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RESEARCH ARTICLE

ANTIMICROBIAL RESISTANCE IN LOWER RESPIRATORY TRACT INFECTIONS: INSIGHTS FROM SPUTUM CULTURE ANALYSIS AT A TERTIARY CARE HOSPITAL IN TELANGANA

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Abstract

Introduction: Lower respiratory tract infections (LRTIs) remain a major cause of morbidity and mortality globally, particularly in developing countries like India, where the burden is significantly higher. The rise of antimicrobial resistance (AMR especially among Gram-negative bacteria,complicates clinical management, highlighting the need for region-specific surveillance to guide empirical therapy. This study aims to evaluate the bacterial profile and antimicrobial susceptibility patterns of sputum and endotracheal aspirates from patients with suspected LRTIs in a tertiary care center in Telangana.

Materials and Methods:A prospective study was conducted from January 2024 to May 2025 in the Department of Microbiology. A total of 406 sputum and endotracheal aspirate samples were collected from patients aged ≥18 years with clinical features of LRTI. Samples were processed using standard microbiological techniques and assessed using Bartlett's criteria. Isolates were identified by colony morphology, Gram staining, and biochemical tests. Antimicrobial susceptibility testing was performed using the Kirby-Bauer disc diffusion method according to CLSI 2025 guidelines.

Results: Out of 406 samples, 152 (37.33%) yielded positive bacterial growth. The majority of patients were male (69.07%) and aged 41–60 years. Klebsiella pneumoniaewas the most common isolate (51.3%), followed by Pseudomonas aeruginosa (22.4%), Acinetobacter spp. (15.8%), E. coli (6.6%), and Staphylococcus aureus (3.9%). Klebsiella isolates showed high susceptibility to Ciprofloxacin (92.3%) and Cefepime (82.1%). Imipenem was the most effective antibiotic against Pseudomonas (82.3%), Acinetobacter (79.2%), and E. coli (90%). MRSA was detected in 33.3% of Staphylococcus aureus isolates, all of which were sensitive to Vancomycin and Linezolid.

Conclusion: The study underscores a high burden of Gram-negative pathogens in LRTIs with notable multidrug resistance, especially in ICU settings.. Routine culture, local antibiograms, and antimicrobial stewardship programs are essential for optimizing treatment outcomes and combating AMR in respiratory infections.

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Introduction:-

Lower respiratory tract infections (LRTIs) represent a major public health problem, with great morbidity and mortality in people of all ages.They form a continuum of clinic disease, from mild, non-pneumonic infections in otherwise healthy young adults to severe pneumonia or life-threatening exacerbations in those with established chronic obstructive pulmonary disease (COPD). The prevalence of LRTIs such as pneumonia, which is also particularly common in developing countries, is much greater in these regions than in industrialized nations, occuring in up to 20-30% as opposed to only 3-4% in developed countries.[1] Geographical, climatic, and socioeconomic variations, as well as factors linked to LRTI and antibiotic susceptibility, influence the etiological agents of LRTI infections in different countries and populations.[2]

In recent years, the clinical management of LRTIs has been significantly complicated by the rise of antimicrobial resistance (AMR), particularly among Gram-negative bacteria. A tertiary-care study in Karnataka reported that **25.7%** of Gram-negative isolates from clinical samples were multidrug-resistant (MDR), with high rates of carbapenemase and AmpC β-lactamase production in Klebsiella pneumoniae and Escherichia coli. (3)Another study from South India highlighted the prevalence of MDR infections in ICU patients with respiratory infections, where **77.7%** of isolated Gram-negative pathogens showed carbapenem resistance, most strikingly in Acinetobacter baumannii andK. pneumoniae . These trends, driven by factors like indiscriminate antibiotic use, delayed de-escalation, and suboptimal infection control, are especially pronounced in tertiary-care settings housing immunocompromised or ventilated patients—where the risk of selecting and spreading MDR organisms is amplified.

Understanding local bacterial spectra and resistance patterns is therefore essential to inform empirical therapy and guide antimicrobial stewardship. Evidence from tertiary centers across India underscores significant institutional variability in resistance profiles, reinforcing the need for site-specific surveillance data to shape effective treatment protocols. (4) Despite its importance, region-specific data remain limited in several Indian states, including Telangana. The present study addresses this gap by characterizing sputum isolates and their antimicrobial susceptibilities at a tertiary care hospital in Telangana, aiming to support data-driven clinical decisions and broader AMR mitigation strategies.

Material and Methods:-

Study design, period and population

This prospective study was conducted from Jan 2024 to May 2025 in the Department of Microbiology. Participants either from outpatient or inpatient department, who were aged 18 years and older, with symptoms of LRTI (productive cough, fever, and chest pain), who were negative on screening for AFB smears.

Exclusion criteria

Exclusion criteria included patients who had been treated with antibiotics in the past 14 days, history of tuberculosis in the preceding 2 years, being too critically ill to produce an expectorated sputum sample, and those whose samples did not meet Bartlett's criteria.

Collection of sample and data

Two sputum samples were collected from each patient, while endotracheal aspirates were obtained from those on ventilator support. All samples were processed within two hours of collection promptly in the Laboratory of Microbiology.

Isolation and Identification of Isolates

The samples were examined both macroscopically and microscopically as part of the routine microbiological microbiological procedures used to analyze the samples. Gram-stained smears were analyzed to assess the nature of exudates, as well as number and type of microorganisms present. The purulent portion of the approved sputum sample was inoculated onto MacConkey, Chocolate and Blood agar (HiMedia Laboratories Pvt. Ltd., Mumbai, India) with sterile inoculating loop. MacConkey agar plates were incubated aerobically at 37°C for 24 hours, while Chocolate and Blood agar plates were incubated at 37°C for 24 hours in a candle jar to generate 5-10% CO_2 atmosphere. The culture plates were inspected for bacterial growth following a 24-hour incubation period. Following that, the isolates were identified using standard microbiological techniques by relevant biochemical tests. (5)

Initially to evaluate the pure bacterial isolates, colony morphology, Gram staining and hemolysis pattern on blood agar were used. Biochemical assays were used for further identification. Tests for Gram-positive organisms included Bile-esculin agar, Optochin (30µg), Bacitracin (30µg), Coagulase and Catalase. Oxidase, Indole production, Citrate utilization, Urease test, gas and hydrogen sulphide production, and motility testing were all used to identify Gram-negative bacteria.

Antimicrobial susceptibility testing
The disc diffusion technique that was recommended by the Clinical and Laboratory Standards Institute (CLSI) on Mueller-Hinton agar for performing the antimicrobial susceptibility testing. The following antibiotics were used in this investigation in accordance to with CLSI (2025)[6] guidelines: Augmentin, Cefepime, Ceftriaxone, Ceftazidime, Cefoxitin, Ciprofloxacin, Cotrimoxazole, Gentamicin, Imipenem, Tetracycline for Gram-negative isolates, while Ciprofloxacin, Clindamycin, Cotrimoxazole, Erythromycin, Gentamicin, Linezolid, Oxacillin, Tetracycline, Vancomycin were used for Gram-positive isolates. Lastly, the diameter of the zone of inhibition was measured to determine if the result was sensitive (S), resistance (R) or intermediate (I).

Data Processing and Analysis:-

Microsoft Excel was used to enter the patient's demographic data, place of admission, and laboratory results for frequency distribution analysis.

Results:-

Demographic data
406 samples in all were obtained from patients having suspected LRTI who were hospitalized or who visited the outpatient departments during the study period. Of these, 57 were ET secretions and 349 were sputum samples. 152 samples (37.33%) of the processed samples tested positive for culture. Age wise distribution of patients showed that the majority were in the 41-60 years (39.8%), followed by those aged 61-80 years (27.7%) and 21-40 years (19.6%). Patients aged below 20 years accounted for 6.9%, while those above 80 years made up 6% of total cases. Male patients accounted for 105 (69.07%) and female patients for 47 (30.93%) of the 152 positive samples. ICU had the highest culture positivity rate (58.9%), followed by ward samples (28.8%) and OPD samples (12.3%).

Bacterial profile
Out of the total 152 isolates, Klebsiella pneumoniae were the most commonly isolated pathogen, accounting for 78 isolates (51.32%). This was followed by Pseudomonas aeruginosa with 34 isolates (22.37%) and Acinetobacter with 24 isolates (15.79%). E.coliaccounted for 10 isolates (6.58%), while Staphylococcus were the least frequent with 6 isolates (3.94%).

Antimicrobial Susceptibility Patterns
Gram Negative
Klebsiella pneumoniae isolates demonstrated high susceptibility to Cefepime (82.1%), Cefoxitin (82.1%) and Ciprofloxacin (92.3%). Lower susceptibility to Ceftazidime (38.5%) and Augmentin (33.3%) was observed, but moderate susceptibility was observed to Ceftriaxone (66.7%).
According to typical antipseudomonal coverage, Pseudomonas aeruginosa showed the highest sensitivity Imipenem (82.4%), Gentamicin (62.8%) and Ceftazidime (52.9%). Augmentin notably demonstrated extremely low susceptibility (14.7%).

Acinetobacteralso showed best susceptibility to Imipenem (79.2%) and Gentamicin (58.3%), with lower responses to other drugs, especially Augmentin (12.5%) and Cotrimoxazole (16.7%), indicating limited treatment options and suggesting multidrug resistance.

E.coli was most susceptible to Imipenem (90%), Gentamicin (80%), and Ciprofloxacin (70%), while susceptibility to Cefoxitin (20%)and Ceftriaxone (40%) was comparatively lower.

Table 1:- Susceptibility pattern of Gram-negative isolates.

Antibiotics	*Klebsiella pneumoniae* (N = 78) N(%)	*Pseudomonas aeruginosa* (N = 34) N(%)	*Acinetobacter* spp (N = 24) N(%)	*E. coli* (N = 10) N(%)
Augmentin	26 (33.33%)	5 (14.7%)	3 (12.5%)	3 (30%)
Cefepime	64 (82.05%)	20 (58.8%)	10 (41.7%)	6 (60%)
Ceftriaxone	52 (66.67%)	10 (29.4%)	6 (25%)	4 (40%)
Ceftazidime	30 (38.46)	18 (52.9%)	9 (37.5%)	5 (50%)
Cefoxitin	64 (82.05%)	-	-	2 (20%)
Ciprofloxacin	72 (92.31%)	22 (64.7%)	12 (50%)	7 (70%)
Cotrimoxazole	42 (53.85%)	6 (17.6%)	4 (16.7%)	5 (50%)
Gentamicin	49 (62.82%)	24 (70.6%)	14 (58.3%)	8 (80%)
Imipenem	53 (67.95%)	28 (82.3%)	19 (79.2%)	9 (90%)
Tetracycline	35 (44.87%)	12 (35.3%)	9 (37.5%)	6 (60%)

Gram positive

Staphylococcus aureus was isolated in 6 (3.94%) of the 152 culture positive samples. The isolates showed maximum sensitvity to Vancomycin (100%), Linezolid (100%) and Clindamycin (83.3%). Resistance to Erythromycin (66.7%) and Oxacillin (33.3%) was noted, indicating the presence of methicillin-resistant S.aureus (MRSA) in 2 out of 6 isolates.

Table 2:- Susceptibility pattern of Staphylococcus aureus.

Antibiotics	Sensitivity (N = 6) N(%)
Ciprofloxacin	4 (66.7%)
Clindamycin	5 (83.3%)
Cotrimoxazole	4 (66.7%)
Erythromycin	2 (33.3%)
Gentamicin	4 (66.7%)
Linezolid	6 (100%)
Oxacillin	4 (66.7%)
Tetracycline	3 (50%)
Vancomycin	6 (100%)

N = Number of isolates, % = Percentage

Discussion:-

This study provides valuable insights into microbiological profile and antimicrobial susceptibility patterns of pathogens isolated from patients with suspected LRTI in a tertiary care setting in Telangana, India.

This study analyzed 406 respiratory samples - 57 endotracheal aspirates and 349 sputum samples, from oupatient, ward and ICU patients. Of these 152 (37.33%) were culture-positive, consistent with previous studies reporting LRTI culture positivity rates between 35-45% in quality-verified samples.[7]

The majority of culture-positive patients were aged 41-60 years (39.8%) and 61-80 years (27.7%) with a male predominance (~69%). These trends align with data indicating that LRTIs predominantly affect middle-aged to elderly males with susceptible comorbidities. These findings are similar to a study conducted in Jodhpur that showed male predominance due to linked respiratory tract infection risk factors, including alcohol use, smoking, and COPD.[8]

About 89% of the isolates were gram-negative bacteria, with Klebsiella pneumoniae (51.3%), Pseudomonas aeruginosa (22.4%), and Acinetobacter spp. (15.8%) being the most common. This is consistent with findings from Nepal, where Klebsiella is most frequently isolated.[9] The importance of these bacteria in nosocomial infections is highlighted by their high frequency in critical-care settings, which is probably caused by factors such as environmental persistence and biofilm formation on devices.[10]

Klebsiella pneumoniae exhibited high susceptibility to Ciprofloxacin (92.3%) and moderate sensitivity to Cefepime/Cefoxitin (~82%), yet showed poor responses to Ceftazidime (38.5%) and Augmentin (33.3%). This resistance profile suggests widespread extended-spectrum beta-lactamase (ESBL) production - a trend consistent with North Indian ICU data reporting rising Cephalosporin resistance and ESBL rates ~50-60%.[11]

Pseudomonasand Acinetobacter retained susceptibility to Imipenem (~80%) and Gentamicin (~60-70%), while resistance to beta-lactams and cotrimoxazole points to emerging multidrug-resistant (MDR) non-fermenters. Recent surveillance demonstrates increasing MDR rates in Acinetobacter and Pseudomonas, particularly in ICU and ventilator-associated infections.[12] E.coli demonstrated strong sensitivity to imipenem (90%), Gentamicin (80%), and Ciprofloxacin (70%), although resistance to Cefoxitin (20%) and Ceftriaxone (40%), again suggests ESBL presence, in line with studies documenting ESBL carriage among E.coli in India.[13]

Staphylococcus aureus accounted for 3.94% of isolates, but the discovery of 33.3% MRSA is clinically significant. All isolates showed 100% susceptibility to Vancomycin and Linezolid, reinforcing the continuing efficacy of these critical antibiotics in India.[14] Additionally, 83.3% sensitivity to Clindamycin suggests it remains a viable option. Resistance patterns showed considerably lower activity for Erythromycin (33.3%) and moderate resistance to Ciprofloxacin and Gentamicin, reflecting broader nationwide trends in non-beta-lactam antibiotic resistance.[15]

This study paints a stark portrait of the microbial battleground in LRTI, where Gram-negative pathogens dominate, and the lines of antibiotic defence are steadily eroding. The prevalence of Klebsiella pneumoniae and the resistance pattern observed, particularly against Cephalosporins and beta-lactam/beta-lactamase inhibitors. Non-fermenters like Acinetobacterand Pseudomonas continue to resist multiple drug classes, while Staphylococcus aureus shows early signs of methicillin resistance, only deepens this concern. These findings reflect a complex interplay of selective antibiotic pressure, hospital environment, and clinical practices. Rather than relying on last-line antibiotics to hold the line, this data compels a pivot: from reactive treatment to proactive strategies- rapid diagnostics, stewardship, and local surveillance as essential tools in managing LRTIs in the age of resistance.

Conclusion:-

This study highlights a concerning microbial landscape in patients with lower respiratory tract infections in a tertiary care setting in Telangana, marked by a predominance of Gram-negative pathogens and significant levels of antimicrobial resistance. The high prevalence of Klebsiella pneumoniae, Pseudomonas aeruginosa, and Acinetobacter species, along with resistance to key antibiotics such as cephalosporins and beta-lactam/beta-lactamase inhibitor combinations, reflects a growing challenge in the management of LRTIs. The emergence of methicillin-resistant Staphylococcus aureus (MRSA), although less frequent, further underscores the need for continued vigilance.

Importantly, this study does more than catalog resistance patterns; it underscores the urgent need to re-evaluate empirical treatment protocols and promote more judicious use of antimicrobials. The findings call for integration of routine culture and sensitivity testing into clinical decision-making, particularly in ICU settings where resistant organisms are most prevalent. Additionally, the development of localized antibiograms and reinforcement of antimicrobial stewardship programs are essential to preserving the efficacy of currently available drugs.

In the broader context, these results serve as a reminder that antimicrobial resistance is not solely a microbiological issue but a reflection of healthcare practices, infrastructure, and policy implementation. A shift from reactive to proactive strategies—emphasizing prevention, early diagnosis, and rational antibiotic use—is critical. As we confront an era of diminishing antibiotic options, the strength of our response will rest not only on new drug development but on the intelligent, data-driven use of the tools already at our disposal.

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