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Research Article

Keywords: Antimicrobial resistance, lower respiratory tract infection, pathogen, sputum

Posted Date: September 28th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10983136/v1>

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Additional Declarations: No competing interests reported.

Bacterial profile, antimicrobial susceptibility patterns, and associated factors of lower respiratory tract infections among adult patients attending Nekemte Comprehensive Specialized Hospital: A cross-sectional study

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Abstract

Background: Lower respiratory tract infections are among the leading causes of illnesses responsible for causing death and adding significant costs to the public health system. Bacteria are the most common causative agents of lower respiratory tract infections. Currently, there is little information on the prevalence, antimicrobial susceptibility patterns, and associated factors of lower respiratory tract infections among adult patients in Ethiopia. Therefore, the objective of this study was to determine prevalence of lower respiratory tract infection, antimicrobial susceptibility profiles and associated factors in the study area.

Methods: A laboratory-based cross-sectional study was conducted among 376 participants at Nekemte Comprehensive Specialized Hospital from June to September 2024. A structured questionnaire was used to gather sociodemographic and clinical data. Bacterial isolation and identification were done using standard microbiological techniques. The Kirby-Bauer disc diffusion method was used to perform antibiotic susceptibility testing. Data were entered into Epi Data v4.6 and exported to the Statistical Package for Social Science (SPSS) v24 for analysis. Logistic regression analysis was done to assess the association between dependent and independent variables. The strength and significance of the association were determined by adjusted odds ratio (AOR) and p-value < 0.05 , respectively. Finally, the results were presented using text, tables, and figures.

Result: Of 376 sputum samples from adult patients with lower respiratory tract infection, 195 (51.9%) were culture-positive for bacterial pathogens. One hundred ninety-seven bacteria were isolated, with Gram-negative and Gram-positive bacteria accounting for 147 (74.6%) and 50 (25.4%), respectively. *Klebsiella pneumoniae* (19.8%) was the predominant bacterial isolate, followed by *Pseudomonas aeruginosa* (17.8%). Gram-negative bacteria were more sensitive to both ciprofloxacin (78.9%) and piperacillin-tazobactam (78.9%), while Gram-positive isolates were sensitive to clindamycin (96.0%). Age, educational status, marital status and occupation had a statistically significant association with lower respiratory tract infections (LRTIs) with a p-value of < 0.05 .

Conclusion and recommendation: *Klebsiella pneumoniae* was the predominant isolate of the lower respiratory tract infection pathogen followed by *P. aeruginosa*. Most isolates of bacteria were resistant to commonly prescribed antibiotics. A significant association was observed with age, educational status, marital status, and occupation. Culture and antibiotic susceptibility testing is essential before treatment to limit the possibility of antimicrobial resistance.

Key words: Antimicrobial resistance, lower respiratory tract infection, pathogen, sputum

Introduction

Respiratory tract infections (RTIs) are the type of infections that can affect any part of the body that is involved in breathing. They are one of the most prevalent types of infections across the globe and among the leading causes of morbidity and mortality. Respiratory tract infections are commonly divided into two classes: lower respiratory tract infections (LRTIs), which affect the lungs and airways, and upper respiratory tract infections (URTIs), which affect the sinus, throat, and nose (1,2).

Lower respiratory tract infections (LRTIs) are acute infectious diseases that affect the lungs, alveoli, bronchi, and bronchioles. Acute bronchitis, acute bronchiolitis, and pneumonia are among the many infectious inflammatory disorders of the lower respiratory airways that fall within the broad concept of LRTIs (3). It has broad terminologies that include acute bronchitis, pneumonia, bronchiectasis, bronchiolitis, influenza, chronic obstructive pulmonary disorder (COPD), emphysema, lung abscess, and pleural effusion (4). Worldwide, LRTIs pose a significant risk to public health, leading to substantial illness and death across all age groups. Furthermore, these infections are one of the primary contributors to severe illness and death resulting from infectious diseases in both developed and developing countries (5).

Globally, LRTIs are a prime cause of death. An estimated 2.4 million people died and 488.9 million people suffered from LRTIs worldwide. LRTIs are one of the leading causes of death for both adults over 70 and children under five in poor nations, where they account for 20–40% of pediatric hospital visits. The incidence rate of LRTIs varied between 761.1 and 1019.9 cases per 100,000 people throughout the Middle East and North Africa (6). The highest number of LRTI-related deaths worldwide, 66.4 per 100,000 people, occurs in Sub-Saharan Africa (7).

Lower respiratory tract infections (LRTIs) can be caused by both Gram-positive and Gram-negative bacteria, with the majority of bacterial-induced LRTIs being caused by Gram-negative bacteria. Gram-negative bacteria such as *P. aeruginosa*, *H. influenzae*, *K. pneumoniae*, *A. baumannii*, and Gram-positive bacteria such as *S. pneumoniae* and *S. aureus* are among the most common bacterial isolates recovered from LRTIs. In addition to bacterial causes, LRTIs can also be caused by viruses such as respiratory syncytial virus, influenza virus, Parainfluenza virus, human Metapneumovirus, Coronaviruses, and Adenovirus (8–10).

The alarming rise in antimicrobial resistance (AMR) is complicating the management of infectious diseases including LRTIs. It poses a serious risk to human health by contributing to rising treatment failure rates among patients with LRTI (11). In developing nations, the prevalence of antibiotic resistance is rising, making treatment more difficult. The treatment choices for patients with LRTI have been restricted due to rising trends of multidrug resistance (MDR), especially among Gram-negative bacterial isolates (12). Multidrug-resistant (MDR) Gram-negative bacteria are more frequently identified in patients with LRTIs, especially those in intensive care units, leading to increased risks of poor outcomes, prolonged hospital stay, and mortality (13).

Individuals with immunocompromising illnesses or those from households with inconsistent or inadequate access to clean cooking fuel, immunizations, proper diet, and sanitation are frequently at the highest risk of acquiring or dying from lower respiratory infections (14). On other hand, demographic factors (gender, age), socioeconomic factors (income, education, residence), environmental (exposure to smoke, crowding, exposure to cold and humidity), and nutritional factors (low birth weight, malnutrition, lack of breastfeeding) are risks for LRTIs (15). Moreover, it was also reported that immunodeficiency, chronic pulmonary diseases, underlying congenital heart diseases and congenital anomalies are risk factors for LRTIs (16).

Lower respiratory tract infection (LRTIs) can cause a significant risk to public health, leading to substantial illness and death across all age groups. Limited information exists on the prevalence, antimicrobial susceptibility patterns, and associated factors among adult patients with LRTIs in low-income countries, including the study area. For this reason, this study aims to provide information on the prevalence, antimicrobial susceptibility patterns, and associated factors among adult patients with LRTIs.

Methods and materials

Study area, period, and design

The study was conducted at Nekemte Comprehensive Specialized Hospital. The hospital is located in East Wallaga, Nekemte town, in Oromia regional state, at a distance of 331 km from the capital city of Ethiopia. The hospital delivers services in surgical, laboratory, intensive care unit, gynecology, pediatric and neonatal intensive care unit, chronic outpatient, and medical wards that are giving follow-up services by more than 350 hospital staff workers. This study was conducted from June to September 2024 using a laboratory-based cross-sectional study.

Population and eligibility criteria

All patients attending the outpatient department at Nekemte Comprehensive Specialized Hospital for any medical service were source population. All patients whose age was ≥ 18 years and who had symptoms of LRTIs such as cough, chest pain, fever, and confirmed TB-negative were included in the study. Individuals who were not willing and were unable to give informed consent, who were positive for Tuberculosis (TB), who were in critical condition and unable to provide information and samples were excluded.

Sample size determination and sampling technique

The sample size was calculated using the single population proportion formula.

$$n = \frac{(\frac{Z\alpha}{2})^2}{d^2} pq$$

Where: n=number of study participants

$Z\alpha/2$ =Confidence level (95%) =1.96

$Q=1-p=1-0.571=0.429$

d=margin of error=5%=0.05

P=Prevalence of lower respiratory infection taken from the study conducted in Gondar (P=57.1%) (17).

Hence, taking P = 57.1%, Z=1.96 and d=0.05

$$N = \frac{(1.96)^2 \times 0.571 (1-0.571)}{(0.05)^2} = \frac{3.8416 \times 0.571 \times 0.429}{0.0025} = 376$$

Therefore, the final sample size was 376. Convenience sampling, which is a non-probability sampling technique, was employed. Therefore, consecutive samples were collected until the sample size reached 376.

Data collection and laboratory testing

Data and specimen collection

Data collection

Two-day training was given for data collectors on the objective of the study and how to collect data. An interviewer-administered structured questionnaire was used to collect data. Data regarding sociodemographic and clinical conditions were collected by nurses from outpatient and inpatient departments. The questionnaire was initially prepared in English and translated to Afaan Oromo to check the consistency.

Sample collection

A morning sputum specimen was collected as per the specimen management manual and specific standard operating procedure. The sputum samples were collected into a sterilized Falcon tube with a 50 ml capacity. Adequate instruction was given to study participants on how to collect sputum samples. Purulent, mucopurulent and mucoid samples were considered acceptable. The samples were processed within two hours of collection. When immediate processing was not possible, the samples were stored at 2–8°C for up to 24 hours.

Specimen processing and quality assessment

Initially, the sputum specimens were processed and tested for *Mycobacterium tuberculosis* using GeneXpert. After confirming that the specimens were negative for this bacterium, part of the collected sputum specimens were placed on clean microscopic slide with a cotton swab and smeared on the slides. The smear was then heat fixed and Gram stained. The quality of sputum samples was assessed by Bartlett's criteria. This method is performed by microscopic examination of the cellular components in a stained smear of the specimen, seen under the low power field magnification (LPF). Samples with > 25 WBCs/LPF were graded as +2 and those with 10-25 WBCs/LPF were graded as +1. On the other hand, -2 were assigned for samples with >25 squamous epithelial cells (SECs)/LPF and -1 were assigned to those samples with 10-25 SECs/LPF. 1+ to +2 score indicated material derived from the site of an active infection and these samples were categorized as acceptable. Samples with SEC < 10 and Polymorphonuclear leukocytes (PMNL) > 25 were defined as purulent. A "0" or "-" score suggested low sputum quality, excessive Oropharyngeal contamination and these samples were categorized as non-acceptable (18–21).

Isolation and identification

Each purulent sputum sample was transported immediately to Nekemte Public Health Research and Referral Laboratory Centre. The samples were then inoculated on blood agar, chocolate agar, and MacConkey agar (Oxoid Ltd., UK). Chocolate and blood agar plates were incubated in a candle jar, which can generate 5% CO₂. All positive cultures were identified by the colony characteristics of the grown bacteria on the respective media. Presumptive identification of isolated bacteria was undertaken by colony morphology, pigment production, and type of hemolysis on blood agar and Gram staining. The confirmation was done by a series of biochemical reactions. For Gram-positive bacteria, catalase, coagulase, optochin, and bacitracin sensitivity tests were done. On the other hand, Gram-negative bacteria were identified by testing for lactose fermentation, indole production, citrate utilization, motility, gas production, urease production, and oxidase tests (22).

Antimicrobial susceptibility testing

The antimicrobial susceptibility test (AST) was done using the Kirby-Bauer disk diffusion method on Mueller Hinton agar (MHA) (Oxoid Ltd., UK). Five milliliters of sterile normal saline were transferred to a tube. From a refreshed pure culture, 3–5 pure colonies of each bacterium were picked and transferred to the tube and mixed thoroughly to make a homogenous suspension equivalent to 0.5 McFarland standards. Using a sterile cotton swab, the bacterial suspension was distributed evenly over the entire surface of MHA. The inoculated plates were left at room temperature for 15 minutes. Then antimicrobial disks of interest were placed in the media using sterile forceps at least 24 mm away from each other in 150-mm-diameter Petri dishes. The plates were then incubated at 37 °C for 16–18 hours and observed for the zone of inhibition. Grades of the susceptibility profile were read as sensitive (S), intermediate (I), and resistant (R) by comparison of the zone of inhibition with clinical and laboratory standards institute guidelines of the 34th edition of CLSI 2024 (23). Penicillin (10µg), tetracycline (30µg), ciprofloxacin (5µg), trimethoprim-sulfamethoxazole (1.25/23.75µg), gentamicin (10µg), azithromycin (30µg), cefoxitin (30µg), ampicillin (10 µg), ceftriaxone (30 µg), ceftazidime (30 µg), piperacillin-tazobactam (100/10 µg), amikacin (30 µg), amoxicillin-clavulanate (20/10), chloramphenicol (30µg), meropenem (10 µg) and cefepime (30 µg) were tested.

Operational definition

Lower respiratory tract infection: an acute illness usually with cough as the main symptom and at least one other lower respiratory tract symptom (sputum production, dyspnea, wheezing, or chest discomfort or pain).

Overcrowded living conditions: living with more than 10 persons at home

Adult: Age of ≥ 18 at which a person gains control over their actions and affairs.

Multidrug resistance: Refers to bacterial resistance to one and above antimicrobial agent in at least three different antimicrobial classes.

Bartlett's criteria for sputum culture: It is a criterion for checking sputum quality whether it is an appropriate lower respiratory tract sputum sample or cross-contaminated with an upper respiratory tract specimen.

Sensitive - a category defined by a breakpoint that implies that isolate with a zone diameter at or above the susceptible breakpoint are inhibited by usually achievable concentration of antimicrobial agent

Intermediate – a category defined by breakpoint that includes isolates with a zone diameter within the intermediate range that approach usually attainable blood and tissue levels and/or for which response rates may be lower than for susceptible isolates

Resistant – a category defined by a breakpoint that implies that isolates with a zone diameter at or below the resistant breakpoint are not inhibited by the usual concentration of the agent with normal dosage schedules and/or that demonstrate diameter zone that fall in the range in which specific microbial resistance mechanisms are likely and clinical efficacy of the agent against the isolate has not been reliably shown in the treatment studies.

Data management and quality assurance

Data management

Before data collection, orientation was given to data and sample collectors (nurses and laboratory technologists). Information on the objective and relevance of the study was explained to all study participants. The data collection tool was validated by pre-testing 5% of the sample size. The data were checked for completeness and consistency, and any incomplete information was checked and corrected. To ensure consistency, coding, double entry, and cleaning of data were performed. The whole data collection process was guided by the principal investigator.

Quality assurance

Preanalytical phase

Before data collection, data collectors were trained, and study participants were informed and asked for their consent. Patients were identified, and specimens were collected in the reception room. Specimen containers were properly labeled with the patient identifier code, collection date, and time. Then, the collected specimens were checked both macroscopically and microscopically before processing the sample for culture and then transported immediately by triple package to the clinical microbiology laboratory of Nekemte Public Health Research and Referral Laboratory Centre. All patient information was checked for clarity and completeness regularly. The media and all relevant reagents were carefully inspected and checked for expiration dates before use. The sterility of culture media was checked by incubating 5% of the batch at 35–37°C overnight and evaluating it for possible contamination. The questionnaire was prepared in an English version, translated into Afaan Oromo, and then back to English to check consistency.

Analytical phase

All testing procedures were performed depending on the existing SOPs. The standard reference bacteria strains *E. coli* (ATCC 25922), *P. aeruginosa* (ATCC 27853) and *S. aureus* (ATCC 25923) were used. *E. coli* and *P. aeruginosa* were used as negative controls while *S. aureus* was used as positive control.

Post analytical phase

The results were crosschecked by laboratory experts in the clinical microbiology department. The reported test results were verified by a formally assigned result verifier in the laboratory. Laboratory results were recorded carefully on the test result form and registration book. Samples were stored in an appropriate refrigerator as per the specimen retention policy of the laboratory for a specified period.

Data processing and analysis

The collected data was coded, cleaned, and entered into EpiData software version 4.6. From this software, the data were exported to SPSS version 24 for analysis. Descriptive statistics were calculated to describe relevant variables. Binary logistic regression analysis was used to select candidate variables for multivariable logistic regression analysis. Variables with a p-value < 0.25 were considered candidates for multivariate analysis. Model fit was assessed using the Hosmer-Lemeshow test. The adjusted odds ratio (AOR) and 95% CI were used to determine the strength

of the association. A p-value of < 0.05 was considered statistically significant. The results were presented in words, figures, and tables.

Ethical consideration

Ethical approval was obtained from Salale University Institutional Research Ethics Review Committee (SLU- IRERC-261/2016). Then, permission was obtained from the Nekemte Comprehensive Specialized Hospital and Nekemte Public Health Research and Referral Laboratory Center. A written informed consent was obtained from study participants after explaining the purpose and objective of the study, the benefits and risks (if any) associated with the study, and their rights when taking part in the study. The inclusion of study participants was voluntary. The information obtained from them was kept confidential and used only for research purposes. The laboratory results of the study participants were communicated to their physicians for normal patient management. Sputum specimens were used only for research purposes.

Results

Sociodemographic characteristics

A total of 376 LRTI-suspected adult patients were involved in this study. Of them, 206 (54.8%) were males and 170 (45.2%) were female patients. The majority of participants were found within the age range of 18–35 years, accounting for 205 (54.5%). More than half of the participants, 204 (54.3%), live in rural areas. The majority of participants had attended primary education, 152 (40.4%) and 196 (52.1%) of them were married (Table 1).

Table 1: Sociodemographic characteristics of adult patients with lower respiratory tract infection attending Nekemte Comprehensive Specialized Hospital, Nekemte, 2024

Variables		Frequency	Percent (%)
Sex	Male	206	54.8
	Female	170	45.2
Age (years)	18-35	205	54.5
	36-49	90	23.9
	50-64	46	12.2
	>64	35	9.3
Residence	Urban	172	45.7
	Rural	204	54.3
Educational status	No formal education	93	24.7
	Primary education	152	40.4
	Secondary education	69	18.4
	College/University	62	16.5
Marital status	Married	196	52.1
	Single	110	29.3
	Widowed	45	12
	Divorced/Separated	25	6.6
Occupation	Farmer	84	22.34
	Government employee	45	11.96
	Private employee	73	19.41
	Housewife	95	25.3

Monthly income (Ethiopian Birr)	Daily laborer	24	6.4
	Student	55	14.62
	<1000	95	25.26
	1000-2000	97	25.8
	2001-3000	124	32.9
	3001-5000	39	10.4
	>5000	10	2.7

Behavioral and clinical characteristics

Of the total participants, 40 (10.6%) and 70 (18.6%) were cigarette smokers and alcohol drinkers, respectively. About 73 (19.4%) lived in crowded living conditions. It was also observed that 25 (6.6%) study participants had previous tuberculosis exposure. Furthermore, 38 (10.1%) of them had heart disease (Table 2).

Table 2: Clinical and behavioral characteristics of adult patients with lower respiratory tract infection attending Nekemte Comprehensive Specialized Hospital, Nekemte, Ethiopia, 2024

Variables		Frequency	Percent (%)
Cigarette smoking	Yes	40	10.6
	No	336	89.4
Alcohol drinking	Yes	70	18.6
	No	306	81.4
Crowded living condition	Yes	73	19.4
	No	303	80.6
History of the previous TB	Yes	25	6.6
	No	351	93.4
Heart disease	Yes	38	10.1
	No	338	89.9
Previous HIV screening	Unscreened	208	55.3
	Negative	141	37.5
	Positive	27	7.2

Magnitude of lower respiratory tract infections

Of the total sputum samples cultured, 195 (51.9%) demonstrated growth for bacterial pathogens. One hundred ninety-three (51.3%) of the samples showed single bacterial growth while mixed growth was observed with 2 (0.5%) of the samples (**Figure 1**). The mixed growths comprised of *E. coli* and *P. aeruginosa*, and *K. pneumoniae* and *E. coli*.

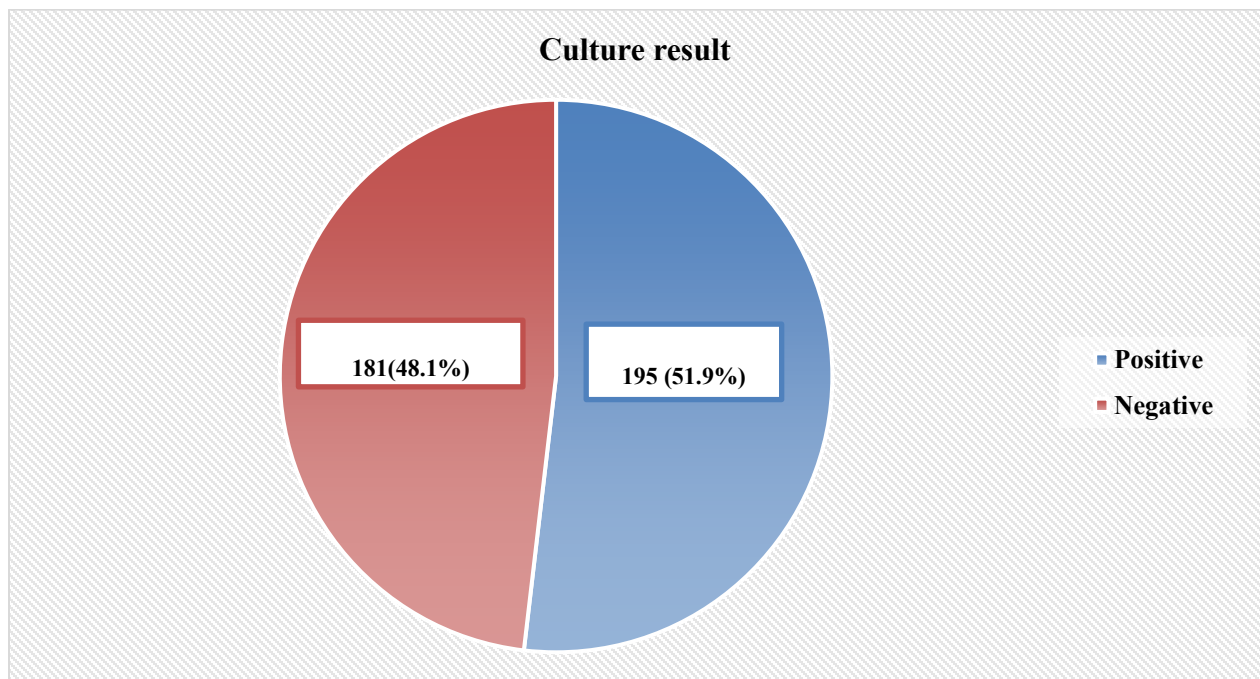


Figure 1: Culture results of patients with lower respiratory tract infections attending Nekemte Comprehensive Specialized Hospital, Nekemte, Ethiopia, 2024

Prevalence of bacteria isolates

One hundred ninety-seven bacterial pathogens were identified in this study with Gram-negative and Gram-positive bacteria accounting for 147 (74.6%) and 50 (25.4%), respectively. The predominant bacterial isolates were *K. pneumoniae* 39 (19.8%) followed by *P. aeruginosa* 35 (17.8%) and *E. coli* 33 (16.8%) (Figure 2).

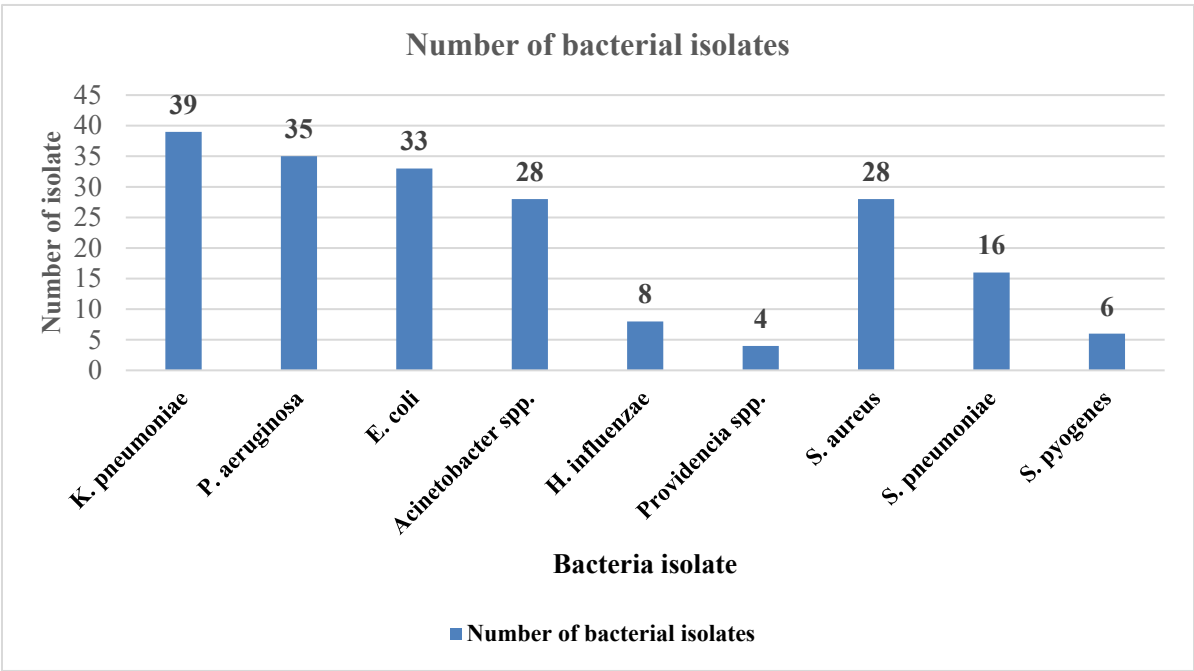


Figure 2: Frequency of bacterial isolates identified from patients with lower respiratory tract infections attending Nekemte Comprehensive Specialized Hospital, Nekemte, Ethiopia, 2024

Antimicrobial susceptibility patterns

According to this study, 27 (96.4%) of *S. aureus* isolates exhibited sensitivity to clindamycin. In addition, 24 (85.7%) of them were sensitive to both azithromycin and gentamicin. On the other hand, 17 (60.7%) of the *S. aureus* were resistant to cefoxitin which indicated that these isolates were methicillin-resistant (MRSA). Furthermore, 27 (96.4%) and 13 (81.3%) of *S. pneumoniae* isolates were sensitive and resistant to clindamycin and tetracycline, respectively ((Table 3).

Table 3: Antimicrobial susceptibility patterns of Gram-positive bacteria isolated from adult patients with lower respiratory tract infection attending Nekemte Comprehensive Specialized Hospital, Nekemte, Ethiopia, 2024

Antibiotics	Bacterial isolates				
	Pattern	<i>S. aureus</i> (N=28), No, %	<i>S. pneumoniae</i> (N=16), No, %	<i>S. pyogenes</i> (N=6), No, %	Total, No, %
FOX	S	8 (28.6)	NT	NT	8 (16.0)
	I	2 (7.1)	NT	NT	2 (4.0)
	R	17 (60.7)	NT	NT	17 (34.0)
TE	S	7 (25.0)	2 (12.5)	6 (100)	15 (30.0)
	I	3 (10.7)	1 (6.3)	0 (0.0)	4 (8.0)
	R	18 (64.3)	13 (81.3)	0 (0.0)	31(62.0)
CD	S	27 (96.4)	15 (93.8)	6 (100)	48(96.0)
	I	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	R	1 (3.6)	1 (6.4)	0 (0.0)	1 (4.0)
CIP	S	22 (78.6)	NT	NT	22 (44.0)
	I	1 (3.6)	NT	NT	1 (2.0)
	R	5 (17.9)	NT	NT	5 (10.0)
TS	S	26 (92.9%)	NT	NT	26 (52.0)
	I	1 (3.6%)	NT	NT	1 (2.0)
	R	1 (3.6%)	NT	NT	1 (2.0)
GEN	S	24 (85.7%)	NT	NT	24 (48.0)
	I	2 (7.14%)	NT	NT	2 (4.0)
	R	2 (7.14%)	NT	NT	2(4.0)
ATH	S	24 (85.7%)	NT	NT	24 (48.0)
	I	2 (7.14%)	NT	NT	2 (4.0)
	R	2 (7.14%)	NT	NT	2 (4.0)
CRO	S	NT	8 (50.0)	2 (33.3)	10 (20.0)
	I	NT	3 (18.8)	0 (0.0)	3 (6.0)
	R	NT	5 (31.2)	4 (66.7)	9 (18.0)
PG	S	NT	NT	2 (33.3)	2 (4.0)
	I	NT	NT	0 (0.0)	0 (0.0)
	R	NT	NT	4 (66.7)	4 (8.0)

FOX-Cefoxitin, TE-Tetracycline, CD-Clindamycin, CIP-Ciprofloxacin, GEN-Gentamicin, ATH-Erythromycin, CRO-Ceftriaxone, PG-Penicillin-G, NT-Not tested TS-Trimethoprim-sulfamethoxazole

Susceptibility test result revealed that about 78.9% of the Gram-negative bacterial isolates were susceptible to both ciprofloxacin and piperacillin tazobactam, followed by gentamicin and meropenem each with susceptibility rates of 76.8%. *K. pneumoniae* exhibited the highest susceptibility to gentamicin 89.7%, ciprofloxacin 87.1% and meropenem 84.6% while 66.6% of the isolates were resistant to amoxicillin-clavulanate. On the other hand, 79.4% and 74.3% of *P. aeruginosa* isolates were susceptible to meropenem and piperacillin-tazobactam, respectively. About 45.7% of *P. aeruginosa* isolates were resistant to ciprofloxacin.

E. coli isolates demonstrated highest susceptibility to trimethoprim-sulfamethoxazole 97.0%. In addition to this, 90.9% of the isolates were found to be susceptible to both gentamicin and piperacillin-tazobactam. The highest resistance pattern was observed with ceftazidime 57.6%. This study also showed that 87.9 – 100% of *Acinetobacter* species was susceptible to ciprofloxacin, gentamicin, trimethoprim-sulfamethoxazole, ceftriaxone, meropenem and piperacillin-tazobactam (Table 4).

Table 4: Antimicrobial susceptibility patterns of Gram-negative bacteria isolated from adult patients with lower respiratory tract infections attending Nekemte Comprehensive Specialized Hospital, Nekemte, 2024

Antibiotics	Bacterial isolates							
	Pattern	<i>K. pneumoniae</i> (N=39) No, %	<i>P. aeruginosa</i> (N=35) No, %	<i>E. coli</i> (N=33) No, %	<i>Acinetobacter</i> spp. (N=28) No, %	<i>H. influenzae</i> (N=8) No, %	<i>Providencia</i> spp. (N=4) No, %	Total (N=147)
AP	S	NT	NT	14 (42.4)	NT	6 (75)	NT	20(13.6)
	I	NT	NT	2 (6.1)	NT	1(12.5)	NT	3(2.0)
	R	NT	NT	17 (51.5)	NT	1(12.5)	NT	18(12.2)
AMC	S	10 (25.6)	NT	17 (51.5)	NT	NT	NT	27(18.5)
	I	3 (7.7)	NT	12 (36.4)	NT	NT	NT	15(10.2)
	R	26 (66.6)	NT	4 (12.2)	NT	NT	NT	30(20.4)
CAZ	S	16 (41.0)	23 (65.7)	12 (36.4)	20 (71.4)	8 (100)	4 (100)	83(56.5)
	I	3 (7.7)	4 (11.4)	2 (6.1)	5 (17.9)	0 (0.0)	0 (0.0)	14(9.5)
	R	20 (51.3)	8 (22.9)	19 (57.6)	3 (10.8)	0 (0.0)	0 (0.0)	50(34.0)
CIP	S	34 (87.1)	18 (51.4)	29 (87.9)	24 (85.7)	8 (100)	3 (75.0)	116(78.9)
	I	0 (0.0)	1 (2.9)	1 (3.0)	1 (3.6)	0 (0.0)	1 (25.0)	4(2.7)
	R	5 (12.9)	16 (45.7)	3 (9.1)	3 (10.8)	0 (0.0)	0 (0.0)	27(18.5)
CRO	S	19 (48.8)	NT	20 (60.6)	26 (92.9)	NT	3 (75.0)	68(46.3)
	I	7 (17.9)	NT	2 (6.1)	2 (7.1)	NT	0 (0.0)	11(7.5)
	R	13 (33.3)	NT	11 (33.3)	0 (0.0)	NT	1 (25.0)	25(17.0)
GEN	S	35 (89.7)	19 (54.3)	30 (90.9)	25 (89.2)	NT	4 (100)	113(76.9)
	I	0 (0.0)	2 (5.7)	3 (9.1)	2 (7.1)	NT	0 (0.0)	7(4.8)
	R	4 (10.3)	14 (40.0)	0 (0.0)	1 (3.6)	NT	0 (0.0)	19(12.9)
MEM	S	33 (84.6)	25 (71.4)	24 (72.7)	27 (96.4)	NT	4 (100)	113(76.8)
	I	1 (2.6)	3 (8.6)	4 (12.2)	1 (3.4)	NT	0 (0.0)	9(6.1)
	R	5 (12.8)	7 (20.0)	5 (15.1)	0 (0.0)	NT	0 (0.0)	17(11.6)
TE	S	33 (84.6)	NT	9 (27.3)	NT	5 (62.5)	NT	47(32.0)
	I	4 (10.3)	NT	11 (33.3)	NT	2 (25.0)	NT	17(11.6)
	R	2 (5.1)	NT	13 (39.4)	NT	1 (12.5)	NT	16(10.9)

TS	S	18 (46.2)	NT	32 (97.0)	25 (89.3)	NT	2 (50.0)	77(52.4)
	I	2 (5.1)	NT	1 (3.0)	1 (3.6)	NT	0 (0.00)	4(2.7)
	R	19 (48.7)	NT	0 (0.0)	2 (7.1)	NT	2 (50.0)	23(15.6)
PTZ	S	28 (71.8)	26 (74.3)	30 (90.9)	28 (100)	NT	4 (100)	116(78.9)
	I	6 (15.4)	1 (2.9)	0 (0.0)	0 (0.00)	NT	0 (0.00)	7(4.8)
	R	5 (12.8)	8 (22.9)	3 (9.1)	0 (0.00)	NT	0 (0.00)	16(10.9)

AP-Ampicillin AMC-Amoxicillin-clavulanate CAZ-Ceftazidime CIP-Ciprofloxacin CRO-Ceftriaxone TE-Tetracycline PTZ-Pipperacillin-tazobactam GEN-Gentamicin TS-Trimethoprim-sulfamethoxazole MEM-Meropenem NT-Not tested

Multidrug resistance

In this study, the overall multidrug resistance (MDR) rate was 59 (29.9%). Forty-nine (24.9%) of the bacterial isolates were susceptible to all classes of antibiotics. Among the Gram-positive isolates, 19(38%) were multidrug resistant while 40 (27.2%) of Gram-negative isolates were multidrug resistant. *S. aureus* was the most isolate that showed MDR 17 (60.7%) followed by *E. coli* 17 (51.5%) and *K. pneumoniae* 14 (35.9%) (Table 5)

Table 5: Multi-drug resistance rate of bacterial isolates among adult patients with lower respiratory tract infections attending Nekemte Comprehensive Specialized Hospital, Nekemte, Ethiopia, 2024

Bacteria isolates	Antimicrobial susceptibility patterns, No (%)				Total MDR
	R0	R1	R2	≥ R3	
Gram-positive bacteria					
<i>S. aureus</i> (N=28)	3 (10.7)	3 (10.3)	5 (17.2)	17 (60.7)	17 (60.7)
<i>S. pneumoniae</i> (N=16)	3 (18.8)	9 (56.3)	2 (12.5)	2 (12.5)	2 (12.5)
<i>S. pyogenes</i> (N=6)	2 (33.3)	0 (0.0)	4 (66.7)	0 (0.0)	0 (0.0)
Total (N = 50)	8 (16.0)	12 (24.0)	11(22.0)	19 (38.0)	19 (38.0)
Gram-negative isolates					
<i>K. pneumoniae</i> (N=39)	5 (12.8)	8 (20.5)	12 (35.3)	14 (35.9)	14 (35.9)
<i>P. aeruginosa</i> (N=35)	6 (17.1)	11(31.4)	12 (30.8)	6 (15.4%)	6 (17.1%)
<i>E. coli</i> (N=33)	6 (18.1)	4 (12.1)	6 (18.1)	17(51.5)	17(51.5)
<i>Acinetobacter</i> spp. (N=28)	11 (39.3)	6 (21.4)	8 (28.6)	3 (10.7)	3(10.7%)
<i>H. influenzae</i> (N=8)	6 (75)	1(12.5)	1(12.5)	0 (0.0)	0 (0.0)
<i>Providencia</i> spp. (N=4)	3 (75)	1 (25)	0 (0.0)	0 (0.0)	0 (0.0)
Total (N=147)	37(25.1)	31 (21.1)	39 (26.5)	20 (13.6)	40 (27.2)
Overall (N=50 +147=197)	49 (24.9)	43 (21.8)	46 (23.4)	31(20.1)	59 (29.9)

R0=Sensitive to all tested antibiotics; R1=Resistant to 1 antibiotic; R2=Resistant to two antibiotics; R3= Resistant to three antibiotics; R4=Resistant to antibiotics; R5= Resistant to 5 antibiotics; R6: Resistance for 6 antibiotics; MDR=Multidrug resistant

Factors associated with lower respiratory tract infections

The bivariate and multivariable logistic regression analyses were done to assess the association between dependent and independent variables. All variables were entered in to the model. Variables with p-value < 0.25 were selected for multivariate analysis. Multicollinearity was checked to ensure reliability and interpretability of the model. In bivariate analysis, age, residence, educational status, marital status, occupation, monthly income, living in overcrowded condition, history of TB exposure, and being unscreened for HIV were candidate variables for multivariate analysis. However, in multivariate analysis, being in the age of 18 – 35 and 36 – 49 years, having no formal education, having secondary education, being married, being single, being separated/divorced, being farmer, and being jobless were significantly associated with LRTI. Study participants with age between 18 to 35 years were about 2.299 times more likely to have LRTIs (AOR 2.299; 95% CI: 1.094-4.951). In addition, those study participants whose age lies between 36 to 49 were also 1.441 times more likely to develop LRTIs (AOR 1.441; 95% CI: 1.216-3.899).

Moreover, it was also found that study participants who completed secondary education were about 4.423 times more likely to have LRTIs (AOR 4.423; 95% CI: 1.280-15.284). Divorced participants were also about 1.690 times likely to develop LRTIs (AOR 1.690; 95% CI: 1.650-4.393). This study also revealed that farmers were 3.489 times more likely to develop LRTIs (AOR 3.489; 95% CI: 1.329-9.895). Finally, daily laborers were 2.410 times more likely to develop LRTIs (AOR 1.183-9.915) (**Table 6**).

Table 6: Bacterial profile and associated factors of culture positive sputum sample of adult patients with lower respiratory tract infection attending Nekemte Comprehensive Specialized Hospital, Nekemte, 2024

Variables		Culture result		Bivariate analysis		Multivariate analysis	
		Positive	Negative	COR (95 % CI)	p-value	AOR (95% CI)	p-value
Sex	Male	109 (55.9%)	97 (53.6%)	1.098 (0.731 - 1.648)	0.653		
	Female	86 (44.1%)	84 (46.4%)	Ref.			
Age (year)	18-35	94 (48.2%)	111 (61.3%)	0.616 (0.206 -0.767)	0.001	2.299 (1.094-4.951)	0.041
	36-49	67 (34.4%)	23 (12.7%)	0.291 (0.168 -0.503)	0.026	1.441 (1.216-3.899)	0.024
	50-64	22 (11.3%)	24 (13.3%)	0.924 (.487-1.753)	0.808	0.803 (0.373-1.728)	0.574
	>64	12 (6.2%)	23 (12.7%)	Ref.			
Residence	Urban	98 (50.3%)	74 (40.9%)	0.685(0.455 - 1.030	0.069	0.734 (0.425-1.265)	0.265
	Rural	97(49.7%)	107 (59.1%)	Ref.			
Educational status	No formal education	44 (22.56%)	49 (27.07%)	1.419 (0.742 -2.714)	0.210	4.768 (1.645-13.822	0.004
	Primary education	108 (55.38%)	44 (24.30%)	0.446 (0.244 -0.815)	0.009	1.637 (.619-4.331)	0.321
	Secondary education	26 (13.33%)	43 (23.75%)	1.650 (0.820 -3.320)	0.160	4.423(1.280-15.284)	0.019
	University/College	17 (8.71%)	45 (24.86%)	Ref.			
Marital status	Married	101 (51.8%)	95 (52.5%)	0.436 (0.265 -0.718)	0.021	0.550 (0.307-0.986)	0.045
	Single	78 (40.0%)	32 (17.67%)	12.226(2.806-23.271	0.001	3.859 (1.089-13.274)	0.032
	Divorced/Separated	10 (5.1%)	15 (8.3%)	2.354 (1.180 -4.696)	0.015	1.690 (1.650-4.393)	0.021
	Widowed	6 (3.1%)	39 (21.5%)	Ref.			
Occupation	Farmer	50(25.64%)	34(18.78%)	0.032 (0.004-0.244)	0.001	3.489 (1.329-9.895)	0.033
	Government employ-	40 (20.51%)	5 (2.73%)	0.035 (0.004-0.270)	0.012	0.111 (0.035-0.358)	0.002

	ee						
	Private employee	38 (19.48%)	35 (19.12%)	0.006 (0.001-0.051)	0.001	0.854(0.328-2.221)	0.746
	Housewife	55 (28.20%)	40 (21.85%)	0.043 (0.006-0.340)	0.003	0.511(0.153-1.707)	0.275
	Daily laborer	7 (3.58%)	17 (9.25%)	0.091(0.012-0.725)	0.024	2.410 (1.183-9.915)	0.029
	Student	5 (2.56%)	50 (27.32%)	Ref.			
Monthly income	<1000	60 (30.76%)	35 (19.33%)	0.170 (0.050-0.580)	0.005	0.237 (0.036-1.552)	0.133
	1000-2000	62 (31.79%)	35 (19.33%)	0.1790 (.053-0.606)	0.016	0.368 (0.056-2.392)	0.295
	2001-3000	54 (27.69%)	70 (43.47%)	0.471(0.142-1.562)	0.219	0.546 (.082-3.656)	0.533
	3001-5000	12 (6.15%)	27 (16.77%)	4.364 (0.845-22.545)	0.079	9.310(.739-117.273)	0.084
	>5000	7 (3.58%)	3 (1.86%)	Ref.			
Cigarette Smoking	Yes	21 (10.8%)	19 (10.5%)	1.029 (0.534-1.984)	0.932		
	No	174 (89.2%)	162 (89.5%)	Ref.			
Alcohol drinking	Yes	39 (20.0%)	31(17.1%)	1.210 (0.718-2.039)	0.475		
	No	156 (80.0%)	150 (82.9%)	Ref.			
Crowded living condition	Yes	24 (12.3%)	49 (27.1%)	2.645 (1.544-4.532)	0.004	1.778 (0.877-3.604)	0.111
	No	171(87.7%)	132 (72.9%)	Ref.			
History of previous TB	Yes	16 (8.2%)	9 (5.0%)	0.585 (0.252-1.360)	0.213	1.230 (0.459-3.292)	0.681
	No	179 (91.8%)	172 (95.0%)	Ref.			
Chronic heart disease	Yes	19 (9.7%)	19 (10.5%)	0.920 (0.471-1.800)	0.809		
	No	176 (90.3%)	162 (89.5%)	Ref.			
Previous HIV screening	Unscreened	85 (43.6%)	123 (68.0%)	2.460 (1.074-5.634)	0.033	0.564 (.173-1.839)	0.343
	Negative	93 (47.7%)	48 (26.5%)	0.877(.373-2.064)	0.764	1.398 (.456-4.283)	0.557
	Positive	17 (8.7%)	10 (5.5%)	Ref.			

CI=Confidence interval, COR=Crude odd ratio, AOR=Adjusted odds ratio, Ref=Reference

Discussion

In this study, the overall sputum culture positivity of LRTI among adult patients was 195 (51.9%) 95% CI (46.8%-56.9%). This finding is higher than study findings from Hawassa (33.5%) (24), Jimma (45.0%) (25), Addis Ababa (32.1%) (2), Nigeria (46.0%) (26), Kenya (45.6%) (27) and Italy (39.1%) (10), but similar to study finding from Cameroon (46.8%) (28). However, this finding was lower than the study conducted in Gondar (57.1%) (17) and Bangladesh (93.8%) (29). This difference may be due to geographical location, study period, study design, and socioeconomic status of the study population. Indeed, the distribution of respiratory infections varies between populations and countries, depending on geographical, climatic, and socioeconomic conditions (30).

In this study, a total of 197 bacterial pathogens were identified with Gram-negative and Gram-positive bacteria accounting for 74.6% (74.0–75.2) and 25.4% (17.6–33.3), respectively. Other study findings from Addis Ababa (2), Hawassa (24), Turkey (31), and Dhaka (32) reported Gram-negative bacteria as predominant isolates from LRTIs accounting for 76.6%, 76.1%, 85.1% and 95.2%, respectively. However, the study conducted in Arbaminch showed that Gram-positive bacteria were predominant (33). In general, most of the studies revealed that Gram-negative bacteria were responsible for causing LRTI than Gram-positive bacteria. This might be due to the outer membrane proteins (OMPs) virulence of Gram-negative bacteria that is essential in adhesion, colonization, intracellular invasion, and antimicrobial resistance (34).

The most frequent bacterial isolate in this study was *K. pneumoniae* (19.8%), followed by *P. aeruginosa* 35 (17.8%). This finding was similar to the study conducted in Jimma in which *K. pneumoniae* was the most isolated, followed by *P. aeruginosa* (35). This finding is also similar to the study findings conducted in Gondar (36), Nigeria (37), Egypt (38) and India (39) in which *K. pneumoniae* and *P. aeruginosa* were predominant isolates. In contrast, study findings from Arbaminch (33), Kenya (27) and India (40) revealed that *P. aeruginosa* was predominant followed by *K. pneumoniae*. Furthermore, the prevalence of *E. coli* was found to be 16.8%. Other study findings from Addis Ababa (2), Dessie (41), Gondar (17), Nigeria (26), Iraq (8), and Nepal (12) also reported that *E. coli* were isolated from patients with LRTIs. In addition, *Acinetobacter* spp. isolation rate from LRTI was 14.2%. Other study findings from Addis Ababa (2),

India (40) and Nepal (42) support the current finding. Similarly, *S. aureus* was isolated with a rate of 14.4% in this study which was supported by other study findings from Hawassa (24), Arba Minch (33) and Kenya (27).

Performing antimicrobial susceptibility patterns of bacterial isolates in patients with LRTI is an important element in limiting unnecessary antibacterial prescribing and treating patients effectively (43). According to this study, *K. pneumoniae* shows a high rate of sensitivity to ciprofloxacin (87.1%), tetracycline (84.6%), and piperacillin-tazobactam 71.8%. However, this bacterium demonstrated resistance to amoxicillin-clavulanate 66.6%, ceftazidime 51.3%, and trimethoprim-sulfamethoxazole 48.7%. In contrast to this finding, in a study conducted in Gondar, *K. pneumoniae* exhibited high rates of resistance to tetracycline 87.2% and amoxicillin-clavulanate 94.9% (36). Similarly, in study carried out in Jimma, it was pointed out that *K. pneumoniae* 100% resistant to tetracycline and ampicillin (25). Furthermore, *K. pneumoniae* showed a lower rate of sensitivity to ciprofloxacin 8%, piperacillin-tazobactam 14% and 100% resistant to ampicillin (27).

In this study, *P. aeruginosa* showed highest sensitivity to piperacillin-tazobactam (74.3%), meropenem (71.4%) and ceftazidime (65.7%). However, it showed resistance to ciprofloxacin (45.7%) and gentamicin (40.0%). This result is in agreement with the previous study done in Addis Ababa (2), in Dhaka (32) and in India (1). According to current study, 87.9%, 90.9%, 97.0%, 90.9% of *E. coli* isolates were susceptible to ciprofloxacin, gentamicin, trimethoprim-sulfamethoxazole and piperacillin-tazobactam, respectively but they had showed resistance to ceftazidime 57.6%, ampicillin 51.5% and tetracycline 39.4%. Other study findings from Addis Ababa also reported that trimethoprim-sulfamethoxazole, gentamicin and ciprofloxacin were antibiotics to which most of the isolates showed susceptibility but resistance to ampicillin was observed with the isolates (2). Similarly, study from Jimma, Ethiopia also reported that highest *E. coli* susceptibility to ciprofloxacin, and gentamicin was observed (25). Moreover, in Nigeria (26), it was revealed relatively highest sensitivity of *E. coli* isolates was observed with gentamicin.

The current study revealed that *S. aureus* was highly sensitive to azithromycin 100%, clindamycin 96.4%, and trimethoprim-sulfamethoxazole 96.2 %, as well as gentamicin 85.7%. However, it was resistant to tetracycline 64.3% and ceftazidime 60.7%. In agreement with this, a study from

Jimma, Ethiopia, reported that *S. aureus* had showed high resistance to tetracycline 100%, and ciprofloxacin 31.6%,(25). However, in contrast to our study, low resistance to ciprofloxacin (18.8%) and erythromycin (25.4%) was observed in the study that was carried out in Turkey (31). In this study, majority of *S. pneumoniae* 93.6% demonstrated sensitivity to clindamycin but 81.3% of them were resistant to tetracycline. This finding is similar with other studies in Addis Ababa (2) and Turkey (31) where highest susceptibility was observed with clindamycin with different susceptibility rates.

The overall magnitude of multidrug resistance (MDR) in this study was 29.9% (95% CI: 20.6-43.2). This finding is consistent with a study conducted in Hawassa (24). However, it has been found to be lower than study findings from Addis Ababa 80.2% (2), southwest Ethiopia 77.5% (35), Gondar 72.2% (36) and Kenya (27). This variation may be due to the difference in the type of antibiotic disc used and operational definition of MDR. The predominant MDR bacterial isolate was *S. aureus* (60.7%) followed by *E. coli* (51.5%). These findings are also supported by other studies from Hawassa (24) and Jimma (25) in which *S.aureus* and *E.coli* were reported to be predominant MDR bacteria from patients with LRTIs.

As revealed by this study, as compared to age > 64 years, those with age group 18-35 were 2.299 times, while those with age group 36-49 years are 1.441 times more likely to development infection of lower respiratory tract infections. In line with our finding, the previous study conducted in South Korea (44) were also reported that young age, especially for people who were found within the age range of 18-35, is a significant risk factor for LRTIs. This may be due to the fact that those whose ages are 18-49 years may have exposure to LRTIs risk factors such as cigarette smoking, alcohol drinking, and engaging in overcrowded areas (45).

In this study, study participants with no formal education were about 4.768 times more likely to be the victim of LRTI than those who have attended college or university. This may be due to the fact that those who have no formal education might lack health education, low level of health seeking behavior, and lack of knowledge on hygiene practices and occupational hazards. In agreement with the current study, the previous study done at Dessie town, reported that individuals who had no formal education are more susceptible to LRTI as compared to those individuals who have formal education (41). It was also found that daily laborers were about 2.410 times

more likely to be caught by LRTIs which is also similar to a study in Dessie (41). In addition, participants who had attended secondary education were about 4.423 times more likely to have LRTIs.

Moreover, the current study showed that as compared to those who are widowed, those who are married are 55% less likely to be caught by LRTI, while those who are single are 3.859 times and those who are divorced are 1.690 times more likely to be infected. This is in agreement with previous studies done in Denmark in which those who are married are less susceptible to LRTI than those who are single and divorced (46). In this study, the reasons why single individuals and separated individuals are more susceptible to LRTIs than married individuals might be due to frequent exposure to LRTI risks such as smoking, alcohol drinking, and lack of better stable lifestyles.

Furthermore, being government employee was significantly associated with LRTIs. Study participants who were government employees were 11.1% less likely to have LRTIs. This is consistent with a study conducted Gondar (36) and Hawassa (24). The reason why government employees are less susceptible to LRTIs might be due to having good access to health care and living in a well-controlled environment. In addition, it was found that farmers were 3.489 times more likely to be at risk of LRTIs. Contrary to this, a study from Gondar (36) showed that no significant association was observed between being farmer and LRTI. The reasons why farmers are more susceptible to LRTIs might be due to frequent exposure to harmful organic dust, pesticides, animal livestock exposure, and lack of usage of protective equipment like masks when exposed to harmful substances (47).

Limitation

Due to resource limitations, some common pathogens of lower respiratory tract infection, like *Chlamydia*, *Mycoplasma*, *Legionella* species, and fungal species, were not attempted. In addition, we did not do blood culture. Furthermore, genotypic characterization was not undertaken for accurate identification and detection of resistance genes.

Conclusion

The prevalence of LRTIs in this study was high, with Gram-negative bacterial pathogens predominating among the identified causes, and approximately three in ten isolates demonstrating MDR. Ciprofloxacin, piperacillin-tazobactam, and meropenem showed the highest sensitivity against Gram-negative bacilli, whereas clindamycin, trimethoprim-sulfamethoxazole, and gentamicin were the most effective agents against Gram-positive bacteria. Age, occupation, and educational status were significantly associated with LRTIs. Despite the continued effectiveness of selected antibiotics, the observed resistance, particularly to amoxicillin-clavulanate, ceftazidime, and tetracycline, highlights an increasing threat to effective LRTI treatment. Therefore, strengthening routine microbiological diagnosis and antimicrobial susceptibility testing, promoting culture-guided antibiotic therapy and antimicrobial stewardship, ensuring adherence to appropriate treatment guidelines, and establishing continuous local AMR surveillance are recommended to support rational antibiotic use and limit the further emergence and spread of antimicrobial resistance.

Acronyms

AMR – Antimicrobial Resistance

AOR – Adjusted Odds Ratio

AST – Antimicrobial Susceptibility Test

ATCC – American Type Culture Collection

CI – Confidence Interval

COPD – Chronic Obstructive Pulmonary Disorder

COR – Crude Odds Ratio

HIV – Human Immunodeficiency Syndrome

LRTI – Lower Respiratory Tract Infection

MDR – Multidrug Resistance

MHA – Mueller Hinton Agar

MRSA – Methicillin-Resistant *Staphylococcus aureus*

MTB – *Mycobacterium tuberculosis*

SPSS – Statistical Package for Social Sciences

TB – Tuberculosis

URTI – Upper Respiratory Tract Infection

Author contribution

KT designed the study. KT, ETG and MC trained and supervised the data collectors. Laboratory testing was performed by KT, ETG, AD, MC and ADh. Data analysis and result interpretation was done by KT, ETG, FA, DA, and NB. KT, ETG, AD and GJ prepared the manuscript. All authors were involved in reading and approving the final manuscript.

Funding

Partially funded by Oromia Health Bureau but does not have grant number. The funder had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Data availability

All data are available within the manuscript. Additional data can be obtained from the corresponding author on a reasonable request.

Declaration

Ethics approval and consent to participate

Ethical approval was obtained from Salale University Institutional Research Ethics Review Committee (S/U-IRERC-161/2016). This study was conducted in agreement with the Declaration of Helsinki, Ethical principle for medical research involving human subject (<http://www.wma.net/en/30publications/10policies/b3/index.html>). Then, permission was taken from Nekemte Comprehensive Specialized Hospital to conduct this study. Written informed consent was obtained from study participants after explaining the purpose and objective of the study, the benefits and risks (if any) associated with the study and their right when taking part in the study. Inclusion of study participants was on voluntary basis. Information obtained from them were kept confidential and used only for research purposes. Moreover, sputum specimens were used for only this research purposes.

Clinical trial number

Clinical trial number not applicable

Acknowledgments

The authors are grateful to Salale University and the Oromia Health Bureau for providing opportunity to conduct this research. We also acknowledge Nekemte Comprehensive Specialized Hospital and Nekemte Public Health Research and Referral Laboratory Center for giving permission to conduct this study. We would also sincerely thank the study participants for their participation in the study.

Consent for publication

Not applicable

Conflict of interest

The authors declare no conflict of interests.

References

1. Singh S, Sharma A, Nag V. Bacterial pathogens from lower respiratory tract infections: A study from Western Rajasthan. *Journal of Family Medicine Primary Care*. 2020;9(3):1407-1412.
2. Nurahmed N, Kedir S, Fantahun S, Getahun M, Mohammed A, Mohammed A, et al. Bacterial profile and antimicrobial susceptibility patterns of lower respiratory tract infection among patients attending selected health centers of Addis Ababa, Ethiopia. *Egyptian Journal of Chest Diseases and Tuberculosis*. 2020;69(2):399-406.
3. Calderaro A, Buttrini M, Farina B, Montecchini S, De Conto F, Chezzi C. Respiratory Tract Infections and Laboratory Diagnostic Methods: A Review with A Focus on Syndromic Panel-Based Assays. *Microorganisms*. 2022; 10(1856):1856. 1-26.
4. Mahashur A. Management of lower respiratory tract infection in outpatient settings: Focus on clarithromycin. *Lung India*. 2018; 35(2):143-149.
5. Ramana K. Management of lower respiratory tract infections (LRTI's): clinical microbiologists' perspective. *International Journal of Research in Medical Sciences*. 2014;2(1):10-12.
6. Arab O, Al-Kayali R, Khouri A, Haj Kaddour S. Resistance patterns of bacterial pathogens causing lower respiratory tract infections: Aleppo-Syria. *Annals of Medicine & Surgery*. 2023;85(6):2655–2661.
7. Safiri S, Mahmoodpoor A, Kolahi AA, Nejadghaderi SA, Sullman MJM, Mansournia MA, et al. Global burden of lower respiratory infections during the last three decades. *Frontiers in Public Health*. 2023; 10:1-10.
8. Chawsheen MA, Al-Naqshbandi AA, Abdulqader HH. Bacterial Profile and Antimicrobial Susceptibility of Isolates Recovered from Lower Respiratory Tract Infection for Patients in Rizgary Hospital, Erbil. *ARO*. 2020; 8(2):64–70.
9. Shi T, Arnott A, Semogas I, Falsey AR, Openshaw P, Wedzicha JA, et al. The Etiological Role of Common Respiratory Viruses in Acute Respiratory Infections in Older Adults: A Systematic Review and Meta-analysis. *The Journal of Infectious Diseases*. 2020;222(7):563–569.
10. Santella B, Serretiello E, De Filippis A, Folliero V, Iervolino D, Dell'Annunziata F, et al. Lower Respiratory Tract Pathogens and Their Antimicrobial Susceptibility Pattern: A 5-Year Study. *Antibiotics*. 2021;10 (851):1-12.
11. Serpa PH, Deng X, Abdelghany M, Crawford E, Malcolm K, Caldera S, et al. Metagenomic prediction of antimicrobial resistance in critically ill patients with lower respiratory tract infections. *Genome Medicine*. 2022; 14 (74):1-12.
12. Bhatta DR, Hamal D, Shrestha R, Nayak N. Antibiotic Resistance Patterns of Bacterial Pathogens Associated with Lower Respiratory Tract Infections. *Nepal Journal of Medical Sciences*. 2023; 8(1):5–11.

13. Dung TTN, Phat VV, Vinh C, Lan NPH, Phuong NLN, Ngan LTQ, et al. Development and validation of multiplex real-time PCR for simultaneous detection of six bacterial pathogens causing lower respiratory tract infections and antimicrobial resistance genes. *BMC Infectious Diseases*. 2024; 24(1):164.
14. Troeger C, Blacker B, Khalil IA, Rao PC, Cao J, Zimsen SRM, et al. Estimates of the global, regional, and national morbidity, mortality, and aetiologies of lower respiratory infections in 195 countries, 1990–2016: a systematic analysis for the Global Burden of Disease Study. *The Lancet Infectious Diseases*. 2018;18(11):1191–210.
15. Victora, C.G., 1999. Risk factors for acute lower respiratory infections. *Respiratory infections in children*, pp.41-58.
16. Sürücü Kara İ, Aydın Peker N, Arslan YK, Topal İ. Risk Factors for Lower Respiratory Tract Infection and Recurrent Lower Respiratory Tract Infection in Children. *Van Medical Journal*. 2024; 31(1):53–59.
17. Yohannes H, Belachew T, Assefa M, Getaneh E, Zeray H, Kegne A, et al. Pathogenic bacteria recovered from Gene X-pert tuberculosis-negative adult patients in Gondar, Northwest Ethiopia. *BMC Pulmonary Medicine*. 2023; 23(197):1-9.
18. Mahale RP, Sheth PD, Murthy NS. Evaluating the Sputum Bacteriological Profile of Lower Respiratory Tract Infections with Bartlett Score Analysis in a Tertiary Care Hospital in Southern Karnataka. *Cureus*. 2024; 16(6):1-10.
19. Popova G, Boskovska K, Arnaudova-Danevska I, Smilevska-Spasova O, Jakovska T. Sputum Quality Assessment Regarding Sputum Culture for Diagnosing Lower Respiratory Tract Infections in Children. *Journal of Medical Sciences*. 2019; 7 (12):1926–1930.
20. Lee DH, Kim S. Clinical Analysis of Sputum Gram Stains and Cultures to Improve the Quality of Sputum Cultures. *Laboratory Medicine and Quality Assurance*. 2020; 42(1):33–39.
21. Cartuliales MB, Skjöt-Arkil H, Mogensen CB, Skovsted TA, Andersen SL, Pedersen AK, et al. Gram Stain and Culture of Sputum Samples Detect Only Few Pathogens in Community-Acquired Lower Respiratory Tract Infections: Secondary Analysis of a Randomized Controlled Trial. *Diagnostics*. 2023; 13(628):1-11.
22. Leboffe MJ, Pierce BE. A photographic atlas for the microbiology laboratory. 4th ed. Englewood, Colo.: Morton Pub. Co.; 2011. 1-256.
23. Performance Standards for Antimicrobial Susceptibility Testing. CLSI M100. 35th edition. 1-432.
24. Gebre AB, Begashaw TA, Ormago MD. Bacterial profile and drug susceptibility among adult patients with community acquired lower respiratory tract infection at tertiary hospital, Southern Ethiopia. *BMC Infectious Diseases*. 2021; 21(440):1-10.

25. Regasa B, Yilma D, Sewunet T, Beyene G. Antimicrobial susceptibility pattern of bacterial isolates from community-acquired pneumonia patients in Jimma University Specialized Hospital, Jimma, Ethiopia. *Saudi Journal for Health Sciences*. 2015; 4(1):59-64.
26. Olugbue V, Onuoha S. Prevalence and antibiotic sensitivity of bacterial agents involved in lower respiratory tract infections. *International Journal of Biological and Chemical Sciences*. 2011; 5(2):774-781.
27. Miriti DM, Muthini JM, Nyamache AK. Study of bacterial respiratory infections and antimicrobial susceptibility profile among antibiotics naive outpatients visiting Meru teaching and referral hospital, Meru County, Kenya in 2018. *BMC Microbiology*. 2023; 23(172):1-8.
28. Tchatchouang S, Nzouankeu A, Kenmoe S, Ngando L, Penlap V, Fonkoua MC, et al. Bacterial Aetiologies of Lower Respiratory Tract Infections among Adults in Yaoundé, Cameroon. *BioMed Research International*. 2019; 2019:1–7.
29. Jamil SMT, Faruq MO, Saleheen S, Biswas PK, Hossain MS, Hossain SZ, et al. Microorganisms Profile and their Antimicrobial Resistance Pattern Isolated from the Lower Respiratory Tract of Mechanically Ventilated Patients in the Intensive Care Unit of A Tertiary Care Hospital in Dhaka. *Journal of Medicine*. 2016; 17(2):91–94.
30. Tchatchouang S, Bigna JJ, Nzouankeu A, Fonkoua MC, Nansseu JR, Ndangang MS, et al. Prevalence of respiratory bacterial infections in people with lower respiratory tract infections in Africa: the BARIAFRICA systematic review and meta-analysis protocol. *BMJ Open*. 2018;8(9):1-4.
31. Uskudar Guclu A, Altay Kocak A, Akcil Ok M, Tutluoglu B, Basustaoglu AC, Respiratory Study Group. Antibacterial Resistance in Lower Respiratory Tract Bacterial Pathogens: A Multicenter Analysis from Turkey. *The Journal of Infection in Developing Countries*. 2021; 15(2):254–262.
32. Amarasinghe N, Athavan M, Jayamanne D, Rajapakshe Y, Sadikeen A, Gunasekara K, et al. Bacterial profile and antibiotic susceptibility pattern of adult lower respiratory tract infections in Colombo, Sri Lanka. *Journal of Health and Social Sciences*. 2018;3(1):27-36.
33. Regasa B. Aetiology of bacterial pathogens from adult patients with community-acquired pneumonia in Arba Minch Hospital, South Ethiopia. *Science Journal of Clinical Medicine*. 2014; 3(3):33-36.
34. Cullen L, McClean S. Bacterial Adaptation during Chronic Respiratory Infections. *Pathogens*. 2015; 4(1):66–89.
35. Mussema A, Beyene G, Kebede Gudina E, Alelign D, Mohammed T, Bawore SG, et al. Bacterial etiology, antimicrobial resistance and factors associated with community acquired pneumonia among adult hospitalized patients in Southwest Ethiopia. *Iranian Journal of Microbiology*. 2023; 15(4): 492-502.

36. Assefa M, Tigabu A, Belachew T, Tessema B. Bacterial profile, antimicrobial susceptibility patterns, and associated factors of community-acquired pneumonia among adult patients in Gondar, Northwest Ethiopia: A cross-sectional study. *PLoS ONE*. 2022; 17(2):1-18.
37. Uzoamaka M, Ngozi O, Johnbull OS, Martin O. Current trends in bacterial Etiology of Lower Respiratory Tract Infections and Their Antimicrobial Susceptibility in Enugu. *The American Journal of the Medical Sciences*. 2017; 354 (5):1-15.
38. Amin SI, Abdelsalam HM, Ahmed AA, Gad DM, El Sokkary RH. Antibiotic Susceptibility Pattern of Bacterial Isolated from Lower Respiratory Tract Infections at Respiratory Intensive Care Unit. *The Egyptian Journal of Hospital Medicine*. 2023; 91(1):4624–4631.
39. Atray D, Sheethal S. Bacteriological profile and antibiotic susceptibility patterns of Gram-negative bacilli isolated from lower respiratory tract infections. *Indian Journal of Medical Specialties*. 2023; 14(1):31-36.
40. Bajpai T, Bhatambare G, Shrivastava G, Deshmukh A, Chitnis V. Microbiological profile of lower respiratory tract infections in neurological intensive care unit of a tertiary care center from Central India. *Journal of Basic Clinical Pharmacy*. 2013; 4(3):51-55.
41. Tilahun M, Gebretsadik D, Seid A, Gedefie A, Belete MA, Tesfaye M, et al. Bacteriology of community-acquired pneumonia, antimicrobial susceptibility pattern and associated risk factors among HIV patients, Northeast Ethiopia: cross-sectional study. *SAGE Open Medicine*. 2023;11:1-14.
42. Jha B, Sharma M, Sapkota J, Pant S, Neopane A. Antibiotic susceptibility pattern of bacterial isolates from quantitative culture of bronchoalveolar lavage fluid in patients with clinical suspicion of pneumonia. *Journal of Kathmandu Medical College*. 2020; 9(34):197–200.
43. Uddin TM, Chakraborty AJ, Khusro A, Zidan BRM, Mitra S, Emran TB, et al. Antibiotic resistance in microbes: History, mechanisms, therapeutic strategies and future prospects. *Journal of Infection and Public Health*. 2021;14(12):1750–1766.
44. Kim BG, Kang M, Lim J, Lee J, Kang D, Kim M, et al. Comprehensive risk assessment for hospital-acquired pneumonia: sociodemographic, clinical, and hospital environmental factors associated with the incidence of hospital-acquired pneumonia. *BMC Pulmonary Medicine*. 2022; 22(21):1-11.
45. Núñez-Samudio V, Landires I. Epidemiology of viral respiratory infections in a pediatric reference hospital in Central Panama. *BMC Infectious Diseases*. 2021; 21(43):1-7.
46. Mor A, Ulrichsen SP, Svensson E, Berencsi K, W. Thomsen R. Does marriage protect against hospitalization with pneumonia? A population-based case-control study. *Clinical Epidemiology*. 2013; 5:397–405.
47. Sigsgaard T, Basinas I, Doekes G, De Blay F, Folletti I, Heederik D, et al. Respiratory diseases and allergy in farmers working with livestock: a EAACI position paper. *Clinical and Translational Allergy*. 2020; 10(29):1-30.

