Bacteria that cause infections of the lower respiratory tract in patients in the intensive care unit (ICU).

Mitrabinda Pattanaik[1], *Ansuman Dash[2], Madhushree Mishra[3], Sonam Satpathy[4].

[1PG] Resident,
Department of Microbiology,
Hi-Tech Medical College and Hospital,
Rourkela
Corresponding author:
[2]Associate Professor,
Department of Microbiology,
Hi-Tech Medical College and Hospital,
Rourkela.
[3]Senior Resident,
Department of Dentistry,
Hi-Tech Medical College and Hospital, Rourkela
[4]M.D.S Periodontology,
Sonam Dental Care, Bhubaneswar

KEYWORDS
Immune status, medications, hospital stay, infections, endotracheal tubes, multi-drug resistance.

ABSTRACT
Worldwide, intensive care units (ICU) deal with a significant number of lower respiratory tract infections (LRTIs). Critical care unit patients are at increased risk for contracting multidrug-resistant infections, such as Pseudomonas aeruginosa, Klebsiella pneumoniae, Acinetobacter baumannii, and methicillin-resistant Staphylococcus aureus (MRSA). Their susceptibility is heightened because they have compromised immune systems, must undergo invasive medical procedures, and spend more time in the hospital. The aim of the present study was to determine the bacteria that cause infections of the lower respiratory tract in patients admitted in the intensive care unit (ICU). Approach and Materials: The research was placed in Rourkela's Hi-Tech Medical College & Hospital from January to June of 2024. Out of 150 people who agreed to take part in the study, participants were ICU patients whose physicians had reason to assume they had a lower respiratory tract infection. Adults and infants alike contributed clinical samples of sputum and tube secretions for the study. A diagnosis of LRTI was made for patients who were observed from the start of the study until they were sent home. Some of the symptoms included a high temperature, clear ET secretions, infiltrates seen on chest X-ray, an increase in white blood cell counts, and indicators of inflammation. The research determined that 150 patients from the PICU and MICU had their LRT samples evaluated. Results from culture tests showed a single pathogen in 82% of instances, and 62% of patients had positive results. In 89.77% of patients, it was determined that the sickness was caused by Gram-negative bacteria. Species of Acinetobacter, Staphylococcus aureus, Klebsiella, Pseudomonas, and Escherichia coli were the most prevalent. The resistance to Klebsiella and Acinetobacter species was higher in patients who were adults or older. The outcomes are: Rare LRTIs commonly cause

antibiograms and culture isolation in patients in the critical care unit. Because of factors such as antibiotic overuse, treatment resistance, and neglect, health care-associated infections pose an issue in critical care units in India. The effective and prompt treatment of infections depends on the implementation of an antimicrobial stewardship policy.
.

Introduction:

Patients referred to intensive care units (ICUs) are particularly vulnerable to lower respiratory tract infections (LRTIs), which are a major concern globally. Treating infections that are multidrug-resistant (MDR) is incredibly tough for healthcare systems. Among them are Acinetobacter baumannii, Pseudomonas aeruginosa, Klebsiella pneumoniae, and Methicillin-resistant Staphylococcus aureus (MRSA) [1-3]. Several factors, including patients' compromised immune systems, the duration of their hospital stay, the intrusive procedures they endure, and the drugs they take, increase the likelihood that patients in the intensive care unit may get these infections [4, 5]. LRTIs have become increasingly difficult to control in intensive care units due to the rise of antibiotic resistance. The development of resistance in common bacteria to standard antimicrobials is a major contributor to increasing mortality rates, prolonged hospitalizations in critical care units, and healthcare expenditures. Some of these harmful microorganisms are Acinetobacter baumannii, Klebsiella pneumoniae, Pseudomonas aeruginosa, and MRSA. Implanted tracheostomy and endotracheal tubes allow bacteria and other microbes easier access to the lower respiratory system, where they can multiply [6-8]. It could be difficult to diagnose a patient in the critical care unit with a multidrug-resistant LRTIs since the symptoms are often identical to those of other illnesses [9, 10]. Patients in critical care may lack the physical or mental capacity to undergo invasive sample procedures such bronchoalveolar lavage or protected specimen brushing, which are necessary for microbiological confirmation [7, 8]. Due to the lengthy time it takes to receive culture results, antibiotic therapy is often based on speculation, which can be problematic when dealing with infections that are resistant to many medications [4-6].

Researchers are presently looking into the causes, prevalence, and best treatment techniques for multidrug-resistant LRTIs [1-4]. Better outcomes can be achieved for this high-risk patient population by collaborative interdisciplinary efforts, innovative pharmacological treatments, and genetic testing. Current knowledge of bacterial LRTIs acquired in intensive care units (ICUs) that are multidrug-resistant (MDR) is reviewed in this paper. The clinical repercussions, diagnostic problems, and prospective treatment options are the main areas of emphasis in order to tackle this major healthcare issue [3-5]. Patients admitted to the intensive care unit with a suspected infection will be studied to identify the bacteria responsible for the disease. Hence, the aim of the present study was to determine the bacteria that cause infections of the lower respiratory tract in patients admitted in the ICUs.

Materials & methods:

The Institutional Ethics Committee at Rourkela's Hi-Tech Medical College & Hospital gave the go-ahead for the research. The research took place from January 2022 until June 2024. This study used a prospective observational approach. In all, 150 individuals volunteered for this research. We included all patients (regardless of gender) who were admitted to the critical care unit within 48 hours of the first admission and had symptoms of a lower respiratory tract infection. Treatment included inserting an endotracheal tube and irrigating the trachea. Participants' sputum and tube secretions were collected from individuals of all ages, from babies to adults. Male or female

participants are welcome, but only if there is a clinical suspicion of an active LRTI. A minimum of 48 hours of critical care unit stay is also required. If a participant's medical records revealed a history of immunosuppression due to HIV infection, diabetes mellitus, or cancer, they were not eligible to participate in the research. Exclusion of these patients was made. The same team of researchers tracked the subjects from the time they enrolled in the study until they were discharged from the hospital. The diagnostic criteria for LRTI include fever, purulent ET secretions/sputum, elevation of white blood cell count, patchy or recent infiltration on chest X-ray, and other inflammatory indicators such as C-reactive protein and enhanced serum redness. Standard bacteriological procedures, including Gram staining and semi-quantitative culture analysis, were applied to the collected respiratory samples.

Statistical analysis:

The data comprise the frequency distribution of multi-drug-resistant infections. Age and duration in the critical care unit are examples of continuous variables whose data includes standard deviations, medians, and means. Categorical data, such the kinds of pathogens and the increases in resistance, are best described by percentages.

Results:

One hundred ICU and pediatric intensive care unit (PICU) patients had their LRT during the study period. While 62 (or 62% of the total) specimens tested positive for culture, 38 (or 38% of the total) had no growth at all. A total of 100 and 150 patients were enrolled, with 36 females and 54 males making up 36% and 54%, respectively. Eighty-two patients (82%) were infected with a single pathogen, whereas eighteen patients (18%) were infected with a variety of germs. The majority of the 62 instances that tested positive for bacteria in the culture were gram-negative (89 cases), with just 11 cases being gram-positive (11%).

Table 1: Specimen analysis results:

Parameter	Value	Percentage (%)
Total specimens assessed	100	100
Culture-positive specimens	62	62
Non-significant growth	38	38

Table 2: Gender distribution of patients.

Gender	Number of cases	Percentage (%)
Male	54	54
Female	36	36

Table 4: Bacterial classification

Bacterial type	Number of cases	Percentage (%)
Gram- Negative	89	89
Gram-Positive	11	11

The most common bacteria were Acinetobacter species (n=28). The following were species of E. coli (n=8), Pseudomonas (n=20), Klebsiella (n=25), and nine strains of Staph. aureus (n=10) that were not fermenters. The vast majority of the microbes found were Gram-negative pathogens. Strains of Klebsiella and Acinetobacter that are resistant were much more common in the adult and senior population (those aged 18–60) than in the pediatric population (those aged 1–5).To

clarify, polymyxin B was effective against every single Acinetobacter strain, however Meropenem only worked against 60.7% of them. Amikacin was effective against 75% of the Pseudomonas species tested. The effectiveness of Meropenem against Klebsiella was just 76%. The number of S. aureus genotypes that included MRSA was a mere six.

Table 5: Distribution of Microbes

Microbe	Number of cases
Acinetobacter species	28
Pseudomonas species	20
Klebsiella species	25
E.Coli	8
Non-fermenter species	9
Staphylococcus aureus	10

Discussion:

The results of this study shed light on the microbiome of ICU and LRTIs. Out of the 100 instances that were included, there were more male patients (54% vs. 36%). Previous study has shown that LRTIs are more common in men due to hormonal, structural, and lifestyle factors, such as smoking and occupational exposures. This finding is in line with the male preponderance.

Notable findings emphasize the frequency of monomicrobial infections in patients admitted to intensive care units, with 82% of cases showing a single pathogen. However, polymicrobial etiology was present in 18% of cases, suggesting that weakened host defenses or prolonged ICU stays impact bacterial diversity. The findings stress the significance of precise pathogen identification for the effective personalization of antimicrobial therapies.

An alarming aspect of our study is the high prevalence of Gram-negative bacteria (89% in culture-positive cases), which aligns with global trends. [1–4]. The CDC's National Nosocomial Infections Surveillance (NNIS) reports that aerobic GNB is the causative agent of 60% of nosocomial pneumonias in the United States [1-4]. We found that GNB was the most prevalent bacterium (89%), which is not surprising given the little amount of S. aureus bacteria that we identified. According to the results that were published in [5-8], 92.2%, 93%, and 97.4% of GNBs were found to be isolated, respectively. Pseudomonas aeruginosa and Klebsiella pneumoniae are developing resistance to carbapenems in areas where antibiotics are overused, according to research [11]. A study with similar results [12] linked an increase in multi-drug-resistant Acinetobacter baumannii in intensive care units across Asia to insufficient measures to prevent the spread of infection. It's possible that the non-representative nature of the specimens or their history of antibiotic treatment contributed to the fact that 40% of the samples were sterile when cultured. One factor leading to the increase in nosocomial fungal infections is the increasing utilization of modern medical and surgical procedures. We shouldn't ignore future instances that are comparable, even if none of the patients in our study tested positive for Candida species. In patients admitted to the intensive care unit, antibiotic resistance is a major concern. Cephalosporin resistance is very common among the varied Gram-negative isolates. Reporters from other sources also found similar results, as seen in [5,8,9]. LRTIs caused by MRSA are linked to increased healthcare expenditures, death rates, and morbidity. Research [13] suggests that in the worst-case scenario, mortality rates might exceed 50%, highlighting the detrimental consequences of delaying necessary medical treatment.

Extended stays in the ICU, increased likelihood of subsequent infections, and a heavier burden on healthcare resources are all consequences of MDR infections. The resistance mechanisms used by bacteria that are resistant to many drugs are quite complicated and diverse. Several factors contribute to the emergence of resistance, including extended-spectrum beta-lactamases (ESBLs), biofilm formation, carbapenemases, and efflux pumps. According to a review, [14], plasmids and transposons are mobile genetic components that increase the prevalence of bacteria resistant to many drugs. To treat LRTIs linked to MDR, an accurate and rapid diagnosis is required. Technologies in molecular diagnostics, such as polymerase chain reaction (PCR) and next-generation sequencing (NGS), have greatly enhanced the ability to identify pathogens and profile their resistance. According to a study [15], these technologies can and should be used to direct focused treatments in standard critical care unit settings. The majority of LRTIs in intensive care unit settings are caused by Gram-negative bacteria because of their rapid ability to acquire and propagate resistance genes. The two most common pathogens among Gram-negative bacteria were *Acinetobacter* species (28%) and *Klebsiella* species (25%), which were followed by *Pseudomonas* species (20%) and *Escherichia coli* (8%). The aforementioned findings underscore the concerning prevalence of nosocomial organisms such as *Acinetobacter* and *Klebsiella*, which are infamous for their MDR properties, which might impede the effectiveness of therapy. The fact that 10% of the isolates were *Staphylococcus aureus*, a Gram-positive bacterium, suggests that this pathogen is still prevalent in infections acquired in intensive care units. However, its frequency remains obscured by the preponderance of Gram-negative bacteria in our study. The findings underscore the need of continuing vigilance against both Gram-positive and Gram-negative organisms to assure full infection control measures.

It is very necessary to implement targeted antimicrobial stewardship programs (ASPs) because to the high incidence of Gram-negative infections, particularly those caused by *Acinetobacter* and *Klebsiella* species. The overuse of broad-spectrum antibiotics is a major contributor to the spread of antibiotic resistance, which ASPs should work to curb. Advocating for infection control measures including regular environmental cleaning, PPE usage, and rigorous hand hygiene might help further limit the transmission of germs in critical care units.

This work adds to the growing body of evidence that local monitoring of pathogen profiles and resistance developments must be continual and rigorous. Better patient outcomes and more informed judgments for empirical therapy can result from this data. Additionally, state-of-the-art diagnostic methods, such as molecular approaches, have the potential to enhance the rapid identification of infections, allowing for effective and timely treatment. In addition to providing helpful epidemiological data on LRTI infections in intensive care units, the study emphasizes the importance of Gram-negative bacteria and the increasing danger of multidrug-resistant infectious agents. Specialized treatments, stringent infection control policies, and robust ASPs are necessary to overcome the obstacles of treating LRTIs in critically ill patients.

Conclusion:

Numerous nosocomial bacteria are more common in critical care unit patients, putting them at higher risk of LRTI. An antibiogram and culture isolation are necessary for every episode of LRTI in patients in the ICU. Using too many antibiotics, decreasing the effectiveness of medications, and disregarding infection control guidelines are new problems in Indian critical care units. All of them increase the likelihood of healthcare-associated infections (HCAIs) occurring and spreading.

One major issue is that there are presently no effective treatment options for infections brought on by MROs. To ensure that infections are treated quickly and efficiently, it is imperative to have an antimicrobial stewardship policy.

No conflict of interest exists between any of the writers of this study.

References:

1. Zhang Z, Tan X, Shi H, Zhao J, Zhang H, Li J, Liao X. Effect of single-patient room design on the incidence of nosocomial infection in the intensive care unit: a systematic review and meta-analysis. Frontiers in Medicine. 2024 Jun 10;11:1421055.
2. Sadatsafavi H, Niknejad B, Zadeh R, Sadatsafavi M. Do cost savings from reductions in nosocomial infections justify additional costs of single-bed rooms in intensive care units? A simulation case study. Journal of critical care. 2016 Feb 1;31(1):194-200.
3. Stiller A, Schröder C, Gropmann A, Schwab F, Behnke M, Geffers C, Sunder W, Holzhausen J, Gastmeier P. ICU ward design and nosocomial infection rates: a cross-sectional study in Germany. Journal of Hospital Infection. 2017 Jan 1;95(1):71-5.
4. Stiller A, Salm F, Bischoff P, Gastmeier P. Relationship between hospital ward design and healthcare-associated infection rates: a systematic review and meta-analysis. Antimicrobial Resistance & Infection Control. 2016 Dec;5:1-0.
5. El-Kersh K, Guardiola J, Cavallazzi R, Wiemken TL, Roman J, Saad M. Open and closed models of intensive care unit have different influences on infectious complications in a tertiary care center: a retrospective data analysis. American Journal of Infection Control. 2016 Dec 1;44(12):1744-6.
6. Graves N, Mitchell BG, Otter JA, Kiernan M. The cost-effectiveness of temporary single-patient rooms to reduce risks of healthcare-associated infection. Journal of Hospital Infection. 2021 Oct 1;116:21-8.
7. Behera B, Sahu KK, Bhoi P, Mohanty JN. Prevalence and antimicrobial susceptibility patterns of bacteria in ICU patients with lower respiratory tract infection: A cross-sectional study. Journal of Acute Disease. 2020 Jul 1;9(4):157-60.
8. Nurahmed N, Kedir S, Fantahun S, Getahun M, Mohammed A, Mohammed A, Mohammed F, Arega T, Desta K. Bacterial profile and antimicrobial susceptibility patterns of lower respiratory tract infection among patients attending selected health centers of Addis Ababa, Ethiopia. The Egyptian Journal of Chest Diseases and Tuberculosis. 2020 Apr 1;69(2):399-406.
9. Appa Rao Peddapalli DR, Kamala P, Kakaraparthi YD. Study of Bacterial and Fungal Etiology of Lower Respiratory Tract Infections in a Tertiary Care Hospital.
10. Wang H, Yi M, Jia Y, Li Y, Bai C, Jiang D, Chen O. Incidence Rates, Risk Factors, and Mortality Rates of Ventilator-Associated Pneumonia: A meta-analysis.
11. Bussini L, Pascale R, Rinaldi M, Bartoletti M. Diagnosis, management and treatment of nosocomial pneumonia in ICU: a narrative review. Journal of Emergency and Critical Care Medicine. 2022 Oct 30;6.
12. Chang PH, Lin TL, Chen YJ, Lai WH, Chen IL, Chang HC, Lin YC, Lin YH, Li WF, Liu YW, Wang CC. Risk factors, pathogens, and outcomes of Ventilator-Associated Pneumonia in Non-cardiac Surgical patients: a retrospective analysis. Microorganisms. 2024 Jul 13;12(7):1422.
13. Klompas M, Branson R, Cawcutt K, Crist M, Eichenwald EC, Greene LR, Lee G, Maragakis LL, Powell K, Priebe GP, Speck K. Strategies to prevent ventilator-associated pneumonia, ventilator-associated events, and nonventilator hospital-acquired pneumonia in acute-care hospitals: 2022 Update. Infection Control & Hospital Epidemiology. 2022 Jun;43(6):687-713.
14. De Angelis G, Del Giacomo P, Posteraro B, Sanguinetti M, Tumbarello M. Molecular mechanisms, epidemiology, and clinical importance of β-lactam resistance in Enterobacteriaceae. International journal of molecular sciences. 2020 Jul 18;21(14):5090.
15. Fiore M, Di Franco S, Alfieri A, Passavanti MB, Pace MC, Petrou S, Martora F, Leone S. Spontaneous bacterial peritonitis due to carbapenemase-producing Enterobacteriaceae: Etiology and antibiotic treatment. World Journal of Hepatology. 2020 Dec 12;12(12):1136.