

STUDY OF BACTERIA CAUSING RESPIRATORY TRACT INFECTIONS AND THEIR ANTIMICROBIAL SUSCEPTIBILITY

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Abstract

This study (from January 2020 to June 2020) aimed to determine the antibacterial susceptibility of respiratory tract disease-causing bacteria to chosen antibiotics using the Kirby–Bauer disk diffusion method. 55 respiratory tract specimens were collected from patients with respiratory illness who visited Jinnah Hospital, Lahore, across different age groups. The samples were labeled and processed in the Microbiology Laboratory of Allama Iqbal Medical College, Lahore, following standard laboratory operating protocols. Bacterial isolates were identified based on colony morphology, Gram staining, and biochemical properties.

Samples were streaked on appropriate agar media and cultured them at 37°C for 24 hours to isolate pure colonies. The bacterial isolates in pure colony comprised 75% Gram-negative bacteria and 25% Gram-positive bacteria. The bacteria identified were *Escherichia coli*, *Klebsiella* spp., *Pseudomonas* spp., *Acinetobacter* spp., *Streptococcus* spp., and *Staphylococcus* spp. Antimicrobial susceptibility testing was performed on Mueller–Hinton agar using the Kirby–Bauer disc diffusion method according to CLSI 2020 standards. Ampicillin, Gentamicin, Ciprofloxacin, and Ceftriaxone were tested on all bacterial isolated, but ampicillin-sulbactam was tested against *Acinetobacter* only. Quality control was performed with ATCC reference strains.

Data were analyzed with GNU PSPP Version 2.1.1. Descriptive statistics and the chi-square test were used. Ampicillin and ciprofloxacin showed highly significant differences between susceptible and resistant isolates ($p < 0.001$). Ceftriaxone showed no statistically significant difference ($p = 0.390$). Gentamicin showed a highly significant difference ($p = 0.002$). Ampicillin-sulbactam also showed a statistically significant difference among the *Acinetobacter* isolates ($p = 0.007$).

Ampicillin exhibited low activity against Gram-negative isolates, while ciprofloxacin showed poor activity against Gram-positive isolates. Gentamicin showed good activity against *Staphylococcus aureus*, and ceftriaxone showed good activity against *Streptococcus* isolates. *Acinetobacter* showed poor sensitivity to ampicillin-sulbactam. The findings highlight the need for routine

1. INTRODUCTION

Infections in the upper and lower respiratory tracts must be controlled with antibiotics. Because antibiotic resistance can lead to higher mortality, longer hospital admissions, and clinical failure, it is a major problem in airway clinical practice (Van Hecke *et al.*, 2017). Two main causes drive this antibiotic problem (Guitor *et al.*, 2018). The first is the unstoppable problem of microbial evolution, which has made many significant pathogens less sensitive to all types of antibiotics (Guitor *et al.*, 2018). The second is the lack of new medicine development (Guitor *et al.*, 2018). The former reflects the inherent biology of bacteria, their exposure to the selective pressure of medications, and their capacity to adapt to the danger of antibiotics through several methods (Guitor *et al.*, 2018). The latter illustrates the financial realities of the anticipated return on investment from creating medications that treat acute illnesses (as opposed to those for chronic diseases, for which drug use may occur across a lifetime) (Guitor *et al.*, 2018). One contributing factor is limited innovation in developing new antibiotics because scientific obstacles mirror the difficulty of finding novel, safe, and effective medicines (Guitor *et al.*, 2018). As a result, new drug research and discovery are not meeting clinical demand for new medications. The most common infectious disease-related cause of mortality worldwide is lower respiratory tract infections (WHO, 2018). Children, the elderly, and those with weakened immune systems are most at risk of contracting respiratory infections (Van Hecke *et al.*, 2017; Beckett *et al.*, 2015; Troeger *et al.*, 2017). Treating the elderly population is more difficult because of changes in immune function, respiratory tract anatomy, and comorbidities; selecting the right antibiotics is crucial (Kline & Bowdish, 2016). Resolving respiratory infections in all groups, especially the elderly, will remain a worldwide health problem due to growing antibiotic resistance (Guitor *et al.*, 2018). To effectively manage airway infections in

the short and medium term, it is crucial to understand the processes of antibiotic resistance, their origins, and their spread (Guitor *et al.*, 2018). Guitor *et al.*, 2018 covered several resistance mechanisms to important antibiotics in airway infections, as well as their selection and development.

The World Health Organization published a list of priority infections in early 2017 that require further study and development of antibiotic treatments (WHO, 2018). This list includes bacteria like carbapenem-resistant *Acinetobacter baumannii* that are frequently linked to respiratory illnesses; *Pseudomonas aeruginosa* that is resistant to carbapenem; *Enterobacteriaceae* that are resistant to carbapenem and third-generation cephalosporins, including *Klebsiella pneumoniae*; *Staphylococcus aureus* that is resistant to methicillin, vancomycin-intermediate, and vancomycin; *Streptococcus pneumoniae* that is not susceptible to penicillin; and *Haemophilus influenzae* that is resistant to ampicillin (WHO, 2018; Pfaller *et al.*, 2012). *Mycobacterium tuberculosis*, a respiratory infection that was previously identified as a global health priority due to multidrug resistance and the need for novel treatments, is not included on this list (WHO, 2018).

Another respiratory pathogen, *Moraxella catarrhalis*, has demonstrated decreased sensitivity to macrolides and fluoroquinolones and is often resistant to β -lactams due to the high prevalence (>80%) of β -lactamases (Saito *et al.*, 2015; Jetter *et al.*, 2009; Zhang *et al.*, 2016; Du *et al.*, 2017; Wang *et al.*, 2016; Hu *et al.*, 2016). Immunization has addressed respiratory pathogens, including *S. pneumoniae*, *H. influenzae*, and *Bordetella pertussis* (Guitor *et al.*, 2018). Although *B. pertussis* has been successfully reduced, some countries report more cases, often with resistance to tetracyclines, macrolides, and fluoroquinolones (Yang *et al.*, 2015). Vaccination has reduced some *H. influenzae* and *S. pneumoniae* serotypes and antibiotic resistance. In contrast, other serotypes with

growing resistance are now more common in infections (Dunne *et al.*, 2018; Linares *et al.*, 2010; Sheppard *et al.*, 2016). *H. influenzae* produces many β -lactamases and is highly resistant to ampicillin in several nations (Zhang *et al.*, 2016; Wang *et al.*, 2016; Hu *et al.*, 2016; Torumkuney *et al.*, 2018). Globally, *S. pneumoniae* still shows decreased sensitivity to β -lactam antibiotics, and treatment with macrolides and fluoroquinolones has increased resistance to these drugs (Zhang *et al.*, 2016; Wang *et al.*, 2016; Hu *et al.*, 2016; Baek *et al.*, 2018). Lastly, multidrug-resistant (MDR) bacteria, such as MDR *S. pneumoniae* and MDR *A. baumannii*, are becoming increasingly common in the US, along with rising rates of single-agent resistance (Guiton *et al.*, 2018).

CARTIs, or community-acquired respiratory tract infections, are common and contribute significantly to morbidity and death (Doern *et al.*, 2003). For instance, every year in the US, there are 2–3 million episodes of community-acquired pneumonia, which lead to around 10 million doctor visits, 500,000 hospital admissions, and 45,000 fatalities (Bartlett *et al.*, 2000). The development of antibiotic resistance in bacteria that frequently cause CARTIs, particularly *Streptococcus pneumoniae* and *Haemophilus influenzae*, has hindered empirical treatment of these infections in recent years (Guthrie, 2001). Furthermore, the possibility of *Streptococcus pyogenes* developing antibiotic resistance has been raised (Canton *et al.*, 2002; Richter *et al.*, 2003). Most significantly, isolates of *S. pneumoniae* in the US have attained previously unheard-of levels of resistance to β -lactam, macrolide, clindamycin, tetracycline, and co-trimoxazole (Doern *et al.*, 2001). Recent data also show that this bacterium is beginning to develop fluoroquinolone resistance (Whitney *et al.*, 2000). Antimicrobial resistance seriously threatens current and future CARTI treatment, underscoring the need for novel medicines that are consistently effective against resistant organisms and do not contribute to resistance development (Doern *et al.*, 2003). Furthermore, ongoing observation of the development and

dissemination of antibiotic resistance among common respiratory infections is necessary, both locally and nationally. Prospective Resistant Organism, or PROTEKT, a global antimicrobial surveillance study called "Tracking for the Ketolide Telithromycin," began in 1999 to track resistance trends over time in common bacterial respiratory tract infections (Doern *et al.*, 2003). The results of PROTEKT US, a parallel study that started in 2000 to track the activity of several pertinent antimicrobial agents and the novel ketolide telithromycin against clinically significant isolates of *S. pneumoniae*, *H. influenzae*, and *S. pyogenes*, are presented for the first year (2000–2001) by Doern *et al.*, 2003.

Geographical regions have different LRTI etiological agents and antibiotic susceptibility profiles (Mishra *et al.*, 2012; Egbagbe & Mordi, 2006). Bacteria, intracellular bacterial pathogens, viruses, fungi, and parasites can all cause LRTIs; common causes include *Klebsiella pneumoniae*, *Haemophilus influenzae*, *Enterococcus* species, and *Streptococcus pneumoniae* (Shrestha *et al.*, 2013). In community-acquired LRTIs, clinicians have traditionally used an empirical approach (Maduakor *et al.*, 2017). Antibiotic-resistant strains have emerged and spread quickly, making the notion that antibiotics are harmless untenable. This has also complicated the process of choosing antimicrobial medicines (Guthrie, 2001). Another important resistance mechanism that hinders antimicrobial treatment of infections caused by *Enterobacteriaceae* and poses a major danger to the current antibiotic arsenal is the production of extended-spectrum β -lactamases (ESBLs) (Sibghatulla, 2015). However, once etiological agents and their antibiotic sensitivity patterns are identified, selecting antimicrobial treatment for LRTI is straightforward (Okesola and Ige, 2008). Consequently, whether in a community or hospital context, the clinical presentation is insufficiently precise to establish a definitive etiologic diagnosis (Okesola & Ige, 2008; Fang *et al.*, 1990).

The most prevalent lower respiratory tract infections in general practice were pneumonia and bronchitis, which were linked to significant global

mortality and morbidity (Macfarlane *et al.*, 2001). Statistics show that lower respiratory tract infections accounted for 6% of general practitioner visits and 4.4% of hospital admissions (Anderson *et al.*, 1993). Despite the development of several antimicrobial drugs with anti-pseudomonal activity and improvements in medical and surgical care, *Pseudomonas aeruginosa*, which causes life-threatening infections, continues to contribute to hospital-acquired illnesses (Mayhall, 1996). *Pseudomonas aeruginosa* is an aerobic rod that is Gram-negative and a member of the *Pseudomonadaceae* family (Fatima *et al.*, 2012). It is now regarded as an opportunistic pathogen and a significant contributor to nosocomial infections (Fatima *et al.*, 2012). Because of its high incidence of antimicrobial resistance, it was also regarded as the most difficult disease in the world (Hugbo & Olurinola 1992; Trilla, 1994). Due to its extremely low nutritional requirements, *Pseudomonas aeruginosa* grew more quickly in hospital settings (Gilligan, 1995). *Pseudomonas aeruginosa* exhibited resistance to several antimicrobial drugs, and only a small number of antibiotics were effective against the bacteria (Carmeli *et al.*, 1999). Higher death rates from pseudomonal infections have been linked to strong resistance patterns in *Pseudomonas aeruginosa* (Samporn *et al.*, 2004). *Pseudomonas aeruginosa* isolate susceptibility patterns vary by location and hospital setting; therefore, understanding these patterns is necessary to improve outcomes with chemotherapeutic approaches to pseudomonal infections (Fatima *et al.*, 2012). Fatima *et al.*'s (2012) study examined drug susceptibility patterns in patients with lower respiratory tract infections and ascertained the incidence of *Pseudomonas aeruginosa*.

Nosocomial infections are frequently caused by *Acinetobacter* species (Khan *et al.*, 2015). In 1968, Baumann *et al.* named it *Acinetobacter*. *Acinetobacter* species are encapsulated, Gram-negative opportunistic pathogens that are aerobic cocco-bacilli (Bhattacharyya *et al.*, 2013) and do not ferment lactose (Khan *et al.*, 2015). *Acinetobacter* species are pleomorphic and

opportunistic (Badave & Kulkarni, 2015). *Acinetobacter* species easily colonize skin, oropharyngeal secretions, and respiratory tract components (Guerrero *et al.*, 2010). Researchers have identified almost thirty-five *Acinetobacter* species to date (Nahar *et al.*, 2012). Most *Acinetobacter baumannii* is found on the surface of medical equipment (Khan *et al.*, 2015). *Acinetobacter* species are typically detected in hospital intensive care units (Al-Mulhim *et al.*, 2014). The spontaneously transformable tryptophan auxotrophic phenotype of the mutant *Acinetobacter* strain BD413trpe27 is another distinctive feature (Di Nocera *et al.*, 2011). *Acinetobacter* species resist sterilization and disinfection procedures because they can form biofilms, which, in addition to conferring resistance, are crucial for adhesion to medical equipment (Khan *et al.*, 2015). According to Khan *et al.*, 2015, *Acinetobacter* species colonies can remain mucoid for at least six days, increasing their pathogenicity. According to a recent study by Grace *et al.* (2016), mutations in two of the genes of the two-component systems (TCSs), namely AdeR and AdeS, which are involved in the formation of adeA, adeB, and adeC (RND family), cause the antibiotics to be effluxed out of the cell, resulting in multidrug resistance. *Acinetobacter* species can produce six distinct kinds of QS molecules (Richmond *et al.*, 2016). Microbial resistance is an organism's natural biological reaction to heat, food, the environment, antibiotics, and acquired stressors. Examples of antimicrobial resistance mechanisms include reduced access to bacterial targets, mutations that alter targets or cellular activities, and antimicrobial deactivation by enzymes (Labby & Garneau-Tsodikova, 2013).

Over 50 million fatalities worldwide are caused by respiratory tract infections (RTIs), which are among the most common and dangerous illnesses (Zafar *et al.*, 2008). Additionally, RTIs are the most frequent cause of doctor visits and antibiotic prescriptions (WHO, 2005; Mogyoros, 2001). Lower respiratory tract infections include acute exacerbations of chronic bronchitis (AECB) and

community-acquired pneumonia (CAP), which are among the top 10 causes of death in the industrialized world and are linked to notable mortality rates (Zafar *et al.*, 2008). While older people in rich nations have higher rates of illness severity and death, babies under the age of four are more at risk for lower RTIs in underdeveloped nations (Macfarlane *et al.*, 1993). The efficacy of treating community-acquired respiratory tract infections (RTIs) may be compromised by rising antibacterial resistance in organisms such as *Haemophilus influenzae* and *Streptococcus pneumoniae* over the past several decades (Zafar *et al.*, 2008). Because of the lack of standardized laboratories and the increased cost of laboratory services, most RTIs in Pakistan are treated empirically (Zafar *et al.*, 2008). To develop guidelines, guide empirical therapy, and identify regional trends in antibiotic resistance, surveillance studies are a crucial tool (Zafar *et al.*, 2008). To determine the susceptibility patterns of common respiratory tract infections in the population, Zafar *et al.* 2008 carried out the study.

Respiratory infections are another frequent cause of primary care visits in Pakistan (Shah *et al.*, 2016). Most patients with respiratory infection signs and symptoms who see a medical practitioner are treated empirically (Zafar *et al.*, 2008). The patient's medical history and physical examination are crucial diagnostic tools for a general practitioner (Shah *et al.*, 2016). Only a small number of people should have a chest X-ray (Shah *et al.*, 2016). Microbiological examinations are very uncommon in Pakistan (Shah *et al.*, 2016). According to estimates from the World Health Organization (WHO), pneumonia claims the lives of two million children under five in Pakistan each year (Bryce *et al.*, 2005). In a different study, Najam and his associates found that children in Pakistan are more likely to have upper respiratory tract infections (Najam *et al.*, 2000). In Pakistan's Federally Administered Tribal Area (FATA) and Khyber Pakhtunkhwa regions, acute respiratory tract infections remained the most frequent reason for consultations; 8954 consultations for acute cases were reported over one year, making

up 32% of all consultations reported (WHO, 2009).

Antibiotic resistance (AR) is an international public health problem (WHO, 2014). Drug-resistant diseases are predicted to kill 10 million people by 2050 and cost the world economy between \$60 and \$100 trillion if they continue to increase at the current rate (El-Mahmood *et al.*, 2010). Respiratory tract infections (RTIs) are frequently associated with increasing bacterial resistance (Promite *et al.*, 2017). *Pseudomonas aeruginosa*, *Escherichia coli*, *Streptococcus pneumoniae*, and *Klebsiella pneumoniae* are the bacteria that cause RTIs (WHO, 2014), (O'Neill, 2015), (Jones & Pfaller, 1998). Additionally, RTIs are a major contributor to morbidity and mortality worldwide (Ball *et al.*, 2002). Today, many prescribers frequently engage in malpractice by improperly prescribing antibiotics for RTIs (Cantas *et al.*, 2013; Martínez-González *et al.*, 2017). In addition to increasing side effects, treatment costs, resource use, and medical consultations, this approach also increases the development of antibiotic-resistant bacterial strains (Cantas *et al.*, 2013; Martínez-González *et al.*, 2017; Baqui *et al.*, 2007).

2. MATERIALS AND METHODS

A cross-sectional study was conducted in the Pathology Department, Microbiology Laboratory, Allama Iqbal Medical College, Lahore, from January 2020 to June 2020. 55 sputum and throat swab samples were collected from patients visiting Jinnah Hospital, Lahore. Patients with respiratory tract infections were included, regardless of age or gender. Patients on antimicrobial therapy were excluded. We excluded patients with any major disease. Informed consent was taken from patients or guardians. Expecterated samples were obtained early-morning in sterile, wide-mouthed, screw-sealed, disposable plastic containers. Gloves were changed for each sample and labeled each sample separately. Samples were immediately processed at the Microbiology Laboratory. The quality of expecterated samples was examined by macroscopic and microscopic examination. Specimens without purulent material that were transparent, thin, and watery were discarded. The

quality of sputum and throat swabs was appraised microscopically using Bartlett's scoring before microbiological culture. Smears were prepared and subjected them to Gram staining and various biochemical test for identification. Catalase, Coagulase, Oxidase, Indole, Citrate, Urease, Motility test and API 20 NE (BioMerieux, France) strip tests were performed for identification. Respiratory bacterial pathogens were isolated by culturing clinical specimens on MacConkey agar, blood agar, and chocolate agar by steak plate method and then incubation at 37 degree Centigrade for 24 hours.. Blood agar was used for the isolation and observation of hemolytic properties of Gram-positive bacteria, and MacConkey agar was used largely for Gram-negative bacteria. Chocolate agar was utilized to recover fastidious respiratory microorganisms, especially *Streptococcus pneumoniae*. After incubation, well-isolated colonies were selected for identification and further antimicrobial susceptibility testing.

After incubation, plates were assessed for purity and homogeneous colony morphology. A new, well-isolated colony from the pure culture was used to prepare the bacterial inoculum for antibiotic susceptibility testing. Before inoculating the appropriate susceptibility-testing medium, the inoculum was standardized according to the laboratory's established AST process.

We performed antimicrobial susceptibility testing of routine bacterial isolates on Mueller-Hinton

agar (Oxoid UK) by inoculating with sterile swab; appropriate supplementary media was used when necessary for fastidious species. Antimicrobial discs were on the surface of the inoculated agar according to the laboratory protocol and incubated plates under 37 degree centigrade for 24 hours. The diameters of the inhibition zones around the antimicrobial discs in millimetres were measured after incubation and interpreted them according to the relevant susceptibility breakpoint recommendations. Quality control was done using the relevant ATCC reference strains (*E. coli* ATCC 25922, *S. aureus* ATCC 25923, *P. aeruginosa* ATCC 27853, *A. baumannii* ATCC 19606, and *K. pneumoniae* ATCC 700603). The ATCC isolates were standardized to 0.5 McFarland and tested them on appropriate susceptibility-testing media. The inhibition zones of ATCC reference strains were measured and compared them with the applicable CLSI QC 2020 limits.

2.1. Statistical Analysis

The data were analyzed using GNU PSPP version 2.1.1. The data were analyzed, tabulated, and graphed. Descriptive statistics summarized the distribution of bacterial isolates and their antimicrobial susceptibility patterns. The chi-square test was used to examine the association between bacterial isolates and sensitivity or resistance to specified antibiotics. Statistical significance was set at $p < 0.05$.

3. RESULTS

Table 3.1 Percentage Distribution of Gram-Negative and Gram-Positive Bacteria

Percentage Distribution of Gram-Negative and Gram-Positive Bacteria		
Gram Positive Bacteria	n=14	25%
Gram-Negative Bacteria	n=41	75%

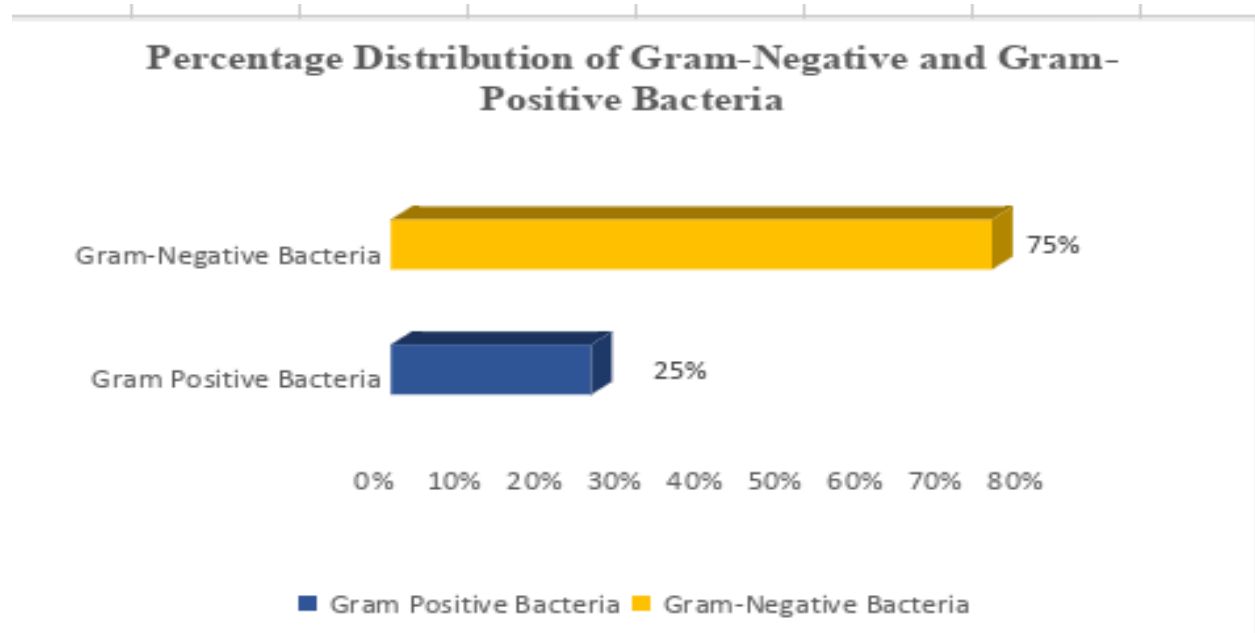


Figure 3.1

Table 3.2 : Prevalence of Gram-Negative and Gram-Positive Bacterial Isolates

Bacteria	Prevalence (%)	Gram group
<i>E. coli</i> (n=20)	36	Gram-negative
<i>Acinetobacter</i> (n=11)	20	Gram-negative
<i>Pseudomonas</i> (n=4)	7	Gram-negative
<i>Klebsiella</i> (n=6)	10	Gram-negative
<i>Staphylococcus</i> (n=6)	10	Gram-positive
<i>Streptococcus</i> (n=8)	14	Gram-positive

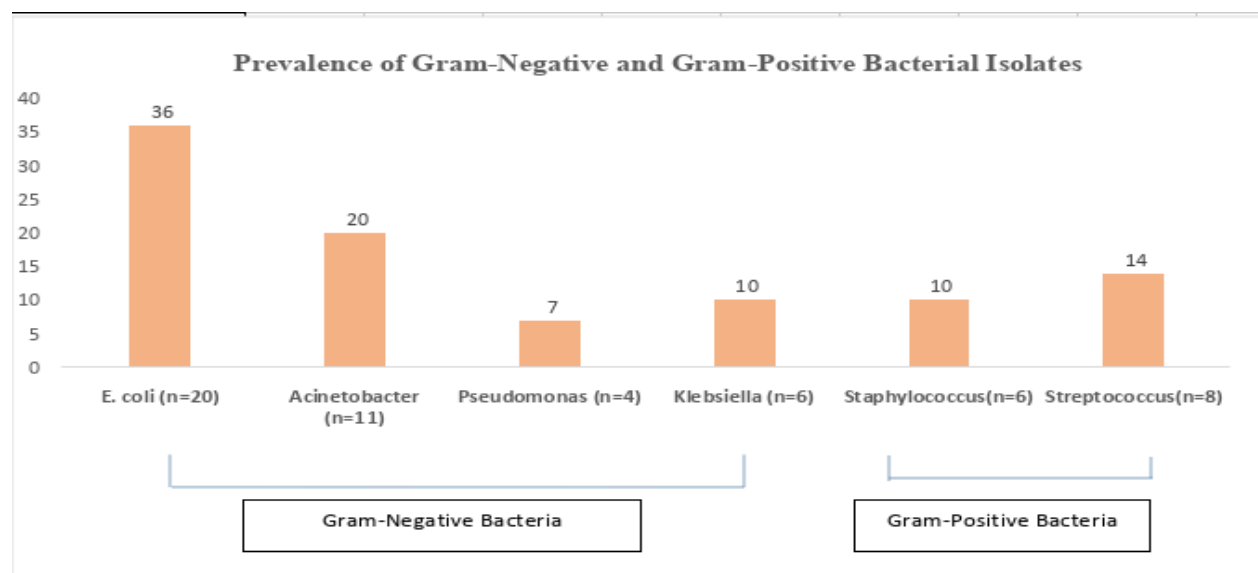


Figure 3.2

Table 3.3: Zone diameter breakpoints of various antibiotics against respiratory tract infection causing bacteria by disk diffusion tests according to the guidelines of CLSI M100 30th Edition.

Bacteria	Susceptibility	Antibiotics			
		Ampicillin (but Ampicillin-sulbactam for Acinetobacter only)	Ceftriaxone	Gentamicin	Ciprofloxacin
<i>E.coli/Klebsiella</i>	Resistant (mm)	Smaller than or equal to 13	Smaller than or equal to 19	Smaller than or equal to 12	Smaller than or equal to 20
	Sensitive (mm)	Greater than or equal to 17	Greater than or equal to 23	Greater than or equal to 15	Greater than or equal to 31
<i>Acinetobacter</i>	Resistant (mm)	Smaller than or equal to 11	Smaller than or equal to 13	Smaller than or equal to 12	Smaller than or equal to 15
	Sensitive (mm)	Greater than or equal to 15	Greater than or equal to 21	Greater than or equal to 15	Greater than or equal to 21
<i>Streptococcus pyogenes</i>	Resistant (mm)			Not administered on following CLSI M100 30 th Edition	Not administered on following CLSI M100 30 th Edition
	Sensitive (ug/ml) MIC	Smaller than or equal to 0.25 ug/ml	Smaller than or equal to 0.5 ug/ml	Not administered on following CLSI M100 30 th Edition	Not administered on following CLSI M100 30 th Edition
<i>Pseudomonas aeruginosa</i>	Resistant (mm)	Not administered on following CLSI M100 30 th Edition	Not administered on following CLSI M100 30 th Edition	Smaller than or equal to 12	Smaller than or equal to 18
	Sensitive (mm)	Not administered on following CLSI M100 30 th Edition	Not administered on following CLSI M100 30 th Edition	Greater than or equal to 15	Greater than or equal to 25
<i>Staphylococcus aureus</i>	Resistant (mm)	Not administered on following CLSI M100 30 th Edition	Not administered on following CLSI M100 30 th Edition	Smaller than or equal to 12	Smaller than or equal to 15

	Sensitive (mm)	Not administered on following CLSI M100 30 th Edition	Not administered on following CLSI M100 30 th Edition	Greater than or equal to 15	Greater than or equal to 21
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Table 3.4: Percentage Susceptibility of Respiratory Tract Infections Causing Bacteria By Disk-Diffusion Method

Bacteria	Ampicillin (but Ampicillin-Sulbactam for Acinetobacter)	Ceftriaxone	Gentamicin	Ciprofloxacin
<i>E. coli</i>	0	30	45	20
<i>Acinetobacter</i>	9.09	18.18	9.09	9.09
<i>Streptococcus pyogenes</i>	75	87.5	Not administered on following CLSI M100 30 th Edition	Not administered on following CLSI M100 30 th Edition
<i>Pseudomonas aeruginosa</i>	Not administered on following CLSI M100 30 th Edition	Not administered on following CLSI M100 30 th Edition	0	0
<i>Staphylococcus</i>	Not administered on following CLSI M100 30 th Edition	Not administered on following CLSI M100 30 th Edition	100	0
<i>Klebsiella</i>	0	50	33.3	66.6

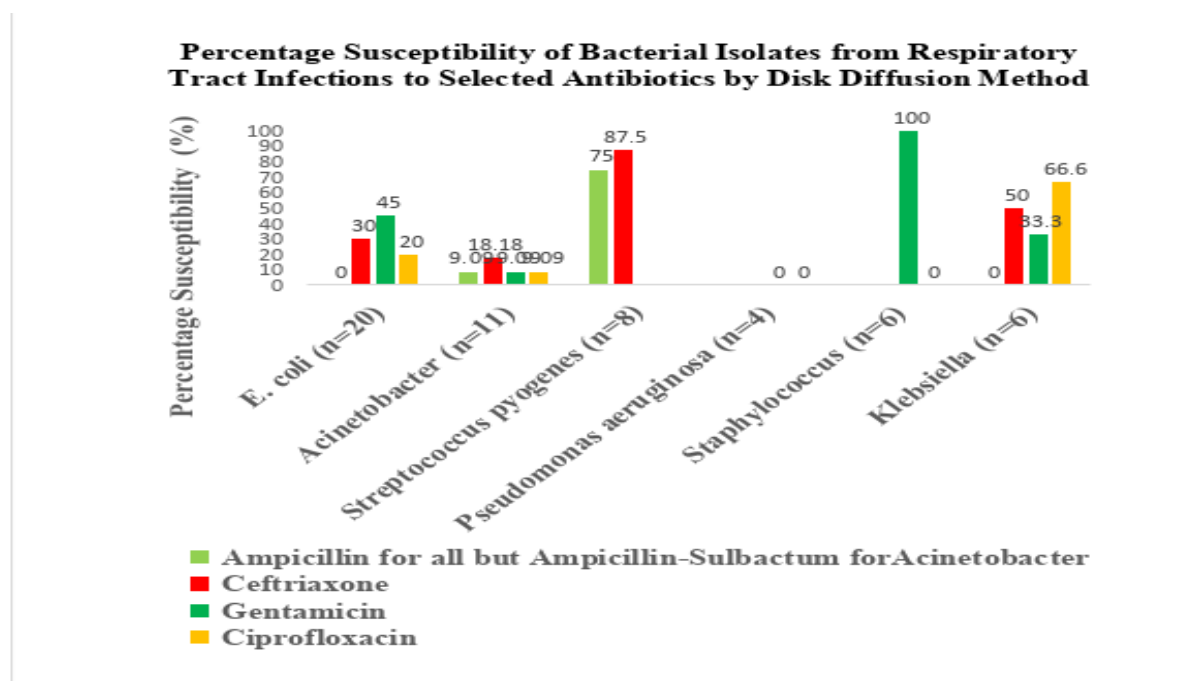


Figure 3.3



*= p < 0.05 Significant

**= p < 0.01 Highly Significant

***= p < 0.001 Very Highly Significant

Figure 3.4 a,b,c,d,e : Showing Antimicrobial Susceptibility of Bacterial Isolates Against Selected Antibiotics

Table 3.5 : Antimicrobial Susceptibility of Bacterial Isolates Against Selected Antibiotics and Their Statistical Significance

Antibiotic	Bacterial Isolate	Sensitive	Resistant	Overall p-value
Ampicillin	<i>E.coli</i> (n=20)	0 (0%)	20 (100 %)	0.000 *** Very Highly Significant
	<i>Streptococcus</i> (n= 8)	6 (75)	2 (25 %)	
	<i>Pseudomonas</i> (n= 4)	Not administered on following CLSI M100 30 th Edition	Not administered on following CLSI M100 30 th Edition	
	<i>Staphylococcus</i> (n= 6)	Not administered on following CLSI M100 30 th Edition	Not administered on following CLSI M100 30 th Edition	
	<i>Klebsiella</i> (n= 6)	0 (0%)	6(100 %)	
Gentamicin	<i>E.coli</i> (n=20)	9 (45%)	11 (55%)	0.002 ** Highly Significant
	<i>Streptococcus</i> (n= 8)	Not administered on following CLSI M100 30 th Edition	Not administered on following CLSI M100 30 th Edition	
	<i>Pseudomonas</i> (n= 4)	0 (0 %)	4 (100 %)	
	<i>Staphylococcus</i> (n= 6)	6 (100 %)	0 (0 %)	
	<i>Klebsiella</i> (n= 6)	2 (33.3 %)	4 (66.7 %)	
	<i>Acinetobacter</i> (n=11)	1 (9 . 09 %)	10 (90.91%)	
Ciprofloxacin	<i>E.coli</i> (n=20)	4 (20 %)	16 (80%)	0.000 *** Very Highly Significant
	<i>Streptococcus</i> (n= 8)	Not administered on following CLSI M100 30 th Edition	Not administered on following CLSI M100 30 th Edition	
	<i>Pseudomonas</i> (n= 4)	0 (0 %)	4 (100 %)	
	<i>Staphylococcus</i> (n= 6)	0 (0 %)	6 (100 %)	
	<i>Klebsiella</i> (n= 6)	4 (66.6 %)	2 (33.4%)	
	<i>Acinetobacter</i> (n=11)	1 (9.09 %)	10 (90.91 %)	
Ceftriaxone	<i>E.coli</i> (n=20)	6 (30 %)	14 (70 %)	0.390 Not Significant
	<i>Streptococcus</i> (n= 8)	7 (87.5 %)	1 (12.5%)	
	<i>Pseudomonas</i> (n= 4)	Not administered on following CLSI M100 30 th Edition	Not administered on following CLSI M100 30 th Edition	
	<i>Staphylococcus</i> (n= 6)	Not administered on following CLSI M100 30 th Edition	Not administered on following CLSI M100 30 th Edition	
	<i>Klebsiella</i> (n= 6)	3 (50%)	3 (50 %)	

	<i>Acinetobacter</i> (n=11)	2 (18.18%)	9 (81.82%)	
Ampicillin-Sulbactam	<i>Acinetobacter</i> (n=11)	1 (9.09 %)	10 (90.91 %)	.007 ** Highly Significant

Table 3.6: Antibiotic Sensitivity Among Gram-Positive and Gram-Negative Bacterial Isolates

Antibiotic	Gram-positive (%)	Gram-negative (%)
Ampicillin	75	0
Gentamicin	100	29.27
Ciprofloxacin	0	21.95
Ceftriaxone	87.5	29.73
Ampicillin-Sulbactam	N/A	9.09

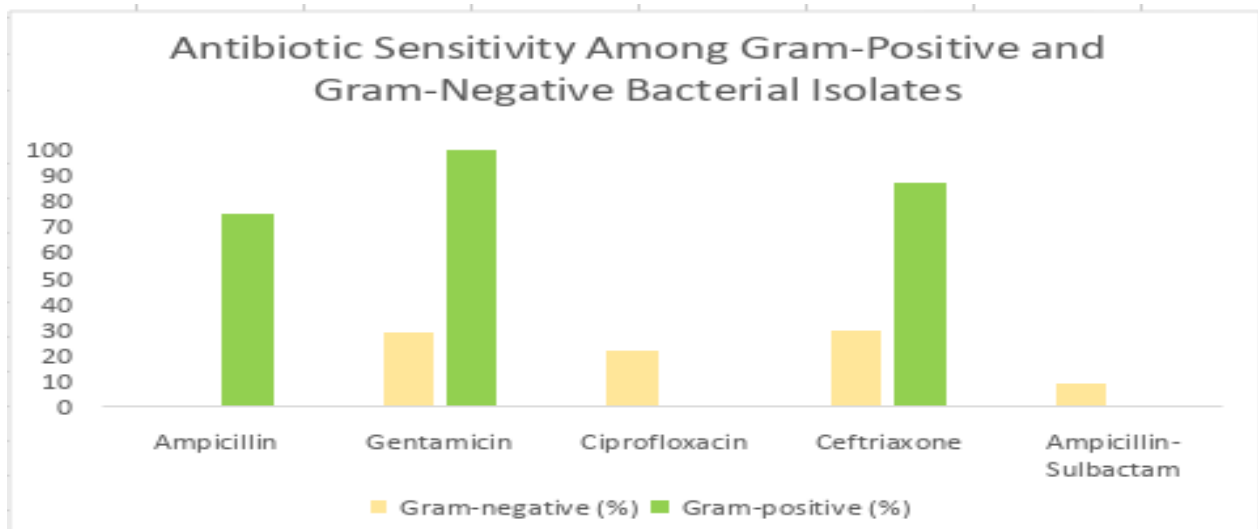


Figure 3.5

4. DISCUSSION

During the study, we included 55 sputum and throat swab samples from patients with respiratory tract infections. Out of 55, 75 percent were Gram-negative bacteria (n=41) and 25 percent were Gram-positive bacteria (n=14), as shown in Figure 3.1. Among the 41 Gram-negative bacteria, 20 were *E. coli* (36%), 11 were *Acinetobacter* (20%), 4 were *Pseudomonas* (7%), and 6 were *Klebsiella* (10%), as shown in Table and Figure 3.1. Among the 25% Gram-positive bacteria, 6 were *Staphylococcus* (10%), and 8 were *Streptococcus* (14%), as shown in Table and Figure 3.1. These findings were consistent with Jabbar *et al.* (2016), who found 79% Gram-negative and 21% Gram-positive bacteria. Jabbar *et al.* (2016) found the

same respiratory tract infection-causing bacteria as in our study, but they also identified 2 additional bacterial isolates: *Haemophilus influenzae* (2%) and *Proteus mirabilis* (1%). In Jabbar *et al.* (2016), the most frequent isolate was *Klebsiella* (28%), whereas in our findings, *Klebsiella* was 10%. In our findings, *E. coli* was the most frequent bacterial isolate (36%). In another study by Regasa *et al.* (2015), the most prevalent bacterial isolate was *Streptococcus pneumoniae* (12%). In our findings, it was 14 percent, and the most prevalent Gram-positive bacterium was also *Streptococcus pyogenes* at 14 percent; in Regasa *et al.* (2015), the most prevalent Gram-negative bacterium was *Pseudomonas aeruginosa* at 6.8 percent. In our study, the most prevalent Gram-negative bacterium was *E. coli*

(36%), and *Pseudomonas Aeruginosa* was 7%. In another study by Olugbue & Onuoha (2011), Gram-positive isolates were 51 percent, and Gram-negative isolates were 48 percent. In the Olugbue & Onuoha (2011) study, *Streptococcus Pneumoniae* was the most prevalent Gram-positive pathogen, and *Klebsiella Pneumoniae* was the most common Gram-negative pathogen. In Maduakor *et al.* (2017), the most prevalent Gram-negative isolate was *Klebsiella Pneumoniae* (49.9%), followed by *Pseudomonas Aeruginosa* (7.9%) and *E. coli* (3.5%). In the Khan *et al.* (2024) study, the most prevalent Gram-positive isolate was *Streptococcus pyogenes* (7.4%), followed by *Staphylococcus aureus* (6.6%), and this result was consistent with our findings. In our study, the most effective antibiotic against Gram-positive bacterial isolates was gentamicin (100% sensitivity), followed by ceftriaxone (87.5% sensitivity), and then, in line, ampicillin (75% sensitivity). In another study by Shah *et al.* 2016, overall resistance of bacterial isolates to gentamicin was generally low. In our study, the most effective antibiotic for Gram-negative bacterial isolates was Ceftriaxone, followed by Gentamicin and then Ciprofloxacin. In our study, Gentamicin was the most effective antibiotic against *Staphylococcus*, with 100% sensitivity, whereas in the study by Shah *et al.*, 2016, gentamicin sensitivity was 66.7%. In our study, the most effective antibiotic against *Klebsiella Pneumoniae* was Ciprofloxacin, with 66.6% sensitivity, followed by Ceftriaxone with 50% sensitivity. In contrast, in a study by Shah *et al.* (2016), gentamicin was 75 percent effective against *Klebsiella Pneumoniae*. It showed the best activity. In Khan *et al.* (2024), Gram-positive bacterial isolates showed less resistance than Gram-negative bacterial isolates. This result was consistent with our finding. In our study, descriptive statistical analysis showed highly significant differences between susceptible and resistant bacterial isolates for ampicillin and ciprofloxacin ($p < 0.001$). Ceftriaxone showed no statistically significant difference between susceptible and resistant isolates ($p = 0.390$). Gentamicin demonstrated a highly significant

difference between susceptible and resistant bacterial isolates ($p = 0.002$). Ampicillin-Sulbactam demonstrated a highly significant difference between susceptible and resistant *Acinetobacter* isolates ($p = 0.007$).

Conclusion:

In our study, Ampicillin showed poor activity against the Gram-negative isolates, and Ciprofloxacin showed poor activity against Gram-positive bacterial isolates. Gentamicin was effective against *Staphylococcus Aureus*. Ceftriaxone showed good activity against *Streptococcus pyogenes*. Ampicillin-sulbactam showed low sensitivity against *Acinetobacter*. These findings highlight the importance of using antibiotics only on a physician's prescription. Routine bacterial identification and antibiotic susceptibility testing should be done to select effective antibiotics and prevent antibiotic abuse.

Recommendation:

- Use a large sample size for antibiotic susceptibility testing.
- Conduct routine surveillance of antibiotic susceptibility patterns to guide appropriate antibiotic prescribing.
- Prescribe antibiotics only after laboratory susceptibility testing to prevent antibiotic resistance.

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