

# Emerging Patterns of Antibiotic Susceptibility of Bacterial Pathogens at IAHS Hospital

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## ABSTRACT

**Background:** Antibiotic resistance is an increasing public health issue in Bangladesh, attributed to the prevalent neglect and overutilization of antibiotics. Inadequate regulatory enforcement and readily available over-the-counter access have contributed to resistance in prevalent bacterial infections. This development presents significant obstacles to efficient treatment and infection management nationwide. To find out the sensitivity and resistance pattern of different antibiotics used for common bacterial infections this research was performed.

**Materials and methods:** This Cross-sectional Descriptive study was done during the period from July 2024 to March 2025 on 60 patients with the evidence of infection includes (20 dissimilar blood samples, urine samples and sputum samples).

**Results:** In Blood samples *Salmonella* and *Staphylococcus aureus* show high sensitivity to Meropenem and cephalosporins, while *Klebsiella* exhibits moderate resistance to fluoroquinolones and cephalosporins. *E. coli* shows high sensitivity to Meropenem and Nitrofurantoin, while *Klebsiella* exhibits high resistance to key antibiotics but responds better to Amikacin and Meropenem in urine samples. *Klebsiella* shows high resistance to cephalosporins, while carbapenems and Amikacin remain effective, *Pseudomonas* exhibit notable resistance, especially to ceftazidime and piperacillin-tazobactam in sputum.

**Conclusion:** To sum up, the incensing trend of antimicrobial resistance need better monitoring, management and innovation, but depicting how resistance patterns are changing is critical for making therapeutic decisions.

**Key words:** Antimicrobial resistance; Antibiotic susceptibility; Bacterial pathogens.

## Introduction

Globally, multi-drug resistance nosocomial infections are a primary cause of mortality and morbidity among hospitalized patients, imposing a significant burden on both patients and the public health systems of all

nations.<sup>1</sup> Microorganisms present in the bloodstream, whether continually, intermittently or transiently, pose a hazard to every organ in the body.<sup>2</sup> All essential organs in the body are jeopardized by the incursion of germs into the circulatory system. The consequences of infection may include septic shock, multiple organ failure, disseminated intravascular coagulation, and death.<sup>2</sup>

Sepsis is characterized by the presence of bacterial toxins and a significant proliferation of bacteria within the circulatory system. Individuals with bloodstream infections generally have indications of systemic illness, such as increased inflammatory markers, fever and leukocytosis. Bloodstream infections may primarily arise from the dissemination of infective endocarditis.<sup>3</sup> Urinary tract infection, community-acquired pneumonia or secondary infection brought on by surgical procedures or device-associated infections. The gold standard for identifying these infections is blood culture. However, in order to stop uncontrolled development of sepsis, empirical antibiotic treatment is essential.<sup>4</sup>

The Extended Spectrum-  $\beta$ -Lactamase (ESBL) Enterobacteriaceae, Methicillin-Resistant *Staphylococcus aureus* (MRSA) vancomycin-resistant *Enterococcus* and drug-resistant organisms represent significant challenges

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in antimicrobial resistance. Mycobacterium tuberculosis poses significant threats to human health.<sup>5</sup>

Staphylococcus aureus is an opportunistic pathogen commonly located in the upper respiratory tract, nostrils, skin and perineum of humans. Staphylococcus aureus is implicated in a range of conditions, from minor skin infections and food poisoning to severe outcomes such as sepsis and endocarditis.<sup>6</sup> The S. aureus isolates were resistant to penicillin (74%), azithromycin (34%), cefoxitin (5%), ciprofloxacin (5%), tetracycline (4%) and trimethoprim (1%) but sensitive to gentamicin.<sup>11</sup>

Klebsiella species are aerobic or facultative anaerobic gram-negative bacteria that are classified within the family Enterobacteriaceae. Plasmid-mediated Extended Spectrum Beta-Lactamases (ESBLs) are known to degrade antibiotics, rendering them inactive.<sup>7</sup> Previous studies have indicated Klebsiella's resistance to antibiotics reaching 68.3% in south Africa, 54% in India and 97.17% in Equatorial Guinea.<sup>7-9</sup>

A study revealed the highest Klebsiella resistance in case of ampicillin (90.56%) followed by amoxicillin (76.01%) and trimethoprim-sulfamethoxazole (66.91%). A relatively low level of resistance rate was observed to amikacin (16.74%) and cefoxitin (29.73%).<sup>10</sup>

The prevalence of antimicrobial resistance among microorganism that causes Urinary Tract Infections (UTIs) is increasing worldwide including Bangladesh. UTIs narrate the presence of microbial pathogens within urinary tract.<sup>11</sup> Most of the time, antibiotics are prescribed without performing urine culture and sensitivity test. This improper usage of antibiotics consequently has developed antibiotic resistance in bacteria.<sup>12</sup> The most causative bacteria is Escherichia coli which is about 61.8%.<sup>12</sup>

### Materials and methods

This Cross-sectional Descriptive study was conducted in the outpatient Department of Medicine IAHS-Hospital. The study duration was from July 2024 to March 2025. Informed consent was obtained from each patient.

After conducting non-probability consecutive sampling methods, samples from 60 patients with evidence of Bacterial infection were selected. It included 20 blood samples; 20 urine samples and 20 sputum samples.

After sample collection, culture sensitivity testing involved:

- Inoculation–The sample were streaked on culture media (e.g. agar plates) to grow bacteria.
- Incubation–Plates were incubated to allow microbial growth.

iii) Identification and Testing–Colonies were identified, and antibiotic susceptibility was tested (Disc diffusion methods).

iv) Reporting–Results were interpreted according to CLSI guidelines to provide treatment.

### Inclusion criteria

- Age >18 years.
- Patients with evidence of Bacterial infections.

### Exclusion criteria

- Refuse to participate in the study
- Patients with known case of tuberculosis

Data were entered into Microsoft Excel data sheet to generate a master sheet. After completion of the data entry, the master sheet was fed into Statistical package for social science (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp) for processing and analysis. Antibiotic Susceptibility pattern was expressed as percentages.

## Results

**Table I** Antibiotic susceptibility pattern in blood sample (n=20)

Antibiotic	<i>Salmonella species</i>		<i>Staphylococcus aureus</i>		<i>Klebsiella species</i>	
	Sensitivity (%)	Resistance (%)	Sensitivity (%)	Resistance (%)	Sensitivity (%)	Resistance (%)
Amikacin	66.7	33.3	60.0	40.0	53.8	46.2
Amoxicillin + Clavulanic acid	91.7	8.3	42.86	57.14	61.5	38.5
Azithromycin	58.3	41.7	66.67	33.33	69.2	30.8
Cefuroxime	58.3	41.7	71.43	28.57	61.5	38.5
Cefixime	66.7	33.3	50.00	50.00	69.2	30.8
Ceftazidime	50.0	50.0	66.67	33.33	61.5	38.5
Cefepime	50.0	50.0	62.50	37.50	69.7	30.3
Ciprofloxacin	58.3	41.7	71.54	28.46	53.8	46.2
Ceftriaxone	58.3	41.7	83.33	16.67	53.8	46.2
Cotrimoxazole	83.3	16.7	57.14	42.86	N/A	N/A
Doxycycline	66.7	33.3	75.00	25.00	N/A	N/A
Meropenem	83.3	16.7	85.71	14.29	61.5	38.5
Piperacillin + Tazobactam	N/A	N/A	71.43	28.57	69.2	30.8

Table I reflects that *Salmonella species* had high sensitivity to Amoxicillin-Clavulanate (91.7%) Meropenem (83.3%) Ceftriaxone (58.3%). Highest sensitivity observed to Ceftriaxone (83.3%) Meropenem (85.7%) Cefuroxime (71.4%) and Doxycycline (75%) for *Staphylococcus aureus*. *Klebsiella species* revealed 46.2% resistance to Amikacin, Ciprofloxacin and Ceftriaxone.

**Table II** Antibiotic susceptibility observed in urine sample (n=20)

Antibiotic	<i>E. Coli</i>		<i>Klebsiella species</i>	
	Sensitivity (%)	Resistance (%)	Sensitivity (%)	Resistance (%)
Amikacin	78.6	21.4	85.0	15.0
Amoxicillin + Clavulanic acid	42.9	57.1	N/A	N/A
Azithromycin	71.4	28.6	73.3	26.7
Cefuroxime	28.6	71.4	76.7	23.3
Cefixime	21.4	78.6	80.0	20.0
Ceftazidime	42.9	57.1	93.3	6.7
Cefepime	41.7	58.3	66.7	33.3
Ciprofloxacin	64.3	35.7	45.0	55%
Ceftriaxone	80.0	20.0	72.3	27.7
Cotrimoxazole	36.4	63.6	86.7	13.3
Doxycycline	37.5	62.5	80.0	20.0
Meropenem	92.3	7.7	80.0	20.0
Nitrofurantoin	84.6	15.4	63.6	36.4
Piperacillin + Tazobactam	57.1	42.9	66.7	33.3

The above Table shows that *E. Coli* was more sensitive to Meropenem (92.3%), Nitrofurantoin (84.6%), Ceftriaxone (80%), Amikacin (78.6%), Azithromycin (71.4%), Ciprofloxacin (64.3%). The *Klebsiella* isolates showed high sensitivity to amikacin (85%) and ceftriaxone (72.3%), meropenem (80%) while 55% resistance was observed for ciprofloxacin. In contrast, lower resistance rates were noted for amikacin (15%) and meropenem (20%) making them more effective treatment options. Piperacillin + tazobactam demonstrated intermediate sensitivity (66.7%).

**Table III** Sputum sample examination focusing on antibiotic susceptibility (n=20)

Antibiotic	<i>Klebsiella species</i>		<i>Pseudomonas species</i>	
	Sensitivity (%)	Resistance (%)	Sensitivity (%)	Resistance (%)
Amikacin	85.3	14.7	81.8	18.2
Amoxicillin + Clavulanic acid	40.0	60.0	92.4	7.6
Azithromycin	53.3	46.7	93.3	6.7
Cefuroxime	46.7	53.3	86.7	13.3
Cefixime	46.7	53.3	63.5	36.5
Ceftazidime	33.3	66.7	45.0	55.0
Cefepime	53.3	46.7	94.3	5.7
Ciprofloxacin	48.5	51.5	90.3	9.7
Ceftriaxone	26.7	73.3	93.3	6.7
Cotrimoxazole	53.3	46.7	92.7	7.3
Doxycycline	60.0	40.0	96.6	3.4
Meropenem	87.2	12.8	60.9	39.1
Piperacillin + Tazobactam	26.7	73.3	57.0	43.0

It is disclosed by the above Table, in case of *Klebsiella species*, high resistance was observed against Amoxicillin +clavulanic acid (60%) and ceftriaxone (73.3%) while moderate resistance was seen with ciprofloxacin (51.5%). Carbapenems like meropenem remained relatively effective, with resistance around (12.8%). Amikacin showed good activity, with resistance at (14.7%). In contrast, *Pseudomonas* isolates displayed high resistance to ceftazidime (55%) and piperacillin-tazobactam (43%) while carbapenems (Meropenem) had resistance rates of 39.1%.

### Discussion

Table I presents antibiotic sensitivity and resistance profiles for three bacterial species: *Salmonella species*, *Staphylococcus aureus* and *Klebsiella species*.

This antibiotic sensitivity profile can help guide empirical therapy decisions and supports the need for tailored antimicrobial stewardship based on local resistance patterns.

Among *Salmonella isolates*, the highest sensitivity was observed with Amoxicillin + Clavulanic acid (91.7%) and Meropenem (83.3%) while Cefepime and Ceftazidime showed the lowest sensitivity (50%). For *Staphylococcus aureus*, Meropenem (85.71%) and Ceftriaxone (83.33%) were the most effective, followed by Doxycycline (75%) and Cefuroxime (71.43%), Ciprofloxacin (71.54%). However, resistance was highest against Amoxicillin + Clavulanic acid (57.14%). *Klebsiella species* showed (69.2%) sensitivity to Piperacillin + Tazobactam, Azithromycin (61.5%), Cefepime (69.7%) Ceftazidime (61.55) and Cefixime (69.2%) while Ciprofloxacin and Ceftriaxone showed lower effectiveness (53.8%) with higher resistance (46.2%). Overall, Meropenem demonstrated strong efficacy across all three bacterial species, suggesting its reliability as a broad-spectrum option. *Salmonella species* show the highest sensitivity to Amoxicillin + Clavulanic acid and Meropenem. *Staphylococcus aureus* is highly susceptible to Meropenem, Ceftriaxone and Doxycycline. *Klebsiella species* exhibit better sensitivity to broad-spectrum cephalosporins and Piperacillin + Tazobactam.

The meta-analysis by Gebremeskel L et al. reveals a high overall *Klebsiella* resistance rate of 53.75% in Ethiopia, with regional variations ranging from 46.16% (Tigray) to 64.39% (Southern Nations). Resistance is alarmingly high to ampicillin (90.56%) amoxicillin (76.01%) and trimethoprim-sulfamethoxazole (66.91%) but remains relatively low for amikacin (16.74%) and ceftioxin (29.73%). These findings underscore the urgent need for antibiotic stewardship and tailored treatment strategies to combat rising resistance.<sup>10</sup>

Worku M et al. found extremely high resistance in neonatal *K. pneumoniae* isolates to frontline antibiotics like cefotaxime (100%) but noted preserved susceptibility to nitrofurantoin (86.6%) and carbapenems (Imipenem 85.7%) though 57.1% were multidrug-resistant, demanding urgent antimicrobial stewardship. The predominance in bloodstream infections (81.6%) highlights the critical need for neonatal infection control protocols and evidence-based antibiotic selection in this vulnerable population.<sup>13</sup>

Congdon S T et al. found a 21% *S. aureus* prevalence, with high resistance to penicillin (74%) and azithromycin (34%) but notably low resistance to cefoxitin (5%, suggesting rare MRSA) and other tested antibiotics. Isolates remained highly susceptible to gentamicin and rifampin (100%) indicating these as effective treatment options for *S. aureus* infections in this setting.<sup>6</sup>

N.V. et al. revealed alarmingly high resistance in *S. aureus* isolates to macrolides (Azithromycin 82.28%, erythromycin 82.82%) and clindamycin (82.32%) while glycopeptides (Teicoplanin 0%, vancomycin 2.92%) and newer agents (tigecycline 0.16%) remained highly effective. MRSA (73.02%) and MDR strains (60.90%) were widespread, with ICU isolates showing the highest multidrug resistance (77.78%), emphasizing the urgent need for enhanced infection control and antibiotic stewardship in hospital settings, particularly in surgical and critical care units.<sup>14</sup>

*E. coli* showed high sensitivity to Meropenem, Nitrofurantoin, and Ceftriaxone, indicating their strong effectiveness. In contrast, *Klebsiella* exhibited high resistance to most antibiotics, though Amikacin and Meropenem retained some effectiveness with lower resistance rates (Table II). The study in Bangladesh by Tarannum Haque F et al. found that a 24% culture positivity rate among UTI patients, predominantly in females (73%) with *E. coli* (57.4%) and *Klebsiella* (17.3%) as leading pathogens showing high resistance to quinolones (57%), 3rd-gen cephalosporins (55%) and cotrimoxazole (54%) while carbapenem resistance (5–8.6%) remained low but emerging. The high prevalence of resistance to first-line antibiotics and rising imipenem resistance in Gram-negatives underscores the need for improved diagnostics, antimicrobial selectiveness and alternative treatment strategies for UTIs.<sup>15</sup>

In Table III, *Klebsiella species* showed high resistance to Amoxicillin + Clavulanic acid and Ceftriaxone, while carbapenems and Amikacin remained effective. *Pseudomonas* isolates exhibited notable resistance to Ceftazidime and Piperacillin and Tazobactam combination, with moderate resistance to Meropenem.

### Limitation

- Findings may not be generalizable due to geographic differences in antibiotic prescribing practices, resistance patterns and bacterial strain prevalence.
- Overrepresentation of hospital-acquired infections or specific patient populations (e.g. ICU) may skew resistance profiles, underestimating community trends.
- Without molecular characterization (e.g. Resistance genes, clonal spread), the emerging patterns remain hypothetical.

### Conclusion

Analyzing antibiotic susceptibility patterns is essential for addressing antimicrobial resistance (AMR) and informing effective treatment methods. Significant resistance trends, especially to first-line antibiotics, were detected; nevertheless, regional heterogeneity and data limitations underscore the necessity for systematic surveillance and antimicrobial administration. Confronting these difficulties by synchronized global initiatives, sophisticated diagnostics, and focused medicines will be crucial to maintain antibiotic effectiveness and enhance patient outcomes. Proper measure should be taken to avoid development of antibiotic resistance, which is essential to treat the disease properly and effectively.

### Recommendations

The rapid evolution of resistance necessitates real-time surveillance systems and prompt data dissemination to ensure clinical relevance. Integrating genomic sequencing could enhance early detection of emerging resistance mechanisms.

### Disclosure

The authors declare no conflict of interest.

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