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ORIGINAL ARTICLE

Yield of sputum culture and sensitivity in acute exacerbation of chronic obstructive pulmonary disease patients

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ABSTRACT

Background: Acute exacerbations of chronic obstructive pulmonary disease (COPD) are frequently triggered by bacterial infections, leading to increased morbidity, mortality, and healthcare burden. Identification of causative organisms and their antibiotic sensitivity patterns is crucial for guiding empirical therapy, improving patient outcomes, and combating antimicrobial resistance. This study aim to determine the diagnostic yield of sputum culture and sensitivity in acute exacerbation of COPD patients and assess antimicrobial susceptibility patterns to guide targeted antibiotic therapy and promote antimicrobial stewardship.

Methods: This cross-sectional study was conducted in the Pulmonology Department, Khyber Teaching Hospital, Peshawar, from December 2024 to June 2025. A total of 135 patients, aged 18–80 years, diagnosed with COPD per GOLD criteria, were enrolled using non-probability consecutive sampling. The WHO sample size calculator (5% margin of error) determined the sample size. Exclusion criteria included recent antibiotic use (within 2 weeks), active tuberculosis, coexisting pulmonary diseases, inability to produce sputum, and immunocompromised states such as HIV/AIDS or immunosuppressive therapy.

Results: Of the 135 patients, sputum culture positivity was 71.7%, with all isolates being Gram-negative. The most frequent organisms were Escherichia coli and Citrobacter (17.4% each), followed by Klebsiella (13.8%) and Pseudomonas aeruginosa (8.7%). Acinetobacter and Enterobacter was least common (2.9% each). Highest sensitivities were observed for tigecycline (84.4%), amikacin (78.1%), ertapenem (70.8%), and Meropenem (66.7%), whereas ampicillin, co-amoxiclav, and ceftriaxone showed the highest resistance.

Conclusion: Gram-negative organisms, notably E. coli and Citrobacter, predominated in sputum cultures of COPD exacerbation patients. Tigecycline, amikacin, ertapenem, and Meropenem exhibited the best sensitivity profiles, while ampicillin, co-amoxiclav, and ceftriaxone showed marked resistance. Empirical treatment should focus on antibiotics active against these prevalent Gram-negative pathogens to optimize patient outcomes.

Keywords: Antibiotic Sensitivity, COPD, Chronic Obstructive Pulmonary Disease Exacerbation, Sputum Culture

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Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a leading cause of morbidity and

mortality worldwide, with acute exacerbations representing critical events that often result in hospitalization, functional decline, and increased healthcare costs (1, 2). Acute exacerbations are commonly triggered by bacterial infections, and identification of the causative pathogens through sputum culture and sensitivity (C&S) testing can guide targeted antibiotic therapy (3–5).

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However, culture yields vary widely, and indiscriminate antibiotic use can precipitate antimicrobial resistance, a pressing global health concern (6, 7). As such, understanding the diagnostic yield of sputum C&S in the context of COPD exacerbations is essential to improving therapeutic stewardship and patient outcomes.

Despite widespread utilization, sputum cultures often yield low rates of pathogen detection due to factors such as prior antibiotic use, difficulty in obtaining high-quality specimens, and polymicrobial contamination (8–10). Recent studies have reported yield rates ranging from 20 % to 60 % in varied clinical settings (11–13). Yet data remain limited in resource-constrained regions, where laboratory infrastructure and patient characteristics may differ substantially (14). In Pakistan, particularly Khyber Pakhtunkhwa, such data are scarce, hindering evidence-based guidelines relevant to local clinical practice.

This study addresses two closely related issues: the diagnostic yield of sputum cultures in patients experiencing acute exacerbations of COPD within our healthcare setting, and the antimicrobial susceptibility patterns of the pathogens identified. Its primary objective is to assess the yield of sputum culture and sensitivity testing in such patients, generating local data on pathogen prevalence and resistance trends. These findings aim to guide antibiotic prescribing practices, support antimicrobial stewardship initiatives, and ultimately enhance the quality of care for patients with acute COPD exacerbations.

Methods

This descriptive cross-sectional study was conducted in the Department of Pulmonology at Khyber Teaching Hospital (KTH) Peshawar, Pakistan, from December 2024 to June2025. Adult patients (≥ 18 years) with a known diagnosis of COPD (post-bronchodilator $FEV_1/FVC < 0.70$) presenting with acute exacerbation, defined by the GOLD criteria, were enrolled. An acute exacerbation was characterized by worsening dyspnea, cough, sputum production, or change in sputum character requiring medical attention.

Inclusion criteria included confirmed COPD cases able to produce adequate sputum specimens. Exclusion criteria were prior antibiotic use > 48 hours, alternative diagnoses (e.g., pneumonia, pulmonary embolism), inability to produce sputum, and immunocompromised states (HIV, chemotherapy, and post-transplant).Sample size of 135 patients was calculated using the WHO calculator, based on an expected culture yield with 95% confidence and 5% margin of error. Patients were recruited through non-probability consecutive sampling. Ethical approval for this study was

obtained from the Institutional Review and Ethics Board (IREB) of Khyber Medical College, Peshawar, under notification number 752/DME/KMC, dated 26 September 2024.

Demographic data, smoking history, comorbidities, COPD duration, and exacerbation features were recorded. Sputum specimens were collected before antibiotic initiation, transported to the microbiology laboratory within one hour, and assessed for quality using Bartlett's grading system. Suitable samples were cultured on blood agar, chocolate agar, and MacConkey agar, incubated at 35–37°C for 24–48 hours. Bacterial identification employed standard biochemical tests, and antimicrobial susceptibility testing followed the Kirby–Bauer disk diffusion method according to CLSI guidelines.

Primary outcome was sputum culture yield (percentage of positive bacterial growth). Secondary outcomes included pathogen distribution and antibiotic sensitivity profiles. Data analysis was performed using SPSS version 26, with results expressed as mean ± SD or median (IQR) for quantitative data and frequencies/percentages for categorical data. Chi-square or Fisher's exact test was applied, with $p < 0.05$ considered significant.

Results

A total of 135 COPD patients with acute exacerbation were enrolled in this study, comprising of 81(60%) males and 54(40%) females. Mean age of participants was 58±10.9 years. The demographic details are summarized in table (1).

Table 1: Baseline demographic characteristics

Variables	N	%
Age distribution (years)		
41-50	36	26.6%
51-60	36	26.6%
61-70	40	29.6%
>70	23	17.0%
Gender		
Male	81	60%
Female	54	40%
Duration of COPD		
<5 years	68	49.3%
>5 years	67	48.6%
History of Smoking		
Yes	40	29.6%
No	95	70.4%
Co morbidities		
Hypertension	50	37.0%
Diabetes Mellitus	18	28.9%
Both DM and HTN	12	8.9%
None	34	25.2%

Sputum culture was positive in 96(71.7%) patients, with all isolates being Gram-negative. The predominant organisms were Escherichia coli and Citrobacter (17.4% each), followed by Klebsiella (13.8%) and Pseudomonas aeruginosa (8.7%). Acinetobacter and Enterobacter were least common (2.9% each).These findings are summarized in Figure (1).

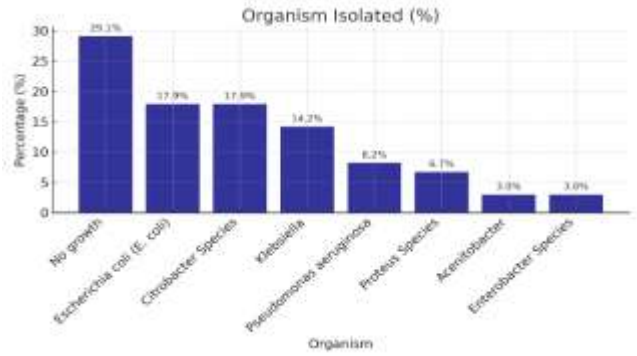

Figure (1): Spectrum of Bacterial Isolates Identified

Among the tested antibiotics Tigecycline showed the highest overall sensitivity (84.4%), followed by Amikacin (78.1%), Ertapenem (70.8%), and Meropenem (66.7%). Moderate susceptibility was noted for Cefoperazone/Sulbactam and Piperacillin–Tazobactam (64.6% each). In contrast, Ampicillin (10.4%), Co-amoxiclav (13.5%),

and Co-trimoxazole (15.6%) demonstrated the lowest sensitivity rates, indicating high resistance among isolates.

These findings highlight carbapenems and Tigecycline as the most effective agents against the gram-negative pathogens in this study. The detailed Antibiogram is presented in Table (2),

Table 2: Antibiogram Showing Sensitivity Patterns of Bacterial Isolates

Antibiotics	Klebsiella	Escherichia coli	Citobacter	P. aeruginosa	Proteus	Acenitobacter	Enterobacter	Overall Sensitivity
	N (%)	*N (%)*	*N (%)*	*N (%)*	*N (%)*	*N (%)*	*N (%)*	*N (%)*
Amikacin	14(74)	22(92)	17(71)	10(83)	9(100)	1(25)	2(50)	78.1%
Aztreonam	8(42)	5 (21)	6(25)	9(75)	3(33)	0 (0)	2(50)	34.4%
Cefepime	6(32)	3(12)	9(38)	9(75)	3(33)	0 (0)	0 (0)	31.2%
Cefo /Sulbactom	10(53)	14(58)	15(62)	12(100)	9(100)	2(50)	0 (0)	64.6%
Ceftazidime	6(32)	2(8)	6(25)	7(58)	3(33)	0 (0)	1(25)	26.0%
Ceftriaxone	6(32)	0 (0)	6(25)	5(42)	0 (0)	0 (0)	0 (0)	17.7%
Chloramphenicol	12(63)	15(63)	11(46)	7(58)	0 (0)	2(50)	0 (0)	49.0%
Ciprofloxacin	8(42)	0 (0)	6(25)	9(75)	3(33)	0 (0)	2(50)	29.2%
Co-amoxiclav	6(32)	2(8)	0 (0)	5(42)	0 (0)	0 (0)	0 (0)	13.5%
Co-trimoxazole	6(32)	0 (0)	3(12)	5(42)	0 (0)	1(25)	0 (0)	15.6%
Ertapenem	10(53)	18(75)	20(83)	10(83)	9(100)	1(25)	0 (0)	70.8%
Gentamicin	14(74)	13(54)	11(46)	7(58)	3(33)	2(50)	0 (0)	52.1%
Levofloxacin	6(32)	0 (0)	11(46)	9(75)	3(33)	1(25)	0 (0)	31.2%
Meropenem	10(53)	18(75)	15(62)	12(100)	9(100)	0 (0)	0 (0)	66.7%
Minocycline	11(58)	16(68)	13(54)	7(58)	6(67)	1(25)	0 (0)	56.2%
Piper+Tazobac	10(53)	12(50)	18(75)	12(100)	9(100)	0 (0)	1(25)	64.6%
Doxycycline	17(89)	12(50)	13(54)	7(58)	0 (0)	2(50)	0 (0)	53.1%
Tetracycline	10(53)	10(42)	15(62)	7(58)	0 (0)	1(25)	1(25)	45.8%
Tigecycline	19(100)	21(88)	21(88))	10(83)	6(67)	4(100)	0 (0)	84.4%
Ampicillin	0 (0)	0 (0)	3(12)	2(16)	0 (0)	1(25)	4(100)	10.4%
Colistin	8(42)	10(42)	15(62)	5(42)	3(33)	3(75)	0 (0)	45.8%

The overall sensitivity patterns of the tested antibiotics, along with their variations across different bacterial isolates (p-values), are illustrated in Figure (2).

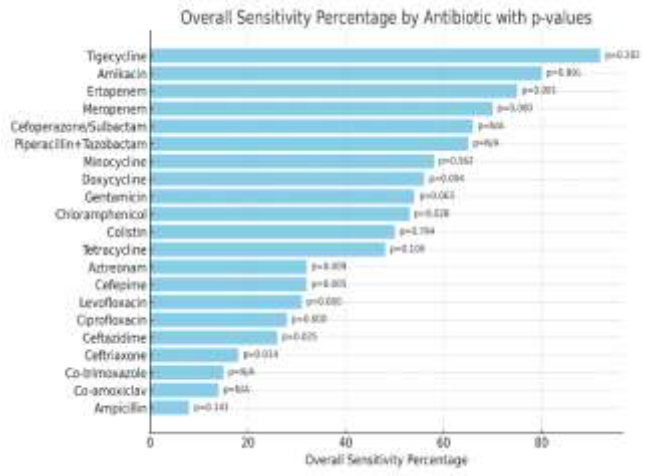

Figure (2): Overall Antibiotic Sensitivity Patterns and Their Variation across Bacterial Isolates

Figure 2 highlights the antibiotics that showed significant variation in sensitivity patterns across different bacterial species. A p-value < 0.05 indicates that resistance or susceptibility rates were not uniform among organisms. The most pronounced differences were observed with Meropenem, Ciprofloxacin, Levofloxacin, and Ertapenem, suggesting their effectiveness depends heavily on the infecting species. Amoxiclav, Doxycycline, and Trimethoprim–sulfamethoxazole also showed notable inter-species variability. In contrast, antibiotics with p ≥ 0.05, such as Amikacin, Colistin, Minocycline, and Tigecycline, demonstrated relatively consistent activity across species

Analysis revealed that gender had a statistically significant association with the overall antibiotic sensitivity pattern (p ≈ 0.0105), indicating that susceptibility rates varied between male and female patients. Comorbidities also showed a strong and highly significant association (p < 0.001), suggesting that the presence of underlying health conditions influenced bacterial susceptibility to antibiotics. In contrast, smoking status did not demonstrate a significant association (p ≈ 0.2113), indicating no meaningful difference in sensitivity patterns between smokers and non-smokers.

Discussion

Our study demonstrated a high rate of positive sputum cultures in hospitalized AECOPD patients, with a clear predominance of Gram-negative organisms. This finding is consistent with recent regional reports. For example, a 2025 investigation from Bahawalpur documented a culture positivity rate of 74.5%, with Klebsiella pneumoniae and Pseudomonas aeruginosa as the most common isolates. In that study, Meropenem and amikacin were the most effective antibiotics, while amoxicillin–clavulanate and co-trimoxazole showed poor activity, patterns that closely parallel our results (15). Comparable trends were observed in Lahore, where *K.* pneumoniae accounted for 62.7% of isolates and amikacin demonstrated the highest sensitivity (16).

Evidence from other parts of South and Southeast Asia further supports the predominance of Gram-negative pathogens and the growing problem of antimicrobial resistance. In Vietnam, a prospective study using both conventional culture and multiplex PCR identified K. pneumoniae, Haemophilus influenzae, Moraxella catarrhalis, and Streptococcus pneumoniae as frequent isolates. Gram-negative bacteria were central to AECOPD in both pneumonia-associated and non-pneumonia cases, with susceptibility data favoring carbapenems and aminoglycosides in severe infections (17). Likewise, studies from Bangladesh and India have consistently identified *Klebsiella* and *Pseudomonas* as leading pathogens, with high resistance rates to third-generation cephalosporins (4, 18). Outside the pulmonary setting, Pakistani hospitals have

also reported widespread multidrug resistance among Gram-negative bacilli, underscoring the urgency of antibiotic stewardship (15).

These findings have important therapeutic implications. Given the predominance of Enterobacterales species (*E. coli, Citrobacter,* and *Klebsiella)* in our cohort, initial empirical therapy for hospitalized AECOPD should ensure strong activity against these organisms—such as piperacillin–tazobactam, cefoperazone–sulbactam, or carbapenems in MDR-suspected cases. Although *Pseudomonas aeruginosa* was less frequent, its intrinsic resistance and potential for poor outcomes in vulnerable patients warrant its consideration in selected high-risk cases. De-escalation based on culture results remains essential to minimize resistance. This approach aligns with GOLD recommendations to start timely antibiotic therapy while tailoring regimens to local resistance trends (20). Moreover, because exacerbations can be triggered by pathogens other than bacteria, incorporating rapid diagnostic tools, including PCR when feasible, may help distinguish colonization from true infection and guide more focused antibiotic use (17, 21). Continued MDR pressure also reinforces the need for facility-specific antibiograms, cautious use of fluoroquinolones and cephalosporins, and limiting antibiotic duration to the shortest effective course (20, 22).

The strength of our study lies in its provision of recent, locally relevant microbiological data. These results both confirm earlier findings from Punjab and Khyber Pakhtunkhwa (15, 16) and expand the evidence base by presenting detailed susceptibility patterns applicable to clinical decision-making. They also differ from older European literature, which more often reported H. influenzae, M. catarrhalis, and S. pneumoniae in community-managed cases, a difference likely related to hospitalization status, prior antimicrobial exposure, and healthcare-associated colonization (21).

Conclusion

Our findings underscore the importance of routine microbiological surveillance to guide targeted therapy and reduce inappropriate empirical antibiotic use. The observed resistance patterns raise concern for the potential spread of multidrug-resistant organisms, making timely diagnosis, rational prescribing, and adherence to antimicrobial stewardship programs essential. Incorporating local antibiogram data into treatment guidelines will improve patient outcomes, limit treatment failures, and help curb antibiotic resistance.

Limitations

Nonetheless, our work is limited by its single-center scope, lack of viral diagnostics, and possible selection bias toward more severe presentations. Multicenter surveillance integrating culture with molecular testing and linking microbiological findings to patient outcomes, such as length of stay and readmission rates, would be a valuable next step.

Recommendations

Future research should explore preventive strategies and assess the impact of tailored antibiotic policies on COPD exacerbation management.

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Disclaimer: This research was undertaken solely for academic and scientific purposes. The conclusions drawn are based on data from a specific group of COPD patients and may not be universally applicable. Although every effort has been made to maintain accuracy and reliability, the information provided should complement, not replace, clinical expertise and individualized patient care.

Conflict of Interest: The authors affirm that there are no conflicts of interest related to this study.

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All the authors agree to take responsibility for every facet of the work, making sure that any concerns about its integrity or veracity are thoroughly examined and addressed.