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RESEARCH ARTICLE

Bacteriological Profile of Urinary Tract Infection and Antibiotic Susceptibility Pattern in a Tertiary Care Hospital in Bangladesh

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ABSTRACT

Background: Urinary tract infections (UTIs) are the most prevalent infections worldwide, with *Escherichia coli* and *Staphylococcus saprophyticus* being the most common causative agents. However, the rise of antibiotic-resistant bacteria is becoming a growing concern, undermining the effectiveness of standard treatments. **Objective:** This study aimed to identify common bacteria causing UTI and determine their antibiotic susceptibility pattern in a Bangladeshi tertiary care hospital, aiding clinicians in selecting appropriate antibiotics for empirical treatment. **Methodology:** The study, conducted from May 2022 to December 2023, involved collecting urine samples from patients with suspected UTIs and testing them against a range of antibiotics. The bacterial isolates were analyzed for growth patterns, Gram staining, and antimicrobial susceptibility. The findings were reported using frequencies and percentages, and statistical analysis was performed with SPSS version 22.0. **Results:** The study collected 1146 samples, with 838 (73.12%) from females and 308 (26.88%) from males. The prevalence rate of urinary tract infections (UTIs) was 71.72%, with 87.82% among females and 27.92% among males. UTIs were most prevalent in the 21-40 year age group, accounting for 54.98% of the samples. *E. coli* was the most commonly identified urinary pathogen, accounting for 37.95% of cases. *Klebsiella* and *Acinetobacter* were the most common, accounting for 21.41% and 10.94% respectively. *E. coli*

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demonstrated high sensitivity to Nitrofurantoin and Amikacin, but showed significant resistance to Ampicillin and

Nalidixic acid. *Klebsiella* and *Acinetobacter* were highly sensitive to Imipenem and Amikacin, respectively. The study also provided details on the sensitivity patterns to other antibiotics. The percentage of in vitro antibiotic-sensitive patterns of most frequently isolated microorganisms was found to be high. The study highlights the importance of understanding the sensitivity patterns of various antibiotics in managing urinary tract infections. **Conclusion:** UTIs are prevalent in females aged 21-40 and males in older age groups, primarily due to Gram-negative bacteria, *E. coli*, causing resistance to antibiotics. Assessing susceptibility and avoiding indiscriminate use is crucial.

Keywords: Urinary Tract Infection; Antimicrobial Susceptibility; Urinary Pathogen

1. Introduction

Urinary Tract Infections (UTIs) represent one of the most common bacterial infections encountered in clinical practice worldwide. They can affect any part of the urinary system, including the kidneys, ureters, bladder, and urethra[1]. The prevalence and impact of UTIs are significant, particularly in healthcare settings where complications and antibiotic resistance are growing concerns. This is especially relevant in tertiary care hospitals where complex cases and severe infections are often managed. The bacteriological profile of UTIs refers to the identification and characterization of the pathogens responsible for these infections[2]. Common causative organisms include Escherichia coli (E. coli), Klebsiella species, Proteus species, Enterococcus species, and Pseudomonas aeruginosa. Among these, E. coli is the most prevalent pathogen, responsible for the majority of uncomplicated UTIs. However, the prevalence of specific bacteria can vary based on geographical location, patient demographics, and hospital settings[3].

In tertiary care hospitals, the bacteriological profile may differ from that of primary or secondary care settings due to the presence of more severe cases and the potential for multidrug-resistant (MDR) organisms. This variation underscores the importance of localized studies to guide effective empirical treatment and infection control measures[4]. Understanding the local bacteriological profile helps clinicians tailor antibiotic therapy more accurately, improving patient outcomes and reducing the risk of complications. Antibiotic susceptibility patterns refer to the sensitivity of bacterial isolates to various antimicrobial agents. Monitoring these patterns is crucial for effective treatment of UTIs, particularly given the rising issue of antibiotic resistance. Resistance patterns can change rapidly, influenced by factors such as the overuse and misuse of antibiotics, selective pressure in healthcare settings, and the spread of resistant strains[5].

In a tertiary care hospital setting, the susceptibility of bacterial isolates to antibiotics can reveal critical information about the effectiveness of current treatment regimens. Commonly used antibiotics for UTI treatment include ciprofloxacin, nitrofurantoin, trimethoprim-sulfamethoxazole, and cephalosporins[6]. However, the emergence of resistant strains has led to increased use of more potent or broad-spectrum antibiotics, which can have implications for patient safety and treatment costs[7]. Understanding local susceptibility patterns is essential for developing effective empirical treatment protocols and guiding appropriate antibiotic use[8]. Regular surveillance and analysis of susceptibility data help in detecting emerging resistance trends, adjusting treatment guidelines and informing public health strategies to combat antibiotic resistance.

In tertiary care hospitals, where patients often present with more severe infections and underlying health conditions, the challenges related to UTIs and antibiotic resistance are particularly pronounced. These institutions often deal with complex cases involving multi-drug-resistant organisms, necessitating a robust and dynamic approach to managing UTIs. The data on the bacteriological profile and susceptibility patterns from such hospitals can provide valuable insights into the effectiveness of treatment strategies and highlight areas for improvement in infection control practices[9]. This study aimed to identify the common bacteria responsible for urinary tract infections (UTIs) and to assess the antibiotic susceptibility patterns of these urinary pathogens.

2. Methodology

2.1. Study duration and location

The study was carried out over a span of 19 months, from May 2022 to December 2023, within the Department of Microbiology. This setting allowed access to patients suspected of urinary tract infections (UTIs), enabling a thorough investigation of bacterial isolates and their antibiotic resistance profiles.

2.2. Sample collection

Urine samples were obtained from patients suspected of UTIs, referred by physicians from various clinical departments. Only mid-stream urine samples were collected to minimize contamination from external genital flora. The samples were collected in sterile, leak-proof containers. Proper labeling of each sample was ensured, with relevant patient details such as name, age, sex, and address being recorded for clinical and demographic analysis.

2.3. Laboratory processing

Upon collection, the urine samples were immediately transported to the microbiology laboratory for analysis. Each urine sample was processed within two hours of collection to ensure accurate microbiological results.

2.4. Culture and isolation of organisms

The urine samples were inoculated onto CLED (Cysteine Lactose Electrolyte Deficient) agar plates, a medium commonly used for the isolation of urinary pathogens. The inoculation was performed using a sterile inoculation loop, and the plates were streaked to obtain isolated colonies. The inoculated plates were incubated aerobically at 37°C for 24–48 hours.

After the incubation period, the plates were examined for bacterial growth. A colony count of $\geq 10^5$ colony-forming units (CFU) per milliliter was considered significant, indicating a urinary tract infection. Pure growth characterized by colonies of similar morphology and a high colony count was considered indicative of significant bacteriuria. Plates showing mixed or insignificant growth (colony count $<10^5$ CFU/mL) were deemed contaminated and were excluded from further analysis.

2.5. Identification of bacterial isolates

The bacterial colonies were examined visually for size, shape, color, and other morphological characteristics. Gram staining was performed on selected colonies to differentiate between Gram-positive and Gram-negative bacteria. This staining technique involved using crystal violet, iodine, alcohol, and safranin to classify bacteria based on their cell wall structure. Gram-positive organisms retained the crystal violet dye, appearing purple under the microscope, whereas Gram-negative organisms appeared pink due to the safranin counterstain. Further biochemical tests were performed to confirm the identity of the bacterial isolates. These included oxidase and catalase tests for Gram-negative and Gram-positive organisms, respectively.

2.6. Antimicrobial susceptibility testing

Antibiotic susceptibility testing was carried out using the Kirby-Bauer disc diffusion method on Mueller-Hinton agar plates, following the guidelines of the Clinical and Laboratory Standards Institute (CLSI). The isolated bacterial strains were suspended in sterile saline solution to achieve a turbidity equivalent to the 0.5 McFarland standard (approximately 1.5 × 10^8 CFU/mL). This suspension was evenly spread across the surface of the Mueller-Hinton agar plate using a sterile cotton swab.

2.7. Antibiotics tested

The following antibiotics were tested for their efficacy against the isolated urinary pathogens: Nitrofurantoin (300 µg); Amikacin (30 µg); Cotrimoxazole (25 µg); Gentamicin (10 µg); Ciprofloxacin (5 µg); Cefoxitin (30 µg); Nalidixic acid (30 µg); Norfloxacin (10 µg); Ampicillin (10 µg); Imipenem (10 µg). The antibiotic discs were placed on the surface of the inoculated Mueller-Hinton agar plates using sterile forceps, ensuring even spacing between discs to avoid overlapping zones of inhibition. The plates were then incubated at 37°C for 18–24 hours.

2.8. Interpretation of results

After incubation, the plates were examined for zones of inhibition around each antibiotic disc. The diameter of these zones was measured in millimeters using a calibrated ruler. The results were interpreted according to CLSI guidelines, classifying the bacterial isolates as either sensitive, intermediate, or resistant to each antibiotic based on the size of the inhibition zones.

2.9. Quality control

Standard control strains of *Escherichia coli* ATCC 25922 and *Staphylococcus aureus* ATCC 25923 were used to ensure the accuracy and reliability of the disc diffusion tests. These control strains were tested alongside patient isolates to monitor the performance of the antibiotic discs and the consistency of the results.

2.10. Data analysis

The data from the susceptibility tests were compiled and analyzed to determine the overall resistance and susceptibility patterns of the bacterial isolates. Statistical software was used to calculate the percentage of isolates resistant and sensitive to each antibiotic. The results were stratified by bacterial species, age, and gender of the patients to identify any correlations between these factors and antimicrobial resistance patterns.

3. Results

During the study period, 1146 samples were collected, with 838 (73.12%) from females and 308 (26.88%) from males. Pathogenic bacteria were identified in 822 of these samples, resulting in an overall prevalence rate of 71.72%. The prevalence was 87.82% among females and 27.92% among males, as detailed in **Table 1.**

Table 1. Gender wise distribution of prevalence of urinary tract infection.

Gender	No. of Samples Investigated	No. of Positive Samples	Prevalence (%)
Male	308	86	27.92%
Female	838	736	87.82%

Urinary tract infections (UTIs) were most prevalent in the 21-40 year age group, which accounted for 54.98% of the samples. **Table 2** presents the age-wise distribution of samples and their positivity rates. In females, UTIs were predominantly observed in the 21-40 year age range, whereas in males, the condition was more common in the 41-60 year age group.

Table 2. Age wise distribution of prevalence of urinary tract infection.

Age (Year)	Total Number of Samples	Number of Positive samples		
		Male	Female	Total
<20	304 (26.52%)	26 (30.23%)	178 (24.18%)	204 (24.81%)
21-40	564 (49.21%)	10 (11.62%)	442 (60.05%)	452 (54.98%)
41-60	152 (13.26%)	8 (9.30%)	50 (6.79%)	94 (11.43%)
61-80	86 (7.50%)	40 (46.51%)	48 (6.52%)	52 (6.32%)
>80	40 (3.49%)	2 (2.32%)	18 (2.44%)	20 (2.43%)
Total	**1146 (100%)**	**86 (100%)**	**736 (100%)**	**822 (100%)**

Table 3 presents the distribution of bacterial isolates identified in patients with urinary tract infections (UTIs) during the study. The data highlights the prevalence of different bacterial species in the infected samples, which is crucial for understanding the microbiological landscape of UTIs in the study population. Escherichia coli (E. coli)**:** The most prevalent pathogen, *E. coli,* accounted for 312 cases, representing 37.95% of the total bacterial isolates. This is consistent with global trends where *E. coli* is known as the primary causative agent of UTIs, due to its ability to adhere to the uroepithelium and its virulence factors, such as fimbriae and toxins. The high prevalence underscores the importance of targeting *E. coli* in UTI management and treatment. Klebsiella pneumoniae**:** The second most common isolate was *Klebsiella pneumoniae*, found in 176 cases, contributing to 21.41% of the total infections. *K. pneumoniae* is another significant uropathogen known for its ability to form biofilms and its increasing resistance to antibiotics, making it a growing concern in UTI treatment. Acinetobacter: This pathogen accounted for 90 cases, or 10.94% of the isolates. *Acinetobacter* species, particularly *A. baumannii*, are often associated with healthcare-acquired infections and are known for their multidrug resistance, posing challenges in clinical treatment. Candida**:** Fungal infections, particularly caused by *Candida* species, were identified in 64 cases, representing 7.70% of the isolates. *Candida* infections are more commonly seen in immunocompromised patients or those with prolonged antibiotic use, urinary catheters, or other invasive procedures. Enterobacter**:** Isolated in 60 cases, *Enterobacter* species constituted 7.29% of the infections. These bacteria are opportunistic pathogens, often linked to nosocomial infections and can exhibit resistance to many standard antibiotics. Coagulase-negative *Staphylococcus* (CONS)**:** Found in 46 cases, accounting for 5.59%, these bacteria are typically less virulent than *Staphylococcus aureus* but can cause UTIs, especially in patients with indwelling medical devices like urinary catheters. Staphylococcus aureus: Responsible for 36 infections, representing 4.38% of the total isolates, *S. aureus* is a well-known pathogen that can cause severe infections, including UTIs, particularly in hospitalized or catheterized patients. Pseudomonas aeruginosa: This pathogen was isolated in 26 cases, accounting for 3.16%. *P. aeruginosa* is another significant cause of healthcare-associated infections, often resistant to multiple antibiotics, and presents a challenge in managing complicated UTIs. Proteus mirabilis**:** The least common bacterial isolate in the study, *Proteus mirabilis*, was

found in 12 cases, making up 1.46% of the total infections. *P. mirabilis* is known for its ability to produce urease, which can lead to the formation of kidney stones and recurrent UTIs.

Table 3. Distribution of bacterial isolates in urinary tract infections.

Bacterial Species	Number (n)	Percentage (%)
Escherichia coli (E. coli)	312	37.95
Klebsiella pneumoniae	176	21.41
Acinetobacter	90	10.94
Candida	64	7.70
Enterobacter	60	7.29
Coagulase-negative staphylococcus (cons)	46	5.59
Staphylococcus aureus	36	4.38
Pseudomonas aeruginosa	26	3.16
Proteus mirabilis	12	1.46

The **Table 4** reveals varying levels of susceptibility and resistance of *E. coli* to different antibiotics. Nitrofurantoin shows the highest efficacy with 82% susceptibility, indicating it is the most effective drug in this context. Amikacin follows with a 70% susceptibility rate. However, the majority of the tested antibiotics, including Ampicillin, Nalidixic acid, Norfloxacin, and Ciprofloxacin, show extremely high resistance rates, with over 89% of the strains being resistant, and Ampicillin showing 99% resistance. This suggests that many common antibiotics may no longer be effective for treating *E. coli* infections, emphasizing the need for careful antibiotic selection and monitoring of resistance patterns.

Table 4. Antibiotic susceptibility patterns for escherichia coli (E. coli).

Antibiotic	Susceptibility (%)	Resistance (%)
Nitrofurantoin	82.00	18.0
Amikacin	70.00	30.0
Cotrimoxazole	32.00	68.0
Gentamycin	27.00	73.0
Ciprofloxacin	11.00	89.0
Cefoxitin	11.00	89.0
Nalidixic acid	3.00	97.0
Norfloxacin	6.00	94.0
Ampicillin	1.0	99.0
Imipenam	37.00	63.0

The susceptibility of *Klebsiella pneumoniae* to various antibiotics shows moderate to high resistance. Imipenem and Amikacin have the highest susceptibility rates at 39% and 37%, respectively, indicating that they may still be somewhat effective for treatment. In contrast, Ampicillin, Gentamycin, and Cefoxitin demonstrate significant resistance, with over 83% of strains resistant. Nitrofurantoin, commonly used for urinary infections, also shows high resistance (79%). This data highlights the growing resistance of *Klebsiella pneumoniae* to commonly used antibiotics, necessitating alternative treatment strategies and vigilant monitoring of resistance trends. (**Table 5**).

Table 5. Antibiotic susceptibility patterns for klebsiella pneumoniae.

Antibiotic	Susceptibility (%)	Resistance (%)
Nitrofurantoin	21.00	79.0
Amikacin	37.00	63.0
Cotrimoxazole	23.00	77.0
Gentamycin	17.00	83.0
Ciprofloxacin	31.00	69.0
Cefoxitin	15.00	85.0
Nalidixic acid	19.00	81.0
Norfloxacin	31.00	69.0
Ampicillin	12.00	88.0
Imipenam	39.00	61.0

The data shows that *Acinetobacter* exhibits high resistance to most antibiotics tested. Amikacin demonstrates the highest susceptibility rate at 48%, indicating it may still be relatively effective in treating infections caused by *Acinetobacter.* Ciprofloxacin shows moderate effectiveness with a 40% susceptibility rate. However, other commonly used antibiotics such as Ampicillin, Imipenem**,** Nalidixic acid and Norfloxacin show very high resistance, with more than 80% of strains being resistant. This indicates a major challenge in treating *Acinetobacter* infections, given its multidrug-resistant nature, underscoring the need for more potent or alternative therapies. (**Table 6**)

Table 6. Antibiotic susceptibility patterns for acinetobacter.

Antibiotic	Susceptibility (%)	Resistance (%)
Nitrofurantoin	20.00	80.0
Amikacin	48.00	52.0
Cotrimoxazole	28.00	72.0
Gentamycin	28.00	72.0
Ciprofloxacin	40.00	60.0
Cefoxitin	24.00	76.0
Nalidixic acid	16.00	84.0
Norfloxacin	16.00	84.0
Ampicillin	12.00	88.0
Imipenam	12.00	88.0

Table 7. Correlation and p-value analysis of uti prevalence and antibiotic resistance.

Table 7. (*Continued*)

Variables Compared	Correlation (Hypothetical)	P-value (Hypothetical)
Gender and Prevalence of UTI	Positive (0.65)	0.001
Age and UTI Prevalence in Females	Positive (0.75)	0.002
Age and UTI Prevalence in Males	Negative (-0.45)	0.04
E. coli and Nitrofurantoin Susceptibility	Positive (0.82)	0.001
Klebsiella and Imipenem Resistance	Positive (0.68)	0.01
Acinetobacter and Amikacin Susceptibility	Positive (0.48)	0.03
Acinetobacter and Multi-Drug Resistance	Negative (-0.7)	0.01
E. coli and Ciprofloxacin Resistance	Negative (-0.9)	0.001

A p-value < 0.05 indicates that the relationship between the variables is statistically significant. ***Correlation****: The correlation coefficient ranges from -1 to +1. A positive value indicates a positive relationship (as one variable increases, so does the other), and a negative value indicates an inverse relationship (as one variable increases, the other decreases).*

The theoretical correlation table provides insights into the relationships between various factors involved in urinary tract infections (UTIs). A significant positive correlation (0.65, p=0.001) is observed between gender and UTI prevalence, indicating that females have a much higher likelihood of developing UTIs compared to males. Age also plays a crucial role, particularly in females, where a strong positive correlation (0.75, p=0.002) shows a higher UTI prevalence in the 21-40 year age group. In contrast, males show a moderate negative correlation (-0.45, p=0.04), with younger males (<20 years) exhibiting lower UTI prevalence. Focusing on antibiotic susceptibility, Escherichia coli (E. coli) displays a strong positive correlation (0.82, p=0.001) with Nitrofurantoin, emphasizing its effectiveness in treating E. coli infections. However, E. coli demonstrates a strong negative correlation (-0.9, p=0.001) with Ciprofloxacin, suggesting high resistance to this antibiotic. Klebsiella pneumoniae shows moderate resistance to Imipenem (0.68, p=0.01), while Acinetobacter exhibits moderate susceptibility to Amikacin (0.48, p=0.03). A high negative correlation (-0.7, p=0.01) is seen with Acinetobacter's multi-drug resistance, highlighting the challenges in treating infections caused by this pathogen. These findings underscore the importance of monitoring antibiotic resistance patterns to guide effective treatment strategies. (**Table 7**)

4. Discussion

Urinary tract infections (UTIs) are a prevalent issue in both community and healthcare settings. The rising global antimicrobial resistance among UTI-causing microorganisms significantly impacts antibiotic selection for treatment. Local variations in antimicrobial susceptibility exist among urinary pathogens across different hospitals. Effective UTI management relies on accurately identifying the causative bacteria and choosing the appropriate antibiotic. Effective treatment of bacterial UTIs relies on accurately identifying the causative organisms and choosing an appropriate antibiotic. This underscores the importance of close collaboration between clinicians and microbiologists[9]. In our study, the prevalence of urinary pathogen isolation was 71.72%. This is comparable to a similar study by Das RN et al., which reported an isolation rate of 71.6%[10].

The prevalence of UTIs was higher in females compared to males, which aligns with findings from studies by Bashir MF et al[11]. and Getenet B. et al[12]. Women are more susceptible to UTIs primarily because their urethra is shorter and closer to the anus[13]. The majority of patients were in the 20-40 year age range, followed by those under 20 years. This is consistent with a study by Beyene G et al[12]., which reported that 53.5% of cases were in the 19-39 year age group. In patients with UTIs, females were most frequently in the 21-40 year age group, while males were more commonly in the 61-80 year range. This aligns with the findings of Susan AMK[14], who observed that uncomplicated UTIs are most common in sexually active women, with fewer cases in older women, pregnant women, and men. In males, the incidence of UTIs tends to rise with age, likely due to prostate enlargement and other age-related issues.

In our study, E. coli was the most frequently isolated organism, a finding consistent with studies by Gupta et al[15]., Moges et al[16]., and Sibi et al[17]. Klebsiella was the second most common pathogen, representing 21.41% of cases. This result aligns with observations made by Khameneh et al[18]. and Chin et al[19]. In our study, E. coli exhibited the highest resistance to Ampicillin, followed by Nalidixic acid and Norfloxacin. Conversely, it was most sensitive to Nitrofurantoin (81.92%), with Amikacin (69.88%) also showing notable effectiveness. These results are consistent with those of Bashir MF et al[20]., who found that organisms were resistant to older urinary antimicrobial agents like ampicillin. This suggests that increased use of specific antibiotics may contribute to the development of resistance. Antimicrobial resistance is a natural biological response of microbes to antimicrobial drugs. Resistance may be inherent[21].

The correlation analysis reveals important relationships in urinary tract infections (UTIs) and antibiotic resistance patterns. Females show a significantly higher prevalence of UTIs than males (correlation: 0.65, p=0.001), especially in the 21-40 age group (0.75, p=0.002), while younger males (<20 years) exhibit lower infection rates (-0.45, p=0.04). Regarding antibiotic susceptibility, Escherichia coli responds well to Nitrofurantoin (0.82, p=0.001) but shows high resistance to Ciprofloxacin (-0.9, p=0.001). Klebsiella pneumoniae exhibits moderate resistance to Imipenem (0.68, p=0.01), and Acinetobacter shows some susceptibility to Amikacin (0.48, p=0.03), though it is highly resistant to multiple drugs (-0.7, p=0.01). These results highlight the critical need for effective monitoring of antibiotic resistance to inform appropriate treatment choices.

Our study showed the susceptibility pattern for *E-coli* as Nitrofurantoin > Amikacin > Impinem The susceptibility pattern for Klebsiella was Impinem >Amikacin > Ciprofloxacin and for Acinitobacter it was Amikacin >> Ciprofloxacin> Gentamycin and Cotrimoxazole. All the three most frequently isolated organisms showed resistant to commonly used antibiotics like Ampicillin, Norfloxacin and Nalidixic acid. Antimicrobial resistance is an inherent biological response of microbes to antimicrobial drugs[22,23].

In our study, E. coli displayed susceptibility in the following order: Nitrofurantoin > Amikacin > Imipenem. For Klebsiella, the susceptibility pattern was Imipenem > Amikacin > Ciprofloxacin, while Acinetobacter showed high sensitivity to Amikacin, followed by Ciprofloxacin, Gentamicin, and Cotrimoxazole. All three of the most frequently isolated organisms demonstrated resistance to commonly used antibiotics such as Ampicillin, Norfloxacin, and Nalidixic acid.

5. Conclusion

This study reveals a high prevalence of urinary tract infections (UTIs), with a significant gender disparity, as females are more affected than males. UTIs were most common in the 21-40 age group, particularly among females. Escherichia coli was the predominant pathogen, followed by Klebsiella pneumoniae and Acinetobacter. These pathogens showed high resistance to commonly used antibiotics like Ampicillin and Ciprofloxacin, while being more susceptible to Nitrofurantoin and Amikacin. The growing antibiotic resistance, especially in Klebsiella and Acinetobacter, highlights the need for careful monitoring and targeted treatment strategies.

Conflict of interest

The authors have no conflict of interest to declare.

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