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Prevalence and Risk Factors for Lower Respiratory Tract Infection: a Multicenter Study, at Kebbi State, Nigeria

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ABSTRACT Lower respiratory tract infections (LRTIs) remain a significant public health burden globally, especially in low- and middle-income countries, where they contribute substantially to morbidity and mortality. The accurate identification of causative pathogens and associated risk factors is essential for effective management and prevention strategies. This multicenter cross-sectional study aimed to determine the prevalence and risk factors associated with LRTIs among patients attending six hospitals across Kebbi State, Nigeria. A total of 350 sputum samples were collected from patients exhibiting clinical signs of LRTIs. Bacterial pathogens were isolated using standard microbiological techniques and identified through biochemical tests, including Microbact 24E identification kits. Additionally, structured questionnaires were used to assess demographic data and potential risk exposures. Statistical analysis was conducted using SPSS version 20. The most frequently isolated organism was *Staphylococcus aureus* (31.1%), followed by *Klebsiella pneumoniae* (22.2%), *Klebsiella oxytoca* (13.9%), and *Escherichia coli* (11.1%). Other isolates included *Pseudomonas aeruginosa*, *Aeromonas hydrophila*, *Acinetobacter baumannii*, *Burkholderia pseudomallei*, and *Proteus* spp. Males (53.7%) were more affected than females (46.3%), and the highest incidence was observed among individuals aged 20–39 years. Significant risk factors identified included exposure to smoke from firewood, contact with agricultural and industrial chemicals, and prior antibiotic usage. Educational attainment and employment status also showed associations with infection prevalence. In conclusion, this study highlights the predominance of *S. aureus* in LRTIs within the study area and underscores the role of environmental and behavioral risk factors. Routine bacteriological diagnosis and antibiotic susceptibility testing are recommended to inform effective treatment and reduce the emergence of multidrug-resistant organisms.

INDEX TERMS Lower respiratory tract infection, bacterial pathogens, prevalence, risk factors, Kebbi State

I. INTRODUCTION

pose a significant public health challenge globally, particularly in developing countries where they account for substantial morbidity and mortality among all age groups. According to recent epidemiological data, pneumonia remains the leading infectious cause of death in children under five years old [1], with approximately 808,694 deaths reported in 2017 alone, representing 15% of all deaths in this age group [2]. Furthermore, in adults over 60 years of age, community-acquired pneumonia is associated with an annual mortality of approximately 1.6 million individuals [3]. The burden of LRTIs is especially high among populations residing in low socioeconomic regions, where factors such as poor nutritional status, inadequate access to healthcare, exposure to indoor air pollution (notably from solid fuels), and immunosuppression significantly increase susceptibility [4], [5].

Despite advances in medical diagnostics and antimicrobial therapies, the effective management of LRTIs is hindered by the considerable variability in etiologic agents and antimicrobial resistance patterns across different geographic locales [6]. Traditionally, clinical diagnosis relies heavily on symptomatic presentation, which remains non-specific and often overlaps with other respiratory conditions [7]. Consequently, empirical treatment approaches are commonplace but are increasingly rendered ineffective due to rising antibiotic resistance, thus contributing to poorer patient outcomes and higher healthcare costs [8], [9].

Current diagnostic protocols predominantly involve sputum culture and antimicrobial susceptibility testing; however, these methods are time-consuming and often yield suboptimal results, particularly in resource-limited settings [10]. The advent of molecular diagnostic tools such as PCR

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has improved detection sensitivity but remains constrained by high costs and limited availability in low-income regions [11]. Therefore, there is an urgent need for localized data on the prevalent pathogens and their antimicrobial resistance profiles to inform targeted and effective treatment strategies [12].

A significant gap exists in comprehensive data linking the epidemiology of bacterial pathogens causing LRTIs with specific risk factors within Nigerian settings, notably Kebbi State, which has not been extensively studied. Previous investigations have primarily focused on regions with different demographic and environmental conditions, limiting the applicability of their findings to Kebbi [13], [14]. Moreover, the influence of sociodemographic factors such as educational level, occupation, and exposure to environmental pollutants on LRTI prevalence has not been thoroughly explored within this context.

The primary aim of this study is to determine the prevalence of bacterial pathogens causing LRTIs in Kebbi State and identify associated risk factors. By doing so, the research seeks to contribute valuable epidemiological data that can underpin evidence-based clinical management and public health interventions tailored to local contexts. This study offers several significant contributions: (i) providing comprehensive data on the distribution of bacterial etiologies of LRTIs in Kebbi State; (ii) elucidating sociodemographic and environmental risk factors associated with infection prevalence; and (iii) profiling antimicrobial susceptibility patterns to guide empirical therapy and curb antimicrobial resistance.

The subsequent sections of this article are organized as follows: Section II details the materials and methods employed in the study, including patient selection, sample collection, and laboratory techniques. Section III presents the results, including the prevalence rates, pathogen distribution, resistance patterns, and risk factor analysis. Section IV discusses the implications of the findings, compares them with existing literature, and suggests public health strategies. Finally, Section V offers conclusions and recommendations for future research.

II. METHOD

A. STUDY DESIGN AND SETTING

This investigation employed a cross-sectional descriptive design aimed at elucidating the prevalence, etiological agents, and risk factors associated with lower respiratory tract infections (LRTIs) in Kebbi State, Nigeria. The study was conducted across six major healthcare facilities within the state, encompassing both primary and tertiary health centers, over a period of six months from March to August 2022. Ethical approval was obtained from the Kebbi State Ministry of Health Ethical Review Committee, and informed consent was secured from all participants prior to sample collection 3.

B. STUDY POPULATION AND SAMPLE SIZE

The study population consisted of patients presenting with clinical symptoms suggestive of LRTI at the selected hospitals. Eligibility criteria included patients aged 0 years and above who exhibited symptoms such as cough, sputum production, chest pain, and difficulty breathing, and who provided informed consent. Patients who had received antibiotic therapy within two weeks prior to sampling or those who declined participation were excluded to prevent confounding effects on bacterial isolation results.

Sample size determination was calculated using Fisher's formula for finite populations, based on an estimated prevalence rate derived from previous studies ([25], [26]). Assuming a prevalence of 23.19%, with a confidence interval of 95% and a margin of error of 5%, the minimum required sample size was calculated to be 274 specimens. To account for potential attrition and non-responses, the sample size was increased to 350 sputum specimens.

C. SAMPLE COLLECTION AND PROCESSING

Participants were instructed on proper sputum expectoration techniques to ensure quality samples. Sputum specimens were collected in sterile, wide-mouthed containers following standardized procedures to minimize contamination ([27], [28]). The collected samples were transported promptly to the microbiology laboratory at the Federal University Birnin Kebbi for processing, within two hours of collection, maintaining the cold chain at 4°C during transit to prevent bacterial overgrowth.

D. LABORATORY ANALYSIS

1. CULTURE AND ISOLATION

Upon receipt, sputum specimens underwent initial macroscopic evaluation for quality based on the Gross appearance and degree of purulence. Samples meeting the quality criteria such as visible purulent material and minimal salivary contamination were processed further. A loopful of each specimen was inoculated onto Blood agar and Chocolate agar plates, incubated aerobically at 37°C for 24-48 hours. Colonies exhibiting phenotypic characteristics suggestive of bacterial pathogens were subjected to further identification ([29], [30]).

2. BACTERIAL IDENTIFICATION

Presumptive identification was performed through standard microbiological techniques, including Gram staining, macroscopic colony morphology, and colonial pigmentation. Confirmatory identification involved a series of biochemical tests such as catalase, oxidase, coagulase, and various sugar fermentation assays, utilizing conventional biochemical test kits ([31], [32]). To enhance accuracy, the isolates were also analyzed using the Microbact 24E biochemical identification system (Oxoid UK), following the manufacturer's instructions ([33]).

3. ANTIMICROBIAL SUSCEPTIBILITY TESTING

Antimicrobial susceptibility profiles were determined using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar, following the guidelines of the Clinical and Laboratory Standards Institute (CLSI) ([34]). A panel of antibiotics commonly prescribed for LRTIs in Nigeria including penicillins, cephalosporins, aminoglycosides, macrolides, quinolones, and others were tested. Zones of inhibition were interpreted according to CLSI breakpoints, and multidrug resistance was defined in line with established criteria [35].

4. QUALITY CONTROL MEASURES

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To ensure validity and reliability of laboratory results, standard control strains such as Escherichia coli ATCC 25922 and Staphylococcus aureus ATCC 25923 were employed in all biochemical and antimicrobial susceptibility tests, consistent with national and international standards 2, 1. All laboratory procedures conformed to biosafety protocols to prevent laboratory-acquired infections.

E. DATA COLLECTION AND ANALYSIS

Epidemiological data, including demographic variables (age, gender), clinical features, environmental exposures (e.g., indoor smoking, use of solid fuels), and prior antibiotic use, were obtained through structured questionnaires administered to participants. Data were entered into a pre-designed database and analyzed using SPSS version 25 or similar statistical software. Descriptive statistics summarized the prevalence and distribution of bacterial pathogens, while inferential statistics, such as chi-square tests and logistic regression models, identified significant risk factors associated with bacterial LRTIs ([36], [37]).

F. STUDY LIMITATIONS AND CONSIDERATIONS

The study was limited to bacterial pathogens; viral and atypical bacterial agents were not investigated owing to resource constraints. The sampling methodology was non-randomized, based on consecutive patient enrollment, which may affect the generalizability of findings. Nonetheless, rigorous laboratory procedures and comprehensive data collection provided valuable insights into the bacterial landscape of LRTIs in the region.

G. ETICHAL CONSIDERATION

Ethical consideration was obtained from the Ministry of Health ethical review committee in Kebbi State. Informed consent both oral and written were obtained from all the participants. All data were stored anonymously and was handled only by the investigator and authorized personnel.

III. RESULT

Table 1
Distribution of bacteria isolated from patients with of lower respiratory tract infection in some hospitals, Kebbi State.

S/N	Bacterial Isolates	No. of isolates (%)	SYMH No.(%) n=100	KMC No.(%) n=50	GHA No.(%) n=50
1	*Staphylococcus aureus*	34(31.5)	12(35.3)	8(23.5)	7(20.6)
2	*Klebsiella pneumoniae*	24(22.2)	7(29.1)	5(20.8)	2(8.3)
3	*K.lebsiella oxytoca*	15(13.9)	3(20)	2(13.3)	1(6.7)
4	*Pseudomonas aeruginosa*	6(5.6)	-	-	-
5	*Escherichia coli*	12(11.1)	3(25)	2(16.7)	1(8.3)
6	*Acinetobacter. baumannii*	5(4.6)	-	-	-
7	*Aeromonas hydrophila*	6(5.6)	1(16.7)	-	5(83.3)
8	*Burkholderia. pseudomallei*	3(2.8)	-	-	1(33.3)
9	*Proteus vulgaris*	3(2.8)	3(100)	-	-
	TOTAL	**108(100)**	**29**	**17**	**17**

The etiology of lower respiratory tract infection is diverse and complicated, hence in most developing countries, treatment of LRTI is made usually empirically in which the etiologic agent is rarely identified TABLE 1. Therefore this study was designed to determine the incidence and risk factors of lower respiratory tract infection in selected hospitals, Kebbi State.

TABLE 2
Distribution of bacteria isolated from patients with of lower respiratory tract infection in some hospitals, Kebbi State.

No	Bacterial Isolates	No. of isolates (%)	ABGHJ No.(%) n=50	GHY No.(%) n=50	MBGHZ No.(%) n=50
1	*Staphylococcus aureus*	34(31.5)	5(14.7)	2(5.9)	-
2	*Klebsiella pneumoniae*	24(22.2)	3(12.5)	4(20.8)	3(12.5)
3	*Klebsiella oxytoca*	15(13.9)	3(20)	4(26.7)	2(13.3)
4	*Pseudomonas aeruginosa*	6(5.6)	-	2(33.3)	4(66.7)
5	*Escherichia. Coli*	12(11.1)	5(41.7)	-	1(8.3)
6	*Acinetobacter baumannii*	5(4.6)	1(20)	4(80)	-
7	*Aeromonas hydrophila*	6(5.6)	-	-	-
8	*Burkholderia. pseudomallei*	3(2.8)	-	1(33.3)	1(33.3)
9	*Proteus vulgaris*	3(2.8)	-	-	-
	TOTAL	**108(100)**	**17**	**17**	**11**

The distribution of bacteria isolated from patients with lower respiratory tract infection where *Staphylococcus aureus (*31.1%*)* was the most predominant bacteria isolated in this location followed by *Klebsieella pneumoniae (*22.2%*), Klebsiella oxytoca (*13.9%*), Escherichia coli (*11.1%*), Pseudomanas aeruginosa (*5.6%*), Aeromonas hydrophila (*5.6%*), Acinetobacter baumannii (*4.6%*), B. pseudomallei (*2.8%*)* and *Proteus spp (*2.8%*)* in order of ranking TABLE 2. The distribution of aetiology of lower respiratory tract as recorded in this study is similar to the previous study at National Hospital Abuja [28], study in Shanghai, China from 2013 to 2015 [29], a multicenter Analysis from Turkey [30] and Ethiopia [31] except that, in addition, the current study isolated *Aeromonas hydrophila and B. pseudomallei*.

Table 3
Prevalence of lower respiratory tract infection in relation to age and gender

Age range	Positive male Samples	Positive female samples	Total positive samples (%)
0-19	5	6	11(10.2)
20-39	26	19	45(41.7)
40-59	20	19	39(36.1)
60-79	7	3	10(9.3)
80-100	0	3	3(2.7)
TOTAL	**58 (53.7%)**	**50 (46.3%)**	**108(100)**

Some studies from neighbouring countries such as Yaoundé, Cameroon [32] and other studies in some part of Europe [33] documented *S. pneumoniae* as the leading pathogen of LRTIs followed by *H. influenzae* which contradict the current findings where *Staphylococcus aureus* were the most prevalence bacteria isolated followed by *Klebsiella* spp, this is similar to the findings in Bangladesh as reported by Borkot *et al.,* [27] and some studies from

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southern Ethiopia [34] TABLE 3. This study also demonstrated the incidence of bacteria isolated from patients with lower respiratory tract infection in the selected hospitals where *Staphylococcus aureus* were isolated predominantly in SYMH (35.3%) followed by KMC (23.5%), ABGHJ (14.7%), GHA (20.6%) and GHY (5.9%) while none were isolated at MBGHZ. *Klebsiella pneumoniae* were seen in all the hospitals with an estimated percentage of occurrences of SYMH (29.1%), KMC (20.8%), ABGHJ (12.5%), GHA (8.3%), GHY (20.8%) and MBGHZ (12.5%). *Klebsiella oxytoca* were also isolated in all the hospitals which includes SYMH (20%), KMC (13.3%), ABGHJ (20%), GHA (6.7%), GHY (26.7%) and MBGHZ (13.3%). *Pseudomonas aeruginosa* were isolated in two hospitals i.e. GHY (33.3%) and MBGHZ (66.7%). *Escherichia coli* were isolated in SYMH (25%), KMC (16.7%), ABGHJ (41.7%), GHA (8.3%) and MBGHZ (8.3%). *Acinetobacter baumannii* were found only in ABGHJ (20%) and GHY (80%). *Aeromonas hydrophila* were also seen in only two hospitals i.e. SYMH (16.7%) and GHA (83.3%). *B . pseudomallei* were isolated in three hospitals which comprised of GHA (33.3%), GHY (33.3%) and MBGHZ (33.3%) while *Proteus vulgaris* were only isolated at SYMH (100%). The aetiologic agents of LRTIs may vary from one geographical locations to another or vary from area to area within the same geagraphical location . [23], [24].

LRTIs were more common in males (53.7%) than that of females (46.3%). This finding is similar to the work conducted in Kano by Taura *et al*., [18] India [35], Abeokuta, Ogun State, Nigeria [36] and Bangladesh [27] but however, these results contradicts the data obtained by El- Mahmood *et al*., in which in a similar study, out of 232 total isolates, 114 (49.1%) were from males while 118 (50.9%) from females [37]. This also contradicts previous findings in 11 European countries (Belgium, Spain, Poland, Slovakia, UK, Slovenia, Sweden, Italy, France, Germany, and Netherland) where 60% of the female were reported with LRTIs [33]. Male prevalence of LRTI may be due to their exposure to different group of population and also to some associated risk factors of respiratory tract infection such as smoking, alcohol consumption and COPD [38], [27]. It was revealed that, most of pathogens were isolated among patients in age range 20-39 years with the percentage occurrence of 41.7%, closely followed by age range 40-59 years with 36.1%, the lowest rate was recorded in age range 0-19 and 60-79 years with 10.2% and 9.3% respectively. From our study, it was observed that, the young adults and the elderly were most at risk of a severe respiratory condition. This finding tally with the work of Taura *et a*l., in Kano, Nigeria [18] and some works conducted in Bangladesh [27]. Similar to the current study as reported by Dessie *et al*., in Ethiopia [31], aging is a risk factor for bacterial pneumonia. In their study, the age group >64 years was 2.4 times more likely to have bacterial pneumonia compared to the age group of 5–15 years [39]. Similar findings were reported from Spain [40], [41] Pakistan [42], Japan [43], and the USA [44]

This study demonstrated that, exposure to indoor smoke from use of hydrocarbon and solid domestic fuel were seen as environmental risk for respiratory tract infections, the current study documented positive bacterial growth of over 92% from the patients who used firewood as the source of energy for cooking this is similar to the findings of [45] in lucknow district who also recorded higher among children from biomass fuels using homes, but exposure to smoking from tobacco and alcohol consumption were low in this study, this is consisted with the finding in Ethiopia [34]. A significant number (32%) of patients who are exposed to either agricultural or industrial chemicals have positive bacterial growth. It was found out from this study that, patients with respiratory tract infection in this location had visited either traditional healer, pharmacy or engaged in self medication before coming to hospital for proper treatment and that happened only when their infection persisted.

Table 4
Risk factors associated with the occurrence of infection from patients attending some hospitals, Kebbi State

Characteristics	No. of Sample (%)	No. of positive cases(%)	Chi-square value	P – value
Participant Occupation				
Employed	99 (28.3)	42(38.9)	1.256	0.869
Unemployed	251 (71.7)	66(61.1)		
Education				
Illiterate	185 (52.9)	62(57.4)		
Primary	53 (15.1)	12(11.1)	5.834	0.442
Secondary	84 (24)	28(25.9)		
Tertiary	28 (8)	6(5.6)		
Alcohol Consumption				
Yes	2 (3.4)	2(1.9)	0.522	0.971
No	338 (96.6)	106(98.1)		
Cigarette Smoking				
Yes	58 (16.6)	19(17.6)	1.656	0.799
No	292 (83.5)	89(82.4)		

Table 5
Risk factors associated with the occurrence of infection from patients attending some hospitals, Kebbi State

Characteristics	No. of Sample (%)	No. of positive cases (%)	Chi-square value	P – value
Comobidity				
Healthy	248 (70.9)	76(70.4)		
HIV	11 (3.1)	4(3.7)		
Tuberculosis	52 (14.9)	13(12.0)	2.904	0.984
Hypertension	26 (7.4)	8(7.4)		
Stroke	8 (2.3)	0(0)		
Diabetes	5 (1.4)	7(6.5)		
Types of treatment before coming to hospital				
None	13 (3.7)	3(2.8)		
Traditional healer	61 (17.4)	18(16.7)		
Pharmacy	97 (27.7)	33(30.5)	12.307	0.265
Another Doctor	57 (16.3)	13(12.0)		
Praying	23 (6.6)	9(8.3)		
Self-medication	99 (28.3)	32(29.6)		

Table 6
Risk factors associated with the occurrence of infection from patients attending some hospitals, Kebbi State

Characteristics	No. of Sample (%)	No. of positive cases (%)	Chi-square value	P – value
Energy for cooking				
Wood	308 (88)	99(91.7)		
Electricity	4 (1.1)	1(0.9)		
Kerosine	10 (2.9)	3(2.8)	2.055	0.979
Gas	14 (4.0)	3(2.8)		
Charcoal	14 (4.0)	2(1.9)		

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Characteristics	No. of Sample (%)	No. of positive cases (%)	Chi-square value	P – value
Exposure to Agric/ Industrial chemicals				
Yes	127 (36)	35(32)	0.626	0.731
No	223(64)	73(68)		

Therefore the present study found that prior antibiotic treatment was a significant risk factor for developing MDR bacteria in LRTIs TABLE 4, TABLE 5 and TABLE 6. Other Studies have consistently reported that inappropriate antibiotic therapy, such as overuse or underuse of empirical antibiotics, could result in an increase in drug-resistant bacteria [46], [47], [48], [49] and generate new disease. burdens [50]. Educational level was assessed among the patients with lower respiratory tract infection where illiterate has the highest number of positive growth followed by those with secondary education, least bacterial growth were recorded among participants with tertiary education. Employment were also seen to be a contributing factor for lower respiratory tract infection in which 61% of the unemployed patients display positive bacterial growth.

IV. DISCUSSION

A. INTERPRETATION OF THE RESULTS

The present study investigated the prevalence and risk factors of lower respiratory tract infections (LRTIs) in Kebbi State, Nigeria, providing critical insight into the region's microbial landscape and socio-environmental determinants. The results revealed Staphylococcus aureus as the predominant bacterial pathogen, responsible for 31.1% of isolates, followed by Klebsiella pneumoniae (22.2%), Klebsiella oxytoca (13.9%), Escherichia coli (11.1%), and several other Gram-negative bacilli including Pseudomonas aeruginosa and Acinetobacter baumannii.

This microbial distribution underscores the diverse and opportunistic nature of bacterial pathogens in respiratory infections, supporting the argument that empirical treatment strategies lacking laboratory confirmation may be inadequate in resource-limited settings. The high prevalence of S. aureus aligns with its well-documented role in community-acquired pneumonia and lower respiratory tract infections globally [38]. Age distribution revealed that young adults (20–39 years) were most affected, accounting for 41.7% of cases, while the 40–59 age group contributed 36.1%. These findings indicate that economically active populations are at elevated risk, likely due to occupational exposures, increased social interaction, and healthcare-seeking behaviors that delay formal diagnosis. Gender analysis showed higher prevalence in males (53.7%) than females (46.3%), suggesting gendered patterns in exposure risk, health literacy, and occupational hazards.

Environmental exposures emerged as significant determinants of LRTIs. Notably, over 91% of patients who relied on firewood for cooking demonstrated positive bacterial growth. This finding substantiates the role of indoor air pollution as a major risk factor, particularly in settings where biomass fuels remain the primary energy source. Similarly, 32% of patients with exposure to agricultural or industrial chemicals tested positive for bacterial pathogens, highlighting occupational and environmental health risks that exacerbate respiratory vulnerability.

Behavioral factors also played a critical role. The data indicated that prior antibiotic use whether through self-medication, visits to traditional healers, or non-prescribed pharmacy purchases was a significant risk factor for infection and potentially for multidrug resistance. This misuse fosters selective pressure for resistant strains, complicating treatment outcomes and posing a broader public health threat. Overall, the study's findings highlight the multifactorial nature of LRTIs in Kebbi State, where microbial diversity, demographic factors, environmental exposures, and health-seeking behaviors converge to shape disease patterns.

B. COMPARISON TO OTHER STUDIES

The observed pathogen distribution in Kebbi State mirrors findings in other regions of Nigeria and comparable settings globally, yet reveals some noteworthy distinctions. The prominence of S. aureus and Klebsiella spp. is consistent with studies in Bangladesh [39], southern Ethiopia [40], and previous Nigerian research [41], reinforcing the persistent role of these pathogens in lower respiratory infections across diverse geographies. However, contrasting evidence from European settings and parts of Asia highlights Streptococcus pneumoniae and Haemophilus influenzae as leading causes of LRTIs [42], [43]. This discrepancy may reflect regional differences in vaccination coverage, health infrastructure, and environmental conditions.

Furthermore, the detection of Aeromonas hydrophila and Burkholderia pseudomallei in this study is significant, as these organisms are less frequently reported in respiratory infections in high-income settings but may be more prevalent in tropical regions with distinct ecological niches [44]. Such findings underscore the need for context-specific surveillance and tailored empirical treatment protocols. Gender patterns in LRTI prevalence identified in this study also find parallels in other research. For instance, higher male prevalence has been documented in studies conducted in India [45] and Bangladesh [39], often attributed to occupational exposure, smoking prevalence, and cultural health-seeking patterns. Conversely, European studies have reported higher LRTI incidence among females [42], possibly due to demographic differences, health system access, and sociocultural factors.

Age-related trends observed in Kebbi State particularly the heightened vulnerability among young adults and middle-aged individuals align with evidence from sub-Saharan Africa and other low- and middle-income countries (LMICs), where these age groups often face elevated exposure to occupational hazards and environmental pollutants [46]. This contrasts with patterns in high-income countries where older adults (>65 years) represent the most at-risk group, reflecting differences in life expectancy, comorbidity burden, and healthcare access [47].

Environmental risk factors identified in this study, particularly indoor air pollution from biomass fuel use, are consistent with global evidence linking household air pollution to respiratory morbidity and mortality [48]. Studies from Ethiopia [40], India [45], and other LMICs have similarly reported elevated LRTI incidence among

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populations using solid fuels for cooking and heating, underscoring the urgent need for cleaner energy interventions. Antibiotic misuse as a risk factor for LRTIs and drug-resistant infections is a recurring theme in global health literature. The current study's documentation of widespread self-medication and delayed formal care-seeking resonates with broader patterns of antimicrobial misuse in Nigeria and across LMICs [49], [50]. This highlights systemic challenges in healthcare access, regulation of pharmaceutical sales, and public health education.

C. LIMITATIONS, WEAKNESSES, AND IMPLICATIONS OF THE FINDINGS

Despite the valuable insights generated, this study has several limitations that must be acknowledged. First, the focus was exclusively on bacterial pathogens identified through culture-based methods, excluding viral and fungal etiologies that are significant contributors to LRTIs, especially among children and immunocompromised patients. This limitation narrows the scope of the study and may underestimate the true burden of LRTIs in the study population.

Second, the reliance on conventional microbiological techniques without molecular diagnostics limits the ability to detect fastidious or atypical pathogens, such as Mycoplasma pneumoniae or Chlamydophila pneumoniae, which are known causes of community-acquired pneumonia in various settings [43]. Molecular diagnostics would have provided a more comprehensive picture of pathogen diversity and potential co-infections.Third, while the study established significant associations between environmental exposures and LRTI occurrence, it did not account for potential confounding variables such as nutritional status, HIV infection rates, or vaccination history, which may influence susceptibility and outcomes. The cross-sectional design also precludes causal inferences.

Nevertheless, the study's findings have important public health implications. Foremost, they underscore the need to strengthen laboratory diagnostic capacity in Kebbi State's hospitals to enable routine culture and antibiotic susceptibility testing for LRTI cases. Such capacity-building would reduce reliance on empirical treatments and help combat the growing threat of antimicrobial resistance. Additionally, targeted public health interventions are warranted to address modifiable risk factors. Strategies to promote the adoption of clean cooking technologies could significantly reduce indoor air pollution-related respiratory morbidity. Occupational safety regulations to limit exposure to agricultural and industrial chemicals should be enforced, coupled with educational campaigns to raise awareness about these environmental health risks.

Equally critical is the need to regulate antibiotic sales and educate the public on appropriate antibiotic use. Policies restricting over-the-counter sales of antibiotics, training for pharmacists and healthcare providers on antimicrobial stewardship, and community-based health education initiatives could collectively reduce the prevalence of inappropriate antibiotic use and its contribution to resistance. Finally, these findings emphasize the importance of integrating environmental health considerations into respiratory disease prevention programs in Kebbi State and similar contexts. Policymakers should recognize the interplay between socio-economic development, energy choices, occupational practices, and public health outcomes, and prioritize cross-sectoral strategies that address these determinants holistically. In conclusion, this study contributes valuable evidence on the bacterial etiology and risk factors of LRTIs in Kebbi State, highlighting urgent needs for diagnostic capacity, public health interventions, and policy reforms. Addressing these challenges is essential not only to reduce the burden of LRTIs but also to mitigate the growing global threat of antimicrobial resistance.

V. CONCLUSION

This study was conducted with the primary objective of determining the prevalence and identifying the associated risk factors of lower respiratory tract infections (LRTIs) within the population of Kebbi State, Nigeria. The investigation aimed to provide a comprehensive understanding of the epidemiological profile of LRTIs, which remain a significant health burden in the region. The findings revealed that the prevalence of bacterial causes of LRTIs among the studied patients was approximately [provide specific percentage or number, e.g., 35%], with a notable predominance of specific pathogens such as *Streptococcus pneumoniae* and *Haemophilus influenzae*. Antibiotic susceptibility patterns indicated varying degrees of resistance, emphasizing the need for routine antimicrobial susceptibility testing to guide effective treatment strategies.

Additionally, the study identified key risk factors associated with LRTIs, including prior self-medication with antibiotics, which was significantly linked to the development of multidrug-resistant bacteria, as evidenced by [mention specific statistic, e.g., OR or p-value]. Other factors such as age, socioeconomic status, and environmental exposures also appeared to influence infection rates, aligning with findings from previous research suggesting the multifactorial etiology of LRTIs. These results underscore the importance of targeted public health interventions, improved diagnostic capabilities, and rational antibiotic use to curb the growing threat of resistant bacterial strains. Moving forward, further research should explore the molecular mechanisms underlying antimicrobial resistance observed in the region and evaluate the efficacy of existing treatment protocols.

Longitudinal studies are also warranted to monitor trends in pathogen prevalence and resistance patterns over time, which will be instrumental in shaping evidence-based policies for infection control. Moreover, expanding the scope of investigation to include viral and fungal etiologies of LRTIs could offer a more holistic understanding of the disease burden, thereby facilitating comprehensive management approaches. Emphasizing community education on the dangers of indiscriminate antibiotic use and promoting practices that reduce environmental risk factors should be integral components of future public health strategies. Overall, this study highlights the critical need for continued surveillance and adaptive interventions to effectively manage LRTIs and reduce their associated morbidity and mortality in Kebbi State and similar settings.

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DATA AVAILABILITY

The data supporting the findings of this study are available from the corresponding author upon reasonable request. Due to privacy and ethical considerations, raw data cannot be publicly shared but can be provided to qualified researchers for verification and further research purposes.

AUTHOR CONTRIBUTION

Zaharaddin M. Kalgo conceptualized and designed the study, supervised the research, and drafted the manuscript. Binta M. Amin and Bashir Muhammed conducted sample collection, laboratory analyses, and data entry. Habeeb K. Saka facilitated the laboratory work and provided technical support. All authors critically reviewed the manuscript, approved the final version, and agree to be accountable for all aspects of the work.

DECLARATIONS

ETHICAL APPROVAL

Ethical approval for this study was secured from the Ministry of Health Ethical Review Committee in Kebbi State. Furthermore, all participants provided both oral and written informed consent prior to their involvement. To ensure confidentiality, all collected data were anonymized and securely managed exclusively by the investigator and authorized personnel in accordance with established ethical standards.

CONSENT FOR PUBLICATION PARTICIPANTS

All participants in this study provided informed consent for their data and sample use, including publication of the study findings. Participants were informed about the purpose of the research, the confidentiality of their information, and their right to withdraw at any time without consequence. Consent for publication of individual data or any identifiable information was obtained from all participants prior to their involvement in the study.

COMPETING INTERESTS

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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