Original Article

The Rising Threat of Antimicrobial Resistance in Respiratory Tract Infections in Bangladesh

Chakroborty P[1*], Dhar P[2], Hridoy MH[3], Munna JA[4], Benzamin M[5].

1. Dr. Pranto Chakroborty, Research Associate, Dr. Benzamin's Pediatric Liver Research Center and Nutrition Clinic, Sylhet.
2. Dr. Prima Dhar, Medical Officer, Mount Adora Hospital, Sylhet.
3. Dr. Mahabub Hasan Hridoy, Medical Officer, Mount Adora Hospital, Sylhet.
4. Dr. Jabed Ahmed Munna, Medical Officer, Mount Adora Hospital, Sylhet.
5. Dr. Md. Benzamin, Registrar, Paediatric Gastroenterology & Nutrition, Sylhet MAG Osmani Medical College Hospital, Sylhet.

***Corresponding Author**

Abstract

Background: Respiratory tract infections (RTIs) contribute substantially to morbidity and healthcare burden in Bangladesh, where overcrowding, high antibiotic misuse, and limited diagnostic capacity accelerate the emergence of antimicrobial resistance. Despite this, local data on pathogen distribution and resistance patterns remain limited. To address this gap, this study investigates the bacterial profile and antimicrobial resistance patterns in sputum samples from patients with suspected RTIs.

Materials and Methods: A retrospective cross-sectional study was conducted at Mount Adora Hospital, Sylhet, Bangladesh, from July 2023 to February 2024. A total of 342 sputum samples were collected, and sample quality was assessed using the Bartlett scoring system. Only culture-positive specimens with Bartlett score ≥1 were included. Bacterial identification was performed using standard microbiological techniques, and antimicrobial susceptibility testing (AST) was conducted by the Kirby–Bauer disk diffusion method following Clinical and Laboratory Standards Institute (CLSI).

Results: Out of 342 sputum samples, 259 (76%) acceptable-quality specimens were analyzed. Gram-negative bacteria predominated (61%), with Klebsiella pneumoniae (41.7%) being the most frequent isolate. Among gram-positives, Streptococcus pneumoniae (23.6%) was common. Gram-negative isolates showed highest resistance to azithromycin (80.1%) and cefixime (79.9%). Gram-positive isolates exhibited high resistance to cefixime (80.2%) and azithromycin (80.2%).

Conclusion: A high level of resistance to commonly used antibiotics was observed, indicating a growing threat of antimicrobial resistance. Continuous surveillance, rational antibiotic use, and implementation of antibiotic awareness programs are essential to combat resistant pathogens.

Keywords: Antimicrobial resistance, Respiratory tract infection, Sputum, Bangladesh.

Introduction

Lower respiratory tract infections (LRTIs) are a major cause of global morbidity and mortality, responsible for approximately 2.74 million deaths each year.[1] They account for nearly 4.4% of hospital admissions for severe illness worldwide.[2] The primary bacterial pathogens implicated in LRTIs vary geographically but commonly include Gram-positive cocci such as Streptococcus pneumoniae and Staphylococcus aureus, as well as Gram-negative bacilli like Klebsiella pneumoniae, Pseudomonas aeruginosa, Haemophilus influenzae, and Acinetobacter baumannii.[3,4] A five-year hospital-based surveillance from Italy identified A. baumannii (18.6%), S. aureus (15.2%), P. aeruginosa (14.2%), and K. pneumoniae (10.9%) as the leading LRTI pathogens, with 72.5% of isolates being Gram-negative.[4]

In low- and middle-income countries (LMICs) such as Bangladesh, irrational antibiotic use, over-the-counter drug availability, and lack of infection control measures contribute significantly to the rise in multidrug-resistant (MDR) pathogens in LMICs.[5] In Bangladesh, antimicrobial resistance (AMR) is a rapidly growing public health threat: national surveillance by IEDCR from 2016 to 2023 found that ~8% of isolates may be pan-drug resistant, and resistance among Enterobacterales climbed from 59% to nearly 79% over time.[6] Laboratory data from over one million culture records (2016–2020) showed a bacterial growth rate of around 28.9%, with common pathogens including E. coli, Klebsiella, and Pseudomonas.[6]

Empirical treatment of LRTIs often begins before laboratory results are available, making it crucial to understand the local bacterial profile and susceptibility patterns. Updated, region-specific data can guide more effective empiric therapy, reduce inappropriate antibiotic use, and support antimicrobial stewardship programs. This study aimed to determine the microbiological spectrum and antimicrobial resistance patterns in sputum samples collected from patients with respiratory tract infections at a hospital in Bangladesh between July 2023 and February 2024. Findings were compared with national and international data to assess the current resistance landscape and support clinical decision-making.

Materials and Methods

This retrospective study was conducted in Mount Adora Hospital, Sylhet, Bangladesh, between July 2023 and February 2024. Sputum samples were collected from both inpatients and outpatients with clinically suspected lower respiratory tract infections, defined by the presence of cough, fever, purulent sputum, dyspnea, and/or radiological evidence consistent with LRTI. A total of 342 culture-positive sputum samples were initially identified, after which sputum quality was evaluated using the Bartlett scoring system;[7] samples with a score ≥1 were considered acceptable, yielding 259 high-quality specimens for analysis. Only culture positive sputum samples with Bartlett score ≥1 were included in this study. Any patient with incomplete medical records, prior antibiotic use within 72 hours of sputum collection, or contaminated/mixed growth cultures, or any duplicate samples were excluded from this study.

Specimens were Gram-stained and cultured on blood, chocolate, and MacConkey agar, followed by aerobic incubation at 37°C for 24–48 hours. Isolates were identified based on colony morphology, Gram reaction, and biochemical characteristics. Antimicrobial susceptibility testing was performed by the Kirby–Bauer disk diffusion method on Mueller–Hinton agar, and results were interpreted according to current Clinical and Laboratory Standards Institute (CLSI) guidelines.[8]

Patient and laboratory data were retrieved from hospital records using a structured form. Data were analyzed using SPSS version 27, applying descriptive statistics. Ethical approval was obtained from Mount Adora Hospital, and the requirement for informed consent was waived due to the retrospective nature of the study.

Results

A total of 342 sputum samples were analyzed, out of them, 259 (76%) of the samples with acceptable Bartlett score were included in this study. Among 259 patients, the majority of them were aged between 19–60 years (49%) and over 60 years (48.3%), and a male-to-female ratio of 1.44:1.

Table I: Distribution of Organisms Isolated from Sputum samples

Organism Isolated	Frequency (n=259)
Klebsiella pneumoniae	108 (41.7%)
Stretococcus pneumoniae	61 (23.6%)
Pseudomonasaeruginosa	47 (18.1%)
Staphylococcus aureus	21 (8.1%)
Fungus	19 (7.3%)
Acinetobacter sp.	3 (1.2%)

The most commonly isolated organisms were Klebsiella pneumoniae (41.7%), Stretococcus pneumoniae (23.6%), Pseudomonas aeruginosa (18.1%), Staphylococcus aureus (8.5%), fungi (7.3%), and Acinetobacter species (1.2%) (Table I).

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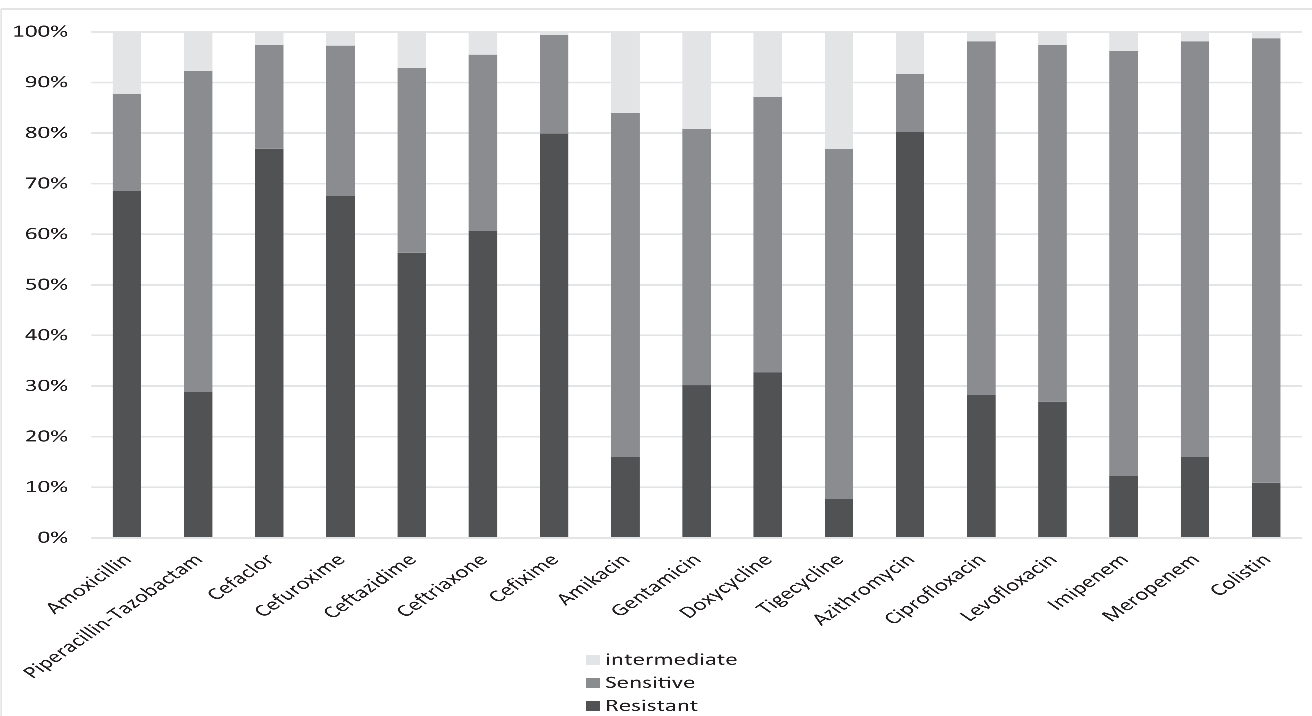
Table II: Antimicrobial Resistance Status in Patients with LRTI Caused by Gram Negative Organisms (n=158)

Antibiotic Group	Antibiotic	Resistant (%)	Sensitive (%)	Intermediate (%)
Penicillin	Amoxicillin	68.6	19.2	12.2
	Piperacillin-Tazobactam	28.8	63.5	7.7
Cephalosporin	Cefaclor	76.9	20.5	2.6
	Cefuroxime	67.6	29.7	2.7
	Ceftazidime	56.4	36.5	7.1
	Ceftriaxone	60.6	34.8	4.5
	Cefixime	79.9	19.5	0.6
Aminoglycoside	Amikacin	16.0	67.9	16.0
	Gentamicin	30.1	50.6	19.2
Tetracycline	Doxycycline	32.7	54.5	12.8
	Tigecycline	7.7	69.2	23.1
Macrolide	Azithromycin	80.1	11.5	8.3
Fluoroquinolone	Ciprofloxacin	28.2	69.9	1.9
	Levofloxacin	26.9	70.5	2.6
Carbapenem	Imipenem	12.2	84.0	3.8
	Meropenem	16.0	82.1	1.9
Polymyxin	Colistin	10.9	87.8	1.3



Column chart 1: Antibiotic Resistance & Sensitivity in Gram negative LRTI organisms

Antimicrobial culture-sensitivity testing in gram negative isolates showed high resistance to Azithromycin (80.1%) and Cefixime (79.9%), while the highest sensitivity rates were observed with Colistin (87.8%), Imipenem (84%) and Meropenem (82.1%) (Table II, Column Chart 1).

Table III: Antimicrobial resistance status in patients with LRTI caused by Gram positive organisms (n=82)

Antibiotic Group	Antibiotic	Resistant (%)	Sensitive (%)	Intermediate (%)
Penicillin	Amoxicillin	24.7	69.1	6.2
	Piperacillin - Tazobactam	18.5	74.1	7.4
Cephalosporin	Cefaclor	40.7	54.3	4.9
	Cefuroxime	30.8	66.7	2.6
	Ceftazidime	69.1	23.5	7.4
	Ceftriaxone	51.9	45.6	2.5
	Cefixime	80.2	18.5	1.2
Tetracycline	Doxycycline	28.4	65.4	6.2
	Tigecycline	2.4	97.6	0.0
Macrolide	Azithromycin	80.2	11.1	8.6
Oxazolidinone	Linezolid	60.9	37.5	1.6
Fluoroquinolone	Ciprofloxacin	55.6	37.0	7.4
	Levofloxacin	35.8	54.3	9.9
Carbapenem	Imipenem	6.2	92.6	1.2
	Meropenem	8.6	88.9	2.5
Others	Vancomycin	44.4	54.3	1.2

Antimicrobial culture-sensitivity testing in gram positive isolates showed high resistance to Cefixime (80.2%) and Azithromycin (80.2%), while the highest sensitivity rates were observed with Tigecycline (97.6%), Imipenem (92.6%) and Meropenem (88.9%) (Table III, Column Chart 2).

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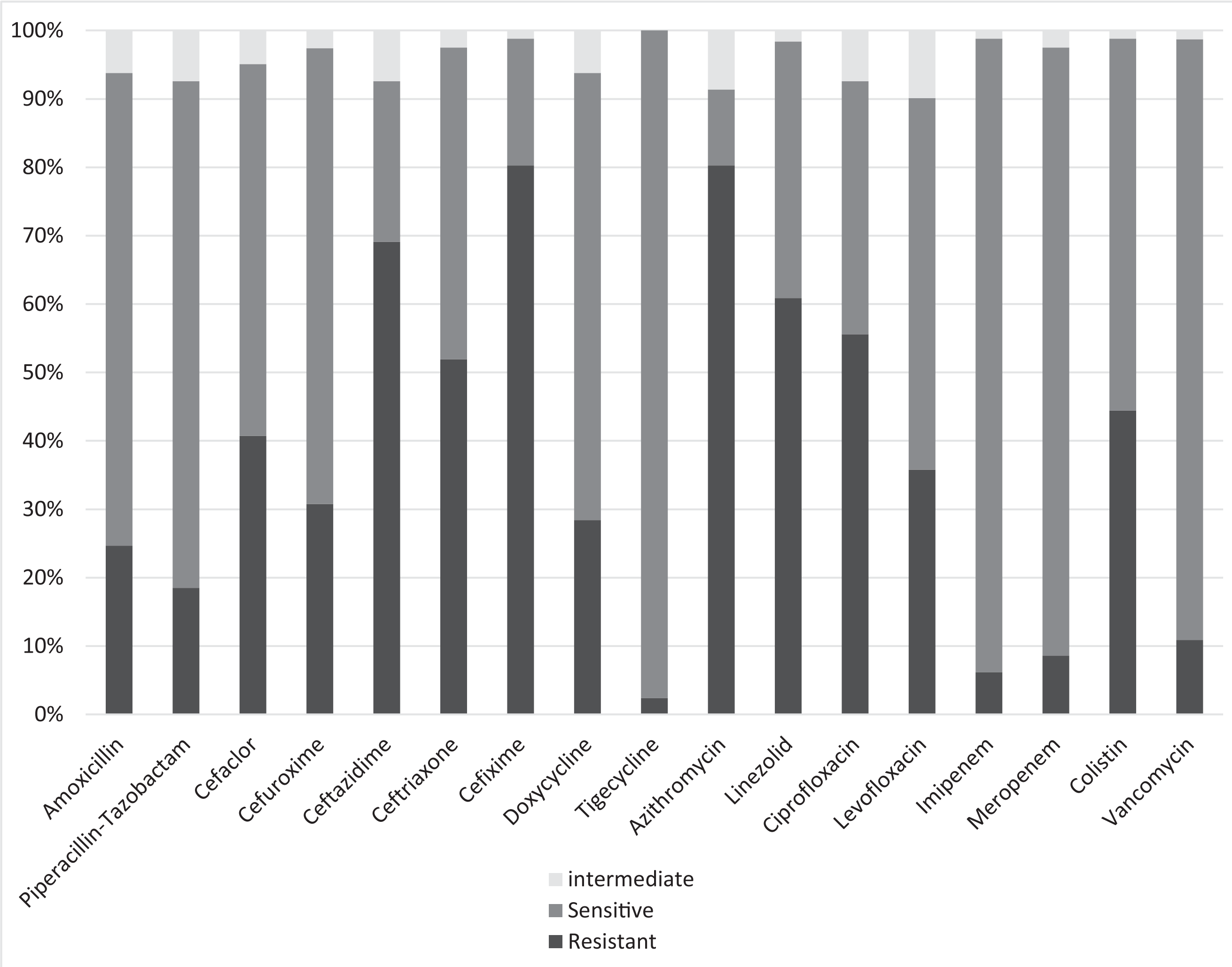

Column chart 2: Antibiotic Resistance & Sensitivity in Gram positive LRTI organisms

Antimicrobial culture-sensitivity testing showed high resistance to Cefixime (81.2%), Azithromycin (80.5%), Linezolid (78.4%) and Vancomycin (72.5%), while the highest sensitivity rates were observed with Imipenem (88.3%), Meropenem (84.4%), Tigecycline (76.5%), Amikacin (65.6%), Levofloxacin (64.0%), and Doxycycline (61.7%) (Table II, Column Chart 1).

Discussion

In this study of 259 patients with LRTI, Gram-negative bacteria predominated. Overall 61.0% of isolates were Gram-negatives (158/259) and 31.7% were Gram-positives (82/259), with 7.3% fungi. Klebsiella pneumoniae was the single most common pathogen (41.7% of all isolates), followed by Streptococcus pneumoniae (23.6%), Pseudomonas aeruginosa (18.1%), and Staphylococcus aureus (8.1%). Antibiotic testing revealed very high resistance, gram-negatives showed 80.1% resistance to azithromycin and 79.9% to cefixime, while the highest susceptibilities were to colistin (87.8%), imipenem (84.0%) and meropenem (82.1%). Gram-positive isolates had 80.2% resistance to cefixime and azithromycin, with 92.6% sensitivity to imipenem and 88.9% to meropenem.

The predominance of Gram-negative bacteria (61%) in our cohort is consistent with other Bangladeshi RTI surveys. For example, Chowdhury et al. found 88.8% Gram-negatives among respiratory isolates (predominantly Pseudomonas and Klebsiella).[9] Similarly, Khan et al. reported 81.3% Gram-negatives (with K. pneumoniae 48.1%, E. coli 26.9%) versus 18.8% Gram-positives.[10] Ahmed et al. identified K. pneumoniae (34.4%), P. aeruginosa (21.3%) and S. pneumoniae (14.8%) as top pathogens in LRTI, again emphasizing Gram-negative dominance.[11] Conversely, Salam et al. (2017) found S. pneumoniae (53.8%) and K. pneumoniae (26.9%) as leading causes of community-acquired pneumonia.[12] The relative under-representation of S. aureus in our data (8.1%) compared to some older CAP series may reflect shifts toward Gram-negative and atypical pathogens or variations in patient populations. These parallels suggest our pathogen distribution is broadly in line with national trends.

Our Gram-negative antibiogram shows alarming resistance rates. Azithromycin (80.1%) and cefixime (79.9%) resistance were highest among Gram-negatives. This mirrors other findings: Promite et al. found respiratory samples to be 100% resistant to amoxicillin and ~75–80% resistant to multiple cephalosporins.[13] Chowdhury et al. similarly reported Gram-negatives “mostly resistant to amoxicillin followed by fluoroquinolones and cephalosporins”,[14] and Khan et al. observed Klebsiella with 91% amoxicillin resistance and 66% cefixime resistance.[10] Amin et al. specifically noted cefixime and azithromycin as the most resisted drugs in both Gram negative and positive organisms.[15] These findings confirm that broad-spectrum beta-lactams and macrolides are largely ineffective against Bangladeshi Gram-negative RTI pathogens. Such high resistance likely reflects rampant antibiotic use and unregulated over-the-counter availability, as previously documented in Bangladesh.[10] These patterns raise concern that empiric therapy with common outpatient antibiotics (macrolides, third-generation cephalosporins) may often fail against Gram-negative RTI pathogens.

By contrast, sensitivity among Gram-negatives remains highest for last-resort drugs. In our data colistin was 87.8% active, imipenem 84.0%, and meropenem 82.1%. Chowdhury et al. similarly found colistin and carbapenems to be the most effective against Gram-negatives,[14] and Khan et al. observed 100% imipenem susceptibility.[10] These data suggest that carbapenems and polymyxins retain high efficacy locally. Global reports echo this, although emerging carbapenem-resistance genes have been noted in some studies. Overall, our results support that severe Gram-negative RTI pathogens in Bangladesh are now largely multidrug-resistant, with the only reliable options being reserve antibiotics. Such dependence on carbapenems underscores the risk of future pan-resistance if stewardship is not improved.

Gram-positive resistance was also high in this study. We saw 80.2% resistance to cefixime and azithromycin among Gram-positives. Linezolid resistance was 60.9% and ciprofloxacin 55.6%, while vancomycin resistance was 44.4%. In Bangladesh, similarly high Gram-positive resistance has been reported. Chowdhury et al. found majority of Gram-positive bacteria resistant to fluoroquinolones and co-trimoxazole, though notably all S. aureus remained vancomycin- and linezolid-susceptible.[9] Amin et al. also highlighted cefixime and azithromycin as the most resisted drugs against respiratory Gram-positives.[15] Our finding of nearly 80% macrolide/cephalosporin resistance in Gram-positives is in line with the global rise of drug-resistant pneumococci and staphylococci; it suggests that even older Gram-positive therapies are compromised in Bangladesh. The vancomycin resistance is particularly striking and somewhat higher than earlier reports of vancomycin efficacy in S. aureus,[9] possibly reflecting

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our inclusion of other Gram-positives. In summary, Bangladeshi Gram-positive RTI isolates now frequently harbor multi-drug resistance, making empiric coverage difficult.

Sensitivity among Gram-positives remained highest for novel or broad agents. Tigecycline (97.6%), imipenem (92.6%) and meropenem (88.9%) showed the highest susceptibility rates in our Gram-positive isolates. Other studies likewise emphasize the continued potency of carbapenems and related drugs against Gram-positives: Chowdhury et al. found 100% S. aureus susceptibility to vancomycin/linezolid and 84% to teicoplanin.[9] Salam et al. noted meropenem as the single most sensitive drug.[12] Therefore, although Gram-positive resistance to penicillins and macrolides is widespread, drugs like linezolid, carbapenems or tigecycline remain reliable.

These findings reinforce that both Gram-negative and Gram-positive organisms in Bangladesh show extreme resistance to broad-spectrum oral agents. These findings emphasize the urgent need for evidence-based prescribing, routine susceptibility testing, and national policies to combat the AMR crisis in LRTIs.

Study Limitations

This study has some limitations, including a single-center design, which may not fully represent national trends. Additionally, molecular characterization of resistance genes was not performed, which could have provided deeper insights into resistance mechanisms.

Conclusion

This study highlights the alarming prevalence of antimicrobial resistance in respiratory pathogens in Bangladesh. Both gram positive and negative isolates showed high resistance to commonly used antibiotics such as cefixime, azithromycin, linezolid, and vancomycin. In contrast, carbapenems, tigecycline, and amikacin remain effective but should be preserved through judicious prescription. These findings emphasize the urgent need for evidence-based prescribing, routine susceptibility testing, and national policies to combat the AMR crisis in respiratory infections.

Data Availability statement: The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

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Conflict of Interest Disclosure: The authors declare no conflict of interest.

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