24 (20)**	**9.5 (10)**	**12 (16)**	**12 (51)**
7	**5 (4)**	**4 (4)**	**16.5 (17)**	**6 (8)**	**8 (33)**
8	**4 (3)**	**2 (2)**	**13 (14)**	**10 (14)**	**8 (33)**
9	**0 (0)**	**3 (3)**	**13 (14)**	**10 (14)**	**8 (31)**
10	**0 (0)**	**1 (1)**	**9 (9)**	**9 (12)**	**5 (22)**
11	**0 (0)**	**0 (0)**	**6.5 (7)**	**2 (3)**	**2 (10)**
12	**0 (0)**	**0 (0)**	**1 (1)**	**1 (1)**	**0.5 (2)**
13	**0 (0)**	**0 (0)**	**1 (1)**	**0 (0)**	**0.25 (1)**
TOTAL	**100 (83)**	**100 (84)**	**100 (103)**	**100 (139)**	**100 (409)**

4. Discussion

One important bacterium that can cause potentially catastrophic urinary tract infections is *Escherichia coli*. Consideration of a number of variables, including host determinant, epidemiology, and antibiotic susceptibility, is necessary for accurate characterization of these diseases (Patil *et al*., 2023). In order to treat a UTI, it is essential to identify the organism and determine its susceptibility to antibiotics. It emphasizes how crucial close communication and coordination are between the microbiologist and the clinician (Moue *et al*., 2015). In the current study, the high rate of UPEC [n=280, 68.5%] was identified in female pediatric patients during the four years of the study period with a higher frequency in 2023 [n=100,72%].and this is conduct with Mexican study [n=86,78.2%] (Ramírez-Castillo *et al*., 2018) and Nepal study [n=132,88.3%] (Raya *et al*., 2020) Hormonal differences between males and females may influence susceptibility to infection and subsequent antibiotic resistance (Vasudevan, 2014) .The urinary tract anatomy varies between sexes, potentially affecting the likelihood of infection and the types of bacteria involved (Minardi *et al*., 2011). In the current study the 1–5-year age group had the highest total percentage of UPEC isolates, indicating a significant burden in this age range. Infants and toddlers with their developing immune systems, are more susceptible to infections and may consequently receive antibiotics more frequently. This increased exposure to antibiotics can elevate the risk of antibiotic resistance (Lee, 2016). One study revealed that over the past ten years, mean temperatures during June, July, August, and September increased by more than 45 degrees Celsius. Conversely, precipitation levels decreased in intensity during the winter and spring, with a decline in monthly mean rainfall (Yehia *et al*., 2023). The study found seasonal variations in the detection of UPEC isolates over the years. While there was a general trend of higher detection rates during colder months in 2020 and 2021, particularly in winter, there were exceptions with peaks occurring in summer months in 2022 and 2023 years and this agree with the findings from the Turkish study (Yolbas *et al*., 2013). The Iraqi study suggests that several factors beyond seasonality may contribute to the increased prevalence of UPEC during summer. These factors include: dietary changes like increased consumption of contaminated food and water and varying hygiene standards in different regions. These factors, in combination, likely create a more favorable environment for the transmission and spread of UPEC (Assafi *et al*., 2022). Overall, There's a general increase in resistance to most antibiotics over the four years, particularly for Ciprofloxacin [n=150,37%] Close to studying in Chile [n=9,22.5%] (Bacigalupo-Gorbea *et al*., 2023), Levofloxacin [n=104,25%] Compatible with an Iraqi study [n=28,38%] (Alfuraiji *et al*., 2022), Nalidixic acid [n=199,49%] not consistent with the Pakistani study [n=56,88%] (Iqbal *et al*., 2021), Trimethoprim-sulfamethoxazole [n=260,64%] It does not correspond to a Roman study [n=212,27%] (Miron *et al*., 2021) , Cefixime [n=195,48%] Relatively close to Iranian study[n=18,35%] (Ghasemi *et al*., 2020) , Ceftriaxone [n=250,61%] not compatible with the Pakistani study [n=118,88.7%] , Ceftazidime [n=153,37%] not appropriate with Turkish study[n=172,15.1%] (Samancı *et al*., 2020), Cefotaxime [n=258,63%] not trend with Vietnam study [n=19,38.8%] (Nguyen *et al*., 2022), and Ampicillin [n=230,56%] Somewhat similar to a Turkish study [n=1932,69.6%] (Samanci and PINARBAŞI, 2023). Amikacin [n=27,7%] does not agree with Indian study [n=23,31%] (Alfuraiji *et al*., 2022) and Nitrofurantoin[n=34,8%] dose not correspond with Pakistani study[n=74,35.3%] (Mir *et al*., 2022) . Chloramphenicol shows a decrease in resistance over time, indicating improved efficacy. Ciprofloxacin, Levofloxacin, Nalidixic acid, Trimethoprim-sulfamethoxazole show High and increasing resistance levels, limiting their effectiveness. Cefixime, Ceftriaxone, Ceftazidime, Cefotaxime, Ampicillin, Amoxicillin-clavulanate show High resistance rates, especially in later years, indicating limited utility. A significant increase in resistance to many antibiotics is observed between 2020 and 2023, highlighting the rapid evolution of bacterial resistance. The results of UPEC isolates based on sexes distribution shows Nitrofurantoin showed the highest susceptibility rates, particularly among females on the other hand high resistance rates were noted for Ciprofloxacin and Nalidixic acid, particularly in males. Overall, resistance and susceptibility patterns varied slightly between males and females, with males generally showing higher resistance rates and this result is conducted with Mexican study (Ramírez-Castillo *et al*., 2018) and Honduras study (Zúniga-Moya *et al*., 2016) The results show older age groups generally higher sensitivity. Infants <1 year often exhibit higher resistance levels. Nitrofurantoin and Amikacin show higher effectiveness across age groups. Trimethoprim-Sulfamethoxazole, Cefixime, Ceftriaxone, and Ampicillin show high resistance across all ages. Based on the search results, there are several key factors that contribute to higher resistance in infants compared to other age groups. The study reveals that the infant gut microbiome harbors a significantly higher abundance of antibiotic resistance genes (ARGs) compared to the adult gut microbiome. This increased abundance is closely linked to the presence and abundance of Escherichia coli, a major reservoir of ARGs. The infant gut microbiome undergoes substantial changes during the first year of life, influencing the overall abundance of ARGs. Notably, the study found a significantly higher relative abundance of ARGs at six weeks of age compared to one year of age. Many of the differentially abundant ARGs are associated with antibiotic efflux mechanisms, suggesting their role in conferring resistance to antibiotics (Lebeaux *et al*., 2021). Infants, with their immature immune systems, are more susceptible to infections compared to older age groups. This increased susceptibility often necessitates antibiotic use, potentially contributing to higher rates of antibiotic resistance development (Desai and Macrae, 2020). Among 409 isolate 96% of the isolates were resistant at least one antimicrobial agent, and 328 (80%) isolates were resistant at least 3 antimicrobials. MDR was defined as resistance to at least three antimicrobial classes as suggested by (Magiorakos *et al*., 2012). The current study shows more than

70% (n=287) of isolates detect MDR compared with Iraqi study (n=38,88%) (Al-Hasnawy *et al*., 2019) Bangladesh study (n= 416,96%) (Nobel *et al*., 2021) Taiwan study (n=58,37%) (Huang *et al*., 2018), South Kerala, Indian study (n=20,24%) (Jitendranath *et al*., 2015) Turkish study (n=81,14.5%) Chinese study (n=189,46%) (Huang *et al*., 2022) Russian study (n=31,29%) (Sarra *et al*., 2021) and South-East Gabon (n=59,44%) (Mouanga-Ndzime *et al*., 2023). Escherichia coli bacteria can develop resistance to antibiotics through several mechanisms Mutations in bacterial DNA can lead to resistance by altering target sites for antibiotics (Mazzariol *et al*., 2017) Transfer of resistance genes between bacteria through plasmids, transposons, or integrins (Khadgi *et al*., 2013).UPEC can expel antibiotics using efflux pumps, reducing drug concentration inside the cell (Yasufuku *et al*., 2011).Biofilms protect bacteria from antibiotics, making them harder to eradicate (Mittal *et al*., 2015). Excessive or inappropriate use of antibiotics accelerates resistance development.

5. Conclusion

The prevalence and trends of antibiotic resistance of UPEC in pediatric urinary tract infections (UTIs) were examined in this study. The empirical treatment of urinary tract infections (UTIs) has become more difficult in this region due to the increasing prevalence of multidrug-resistant (MDR) strains of Escherichia coli (E. coli). Continuous monitoring of MDR organisms and their resistance patterns is crucial to avoid treatment failures and limit the emergence of antibiotic resistance. With this knowledge, medical professionals in Iraq will be better equipped to choose the right antibiotics for UTI patients.

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