e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2024; 16(12); 316-322

Original Research Article

A Study on The Impact of Demographics on Antimicrobial Susceptibility in Lower Respiratory Tract Infections In ICU: From A Bihar Teaching Hospital

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Received: 08-10-2024 / Revised: 13-11-2024 / Accepted: 21-12-2024
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Conflict of interest: Nil

Abstract:

Background: Lower respiratory tract infections significantly contribute to morbidity and mortality globally, particularly in intensive care units, where patients present with complex health conditions. The microbial composition of LRTIs (lower respiratory tract infections) and their patterns of antimicrobic susceptibility can differ based on regional and demographic variables, complicating treatment, especially in intensive care unit (ICU) environments. Demographic characteristics in Bihar, India, may significantly influence the microbial distribution and resistance patterns associated with lower respiratory tract infections (LRTIs).

Aim: To assess the impact of demographic parameters on the microbiological aetiology and antimicrobial susceptibility of LRTIs in ICU patients at a Bihar teaching hospital.

Methodology: This retrospective study comprised 89 ICU patients who had LRTI-positive bacterial cultures. Demographic data, including age and gender, alongside bacterial isolates and their antimicrobial susceptibility patterns, were gathered. Statistical analysis utilised MedCalc software, employing Chi-square tests to assess significance ($p < 0.05$).

Results: The majority of patients were male (68.5%), with the highest proportion being over 60 years of age (30.3%). Klebsiella and Acinetobacter baumannii were the most frequently isolated bacteria. Antibiotic susceptibility testing revealed significant resistance to frequently utilised antibiotics, including cefepime and gentamicin. Colistin and tigecycline exhibited superior efficacy against Gram-negative organisms, whereas vancomycin and linezolid demonstrated significant effectiveness against Gram-positive bacteria.

Conclusion: Demographic variables, particularly age and gender, may influence the microbiological aetiology and antimicrobial susceptibility of LRTIs in ICUs. The study highlights the need for region-specific antimicrobial stewardship programs to tackle multidrug resistance challenges in critically ill patients.

Keywords: A. Baumannii, Antimicrobial Resistance, Antimicrobial Susceptibility, Klebsiella, Lower Respiratory Tract Infections.

Introduction

Lower respiratory tract infections (LRTI) significantly contribute to global morbidity and mortality, representing a critical concern within the health sector worldwide. Lower respiratory tract infections (LRTI) include conditions such as pneumonia, influenza, bronchitis, and acute exacerbations of chronic obstructive pulmonary disease (COPD), among others [1]. This primarily entails infection in the trachea, bronchi, and lungs, which can progress to severe conditions in various populations, especially those that are vulnerable. LRTI lacks a universally accepted definition; however, it typically refers to a category of infections in the respiratory tract characterised by significant variation in severity, clinical presentation, and microbial aetiology. LRTI ranks as a leading cause of hospital admissions worldwide. Its incidence and prevalence are particularly pronounced in intensive care units, where patients often present with complex underlying conditions [2].

The Global Burden of Disease study, supported by the Bill and Melinda Gates Foundation, estimated that approximately 2.38 million deaths due to lower respiratory tract infections (LRTI) occurred in 2016. Lower respiratory tract infections rank as the sixth leading cause of death worldwide across all age demographics. LRTI accounts for approximately 4.4% of total hospital admissions and 6% of outpatient consultations. The situation is exacerbated when patients necessitate admissions to intensive care units. Intensive Care Units (ICUs) typically accommodate patients with multi-system diseases, immunocompromised conditions, or complex comorbidities, which complicate and necessitate urgent treatment of lower respiratory tract infections (LRTI) in these environments [3,4].

The complexity of microbial pathogen populations responsible for LRTI complicates clinical management. Gram-negative microorganisms like Klebsiella, Pseudomonas aeruginosa, Acinetobacter baumannii, and Escherichia coli are frequently isolated from inpatients. Additionally, gram-positive bacteria such as *Staphylococcus aureus* (*S. aureus*) may also be present [5]. Fungal infections may contribute to the burden of LRTIs in specific instances. The microbial causes of LRTIs and their patterns of antimicrobial susceptibility exhibit notable geographical variation. Geographical variations require antimicrobic stewardship strategies that account for the specific microbial patterns and resistance rates present in distinct regions [6].

The increase in antimicrobial resistance has compounded the challenges associated with treating lower respiratory tract infections, particularly in critically ill patients in intensive care units. Misuse and overuse have resulted in resistant strains of bacteria, complicating treatment of infections and contributing to a higher mortality rate. Identifying the pattern of antimicrobial susceptibility in a specific region is essential for developing appropriate treatment protocols to enhance patient outcomes [7,8].

The microbiological causes and patterns of antimicrobial resistance in lower respiratory tract infections exhibit significant variability, influenced by demographic factors including age, sex, underlying health conditions, and socio-economic status. These factors may alter both the prevalence and the types of microorganisms responsible for infections, as well as their susceptibility to the available antimicrobials. In areas with distinct demographic features, such as Bihar, India, understanding the local epidemiology of LRTI is crucial for informing clinical decision-making and public health strategies [9,10].

This investigation seeks to explore the connection between demographic variables and the microbiological causes of LRTIs (lower respiratory tract infections) in ICU (intensive care unit) environments. Bihar, located in the eastern region of India, exhibits a distinctive demographic landscape characterised by a significant rural populace, disparities in healthcare access, and various socio-economic influences. The prevalence of LRTI and the resistance patterns of the microorganisms involved may be influenced by these elements.

This study aims to determine the impact of demographic factors on LRTI in Bihar, with a focus on the difficulties experienced by healthcare providers and the necessity of antimicrobial stewardship tailored to the region. This investigation will examine data gathered from the ICU of a teaching hospital, detail the demographic characteristics of the study population, identify prevalent pathogens, and delineate antimicrobial susceptibility patterns in relation to these two aspects. Ultimately, this will significantly enhance the development of improved strategies for managing LRTI and fostering antimicrobial stewardship in the state of Bihar.

Methodology

Study Design

This retrospective study was conducted at Department of Anesthesiology and Critical care, Anugrah Narayan Magadh Medical College and Hospital, Gaya, Bihar, India for one year The study aimed to analyze the impact of demographic factors on antimicrobial susceptibility in lower respiratory tract infections (LRTIs) in ICU patients.

Study Area

This study conducted at Department of Anesthesiology and Critical care, Anugrah Narayan Magadh Medical College and Hospital, Gaya, Bihar, India. The institution has medical and surgical ICUs, comprising 15 beds each, but the study was restricted to these two ICUs.

Study Population

A total of 109 individuals were admitted to the medical and surgical ICUs during the study period and 89 patients met the inclusion for final analysis. Patients included in the study were those whose cultures were positive for LRTIs.

Inclusion Criteria

- Patients aged above 18 years.
- Both genders.
- Patients were admitted to medical or surgical ICUs.
- Patients with positive bacterial cultures confirm LRTIs.

Exclusion Criteria

- Individuals have bacterial cultures that are negative.
- Multiple species of the same bacterium were isolated from patients.
- People whose medical records are not complete.

Data Collection

Demographic data (age and gender) and microbiological data (bacterial isolates and antimicrobial susceptibility) were extracted from structured data gathering form for medical records. Age groups were ranked into 5 categories: 18 to 30, 31 to 40, 41 to 50, 51 to 60, and over 60 years.

Procedure

Samples were collected aseptically from patients and stored in Cary–Blair transport medium. They were inoculated on blood agar and MacConkey agar plates and incubated aerobically at 35°C–37°C for 24–48 hours. Gram staining, culture, and sensitivity testing were performed using standard microbiological procedures. Identification of bacterial isolates and characterization was based on gram staining and microscopic characteristics.

Statistical Analysis

Data were analyzed using MedCalc software. Descriptive statistics were presented as frequencies (n) and percentages (%). The Chi-square test or Fisher's exact test was used to assess differences in bacterial isolates and antimicrobial susceptibility. A p-value of less than 0.05 was considered statistically significant.

Result

Table 1 shows the demographics of the patients. Of the 89 patients, 28 (31.5%) are female, while 61 (68.5%) are male. The predominant age group among patients is over 60 years, comprising 27 individuals (30.3%), followed by 23 patients (25.8%) in the 51-60 years category. The group aged 41-50 comprises 17 patients (19.1%), whereas the 31–40-year group includes 12 patients (13.5%) and the 18–30-year group contains 10 patients (11.2%).

Table 1: Demographics Profiles of the patients

Variable	N (%)
Gender	
Females	28 (31.5%)
Males	61 (68.5%)
Age group	
>60 years	27 (30.3%)
51–60 years	23 (25.8%)
41–50 years	17 (19.1%)
31–40 years	12 (13.5%)
18–30 years	10 (11.2%)

Table 2 presents a summary of bacterial isolates from the lower respiratory system, detailing their distribution in broncho-alveolar lavage (BAL) and tracheal aspirate samples. CONS was exclusively identified in tracheal aspirates (100%), whereas Pneumococcus was evenly distributed between BAL and tracheal aspirates (50% each). Enterococcus was exclusively identified in tracheal aspirates (100%). S. aureus was exclusively identified in tracheal aspirates (100%). E. coli exhibited a greater prevalence in tracheal aspirates (80.0%) than in bronchoalveolar lavage (20.0%). Klebsiella was found to be more prevalent in tracheal aspirates (90.9%) compared to BAL (9.1%). P. aeruginosa and A. baumannii were primarily found in tracheal aspirates, accounting for 78.3% and 88.5%, respectively, while their presence in BAL samples was 21.7% and 11.5%, respectively.

Table 2: Isolated Bacteria from the Lower Respiratory System

Organism	Broncho-alveolar lavage	Tracheal aspirate
CONS	0 (0%)	2 (100%)
Pneumococcus	1 (50%)	1 (50%)
Enterococcus	0 (0%)	1 (100%)
S. aureus	0 (0%)	3 (100%)
E. coli	2 (20.0%)	8 (80.0%)
Klebsiella	2 (9.1%)	20 (90.9%)
P. aeruginosa	5 (21.7%)	18 (78.3%)
A. baumannii	3 (11.5%)	23 (88.5%)

Table 3 displays the antibiotic susceptibility patterns of four bacterial species: P. aeruginosa, A. baumannii, E. coli, and Klebsiella, in relation to 17 different antibiotics. The highest susceptibility of P. aeruginosa was recorded for Colistin (13) and Minocycline (9), whereas the lowest susceptibility was noted for Ampicillin (0). A. baumannii exhibited the greatest susceptibility to Colistin (26) and Tigecycline (24), while demonstrating the least susceptibility to Ceftazidime (4). E. coli exhibited the greatest susceptibility to Tigecycline (5) and Levofloxacin (4), while demonstrating the least susceptibility to Ampicillin (2). Klebsiella demonstrated the greatest susceptibility to Colistin (14) and Tigecycline (11), while showing the least susceptibility to Ceftazidime (2).

Table 3: Pattern of Antibiotic Susceptibility

Antibiotic	P. aeruginosa	A. baumannii	E. coli	Klebsiella
Tigecycline	9	24	5	11
Piperacillin/Tazobactam	5	9	2	5
Minocycline	9	19	2	8
Meropenem	7	12	3	5
Levofloxacin	8	10	4	6
Imipenem	5	10	3	6
Gentamicin	8	12	4	7
Doripenem	7	5	2	5
Cotrimoxazole	5	8	4	5
Colistin	13	26	4	14
Ciprofloxacin	10	4	2	9
Ceftazidime	5	4	2	2
Cefepime	6	3	2	5
Cefoperazone + Sulbactam	5	9	4	5
Aztreonam	5	11	2	3
Ampicillin	0	0	2	2
Amikacin	5	17	2	5

Table 4 represents the antibiotic susceptibility patterns for Gram-positive isolates, which include CONS, pneumococci, Enterococcus, and S. aureus. Vancomycin demonstrated the highest susceptibility rates for Enterococcus (9.0%) and S. aureus (6.7%). Linezolid exhibited comparable rates for both Enterococcus (6.7%) and S. aureus (6.7%). Teicoplanin exhibited susceptibility towards Enterococcus (6.7%) and Staphylococcus aureus (4.5%). Gentamicin exhibited no susceptibility among all isolates (0.0%), whereas Erythromycin demonstrated effectiveness against CONS (2.2%) and S. aureus (2.2%). Clindamycin and Cefoxitin exhibited moderate susceptibility to Enterococcus at 4.5%, while showing low susceptibility rates for coagulase-negative staphylococci and pneumococci at 2.2%. Rifampicin, Ciprofloxacin, and Cotrimoxazole exhibited reduced efficacy, predominantly impacting Enterococcus at a rate of 4.5%.

Table 4: Pattern of Susceptibility for Gram-positive Isolates

Antibiotic	CONS	Pneumococci	Enterococcus	S. aureus
Vancomycin	4 (4.5)	2 (2.2)	8 (9.0)	6 (6.7)
Teicoplanin	4 (4.5)	2 (2.2)	6 (6.7)	4 (4.5)
Rifampicin	2 (2.2)	2 (2.2)	4 (4.5)	4 (4.5)
Linezolid	4 (4.5)	2 (2.2)	6 (6.7)	6 (6.7)
Gentamicin	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Erythromycin	2 (2.2)	0 (0.0)	0 (0.0)	2 (2.2)
Cotrimoxazole	0 (0.0)	0 (0.0)	2 (2.2)	0 (0.0)
Clindamycin	2 (2.2)	2 (2.2)	4 (4.5)	2 (2.2)
Ciprofloxacin	2 (2.2)	2 (2.2)	2 (2.2)	0 (0.0)
Cefoxitin	2 (2.2)	2 (2.2)	4 (4.5)	0 (0.0)
Cefazolin	2 (2.2)	0 (0.0)	4 (4.5)	4 (4.5)
Amoxyclav	2 (2.2)	0 (0.0)	0 (0.0)	2 (2.2)

Discussion

In this study, Demographic analysis reveals significant gender and age patterns within the studied population. Males constituted 68.5% of the cohort, potentially indicating a higher biological vulnerability to respiratory conditions or differing healthcare-seeking behaviors between genders. As a result, females comprised 31.5% of the total. This aligns with observations from Cameron et al. (2010), who noted that although women typically seek healthcare more frequently, men may exhibit higher rates of morbidity and mortality for specific conditions, such as respiratory diseases [11]. Roxo et al. (2021) elucidated that healthcare-seeking behaviors may be influenced by the severity of the illness at presentation in males, often attributable to delayed presentation for serious conditions [12]. The observed male predominance may reflect social norms or occupational exposure, both of which predispose males to respiratory illness.

Age distribution analysis indicated that the predominant subgroup of patients comprised older adults aged ≥60 years (30.3%), followed by individuals aged 51-60 years, who represented 25.8% of the study participants. Patients aged 41-50 constituted 19.1%, whereas those aged 31-40 and 18-30 represented smaller proportions at 13.5% and 11.2%, respectively. It is proposed that the increase in the prevalence and/or severity of respiratory illnesses is likely associated with advancing age. Declining immunity and chronic comorbidities resulting from cumulative environmental exposures may explain this phenomenon. Therefore, it is essential to implement preventive measures or early interventions to address the significant burden faced by older adults.

The patterns of microbial distribution offered significant insights into respiratory tract infections. Gram-negative bacteria, specifically Klebsiella pneumoniae and Acinetobacter baumannii, were predominant in the tracheal aspirates, with isolation rates of 90.9% and 88.5%, respectively. These organisms are established pathogens in severe respiratory infections, particularly among hospitalized or ventilated patients, where their prevalence is frequently linked to elevated morbidity and mortality rates. The results align with the findings of Rajesh et al. (2023), who similarly documented a significant isolation rate of Gram-negative bacteria from tracheal aspirates in clinical environments [13]. Other Gram-negative pathogens, including Escherichia coli and Pseudomonas aeruginosa, exhibited comparable prevalence, underscoring their significance in lower respiratory tract infections. The isolation of Pneumococcus at comparable frequencies from bronchoalveolar lavage and tracheal aspirates highlights its capacity to colonize various locations within the respiratory system.

The antibiotic susceptibility patterns exhibited significant variability among Gram-negative bacteria. Colistin demonstrated the highest potency, exhibiting elevated susceptibility rates across all tested isolates, including A. baumannii and Klebsiella pneumoniae. Tigecycline demonstrated significant efficacy, aligning with the findings of Maleki et al. (2022), who emphasized its importance in addressing multidrug-resistant A. baumannii [14]. Moderate susceptibility was observed to Levofloxacin, Gentamicin, and Ciprofloxacin, whereas resistance to frequently utilized antibiotics such as Cefepime, Cotrimoxazole, and Doripenem was notably elevated. This trend of resistance aligns with the findings of Denys et al. (2005), which indicated a reduction in susceptibility of ESBL-producing K. pneumoniae isolates to carbapenems and amikacin [15]. The data underscore the increasing issue of multidrug-resistant pathogens and the necessity for robust antimicrobial stewardship to inform empirical therapy and maintain the efficacy of existing antibiotics.

The susceptibility profile of Gram-positive isolates appeared favourable. Vancomycin and Linezolid showed the highest activity (100%) against isolates such as CONS, Pneumococcus, Enterococcus, and Staphylococcus aureus. This study corroborates the findings of Mamtora et al. (2019), which demonstrated a high sensitivity of MRSA isolates to Vancomycin (97.7%) and Linezolid (98%) [16]. Teicoplanin demonstrated reduced efficacy; however, it remained highly dependable. Resistance to Gentamicin and Cotrimoxazole was notably observed, consistent with the findings of Alhumaid et al. (2021), who reported reduced efficacy of these antibiotics against MRSA and Enterococcus species [17]. The variable efficacy of antibiotics such as Clindamycin, Erythromycin, and Rifampicin highlights the necessity for antibiotic-susceptibility testing specific to individual organisms.

This study's demographic and microbiological findings highlight several critical aspects of managing respiratory infections. The significant vulnerability of the elderly necessitates targeted preventive strategies, such as vaccination, early diagnosis, and age-appropriate therapeutic interventions. The significant prevalence of multidrug-resistant Gram-negative bacteria necessitates the implementation of extensive antimicrobial stewardship programs to optimize antibiotic utilization and mitigate the dissemination of resistance. Regular microbial surveillance and susceptibility testing are essential for informing empirical treatment, particularly in environments with a significant prevalence of resistant pathogens.

The findings offer significant insights into the demographic and microbiological characteristics of respiratory infections, highlighting the urgent need for tailored healthcare strategies to address challenges associated with older age, gender disparities, and the increasing prevalence of antimicrobial resistance.

Conclusion

This investigation emphasizes the influence of demographic factors on the variety of microbial isolates and their resistance to antimicrobials in lower respiratory tract infections among ICU patients at a teaching hospital in Bihar. The results indicate a significant prevalence of males and older age demographics, with Klebsiella and A. baumannii identified as the predominant pathogens isolated. The susceptibility patterns exhibited diverse outcomes, with certain agents, including colistin, demonstrating greater efficacy against multi-drug-resistant Gram-negative organisms. In the case of Gram-positive bacteria, vancomycin and linezolid demonstrated a superior efficacy rate. This study highlights the importance of obtaining local epidemiological data to develop effective antimicrobial stewardship strategies within critical care environments.

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