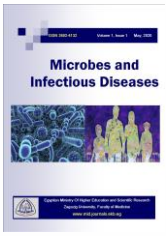
Microbes and Infectious Diseases 2023; 4(2): 497-505



Microbes and Infectious Diseases

Journal homepage: https://mid.journals.ekb.eg/

Original article

Co-infections and antimicrobial resistance profile of *Mycobacterium tuberculosis* and *Streptococcus pneumoniae* among patients with pulmonary infections attending tertiary health facilities in Makurdi, Nigeria

Ageje Moses Isaac [1], Joseph Fuh Nfongeh [2], Yusuf Amuda Agabi [*3], Stella Boko Uneze [3], Paul Ogor Abba [4], Ezekiel Danjuma [5], Kosisochukwu Elijah Udeogu [6], Nanma Tongnan Cosmas [7], Joseph Aje Anejo-Okopi [8], John Danjuma Mawak [3]

1- *Department of Microbiology, Faculty of Science, Federal University of Lafia, Nasarawa State, Nigeria.*
2- *Department of Microbiology, Federal University Lafia.*
3- *Department of Microbiology, Faculty of Natural Sciences, University of Jos, Jos, Plateau State, Nigeria.*
4- *Benue State Unversity Teaching Hospital Makurdi, Benue State, Nigeria.*
5- *TB Reference Laboratory, Jos University Teaching Hospital Jos, Nigeria.*
6- *Department of Medicine and Surgery, University of Nigeria, Nsukka, Nigeria.*
7- *Faculty of Clinical Sciences, College of Health Sciences, University of Jos, Nigeria.*
8- *Federal University of Health Sciences, Utukpo, Benue State, Nigeria.*

ARTICLE INFO

Article history:
Received 14 May 2022
Received in revised form 10 June 2022
Accepted 11 June 2022

Keywords:
Co-infections
Pneumonia
Pulmonary
Tuberculosis

BACKGROUND: Pulmonary infections (Pls) cause mortality in elderly patients that have co-morbidities. These infections are life-threatening in the younger population, especially in infants and children. Co-infection with *Mycobacterium tuberculosis* and *Streptococcus pneumoniae* occurring concurrently may lead to undiagnosed *Streptococcus pneumoniae* leading to inadequate treatment. **Aim:** The study investigates the co-infection and antimicrobial resistance profile of *Mycobacterium tuberculosis* and *Streptococcus pneumoniae* in Makurdi, Nigeria. **Materials and methods:** A total of 273 sputum samples were collected from patients with pulmonary infection attending chest clinics in tertiary health institutions in Makurdi and analysed. Genexpert was used for *Mycobacterium tuberculosis* while *Streptococcus pneumoniae* isolates were identified using Gram-staining reaction, optochin and bile solubility tests. The susceptibility test for *Streptococcus pneumoniae* was performed using Kirby-Bauer method. **Results:** Out of the 273 sputum samples, the percentage occurrence of mono-infections with *Mycobacterium tuberculosis* was 14(5.13%) while that with rifampicin resistance was 1(0.37%). The occurrence of mono-infection with *Streptococcus pneumoniae* was 11(4.03%). The resistance profile showed trimethoprim/sulphamethoxazole (septrin) with the highest resistance 6(54.55%) and vancomycin 5(45.45%) while amoxicillin/clavulanic acid and ceftriaxone had zero resistance (0.0%). There was the occurrence of co-infections in 3(1.10%) out of the 273 patients sampled. There was no significant association ($p > 0.05$) between *Mycobacterium tuberculosis*, *Streptococcus pneumoniae*, their co-infections and the variables analyzed. **Conclusion:** The occurrence rate of *Streptococcus pneumoniae* and *Mycobacterium tuberculosis* co-infections is low among suspected pulmonary infection cases with an occurrence rate of 1.10%. Early detection and proper management of co-infections are recommended.

DOI: 10.21608/MID.2022.138402.1314
* *Corresponding author:* Yusuf Amuda Agabi
E-mail address: yusufagabi@gmail.com

Introduction

Pulmonary infections (Pls) are of high clinical concern and also a big problem in medical research as a result of their influence on increasing the death rate of elderly people. Pulmonary infections also life-threatening to younger populations, for example, infants and children [1]. Good knowledge of the causative agent of infection is very important in the treatment of that infection [2]. Tuberculosis (TB), as well as pulmonary pneumonia, are infections of the lower respiratory tracts, which have an effect on all groups of people, especially in developing countries [3]. *Streptococcus pneumoniae* and *Mycobacterium tuberculosis* cause pneumonitis and tuberculosis by affecting the lobes of the lungs respectively which is a major global cause of death in all age groups [4-6]. Inability to identify the exact causative agent of infection before treatment is a great challenge in most developing countries like Nigeria as a result, many infectious agents are lost out during diagnosis or under-diagnosed [3]. The impact of COVID-19 has further reduced medical attention given to tuberculosis as evident in the data collected by the global tuberculosis network from 33 centres, and 16 countries on 5 continents [7-9]. Pneumonia and tuberculosis co-infection in individuals in which streptococcal pneumonia is the secondary infection leads to serious health management problems than when tuberculosis alone is detected and managed. The most frequently isolated cause of bacterial pneumonia is *Streptococcus pneumoniae*. *Streptococcus pneumoniae* and *Mycobacterium tuberculosis* give rise to inflammatory response to the lobe of the lungs leading to lobular pneumonia [10].

In developing countries such as Nigeria, the issues associated with the inability to locate the main cause of infection, prior to initializing treatment is very high and more grossly in the rural settlement, thus, quite a large number of infectious agents are under-diagnosed or wrongly diagnosed [3].

Co-infection of *Mycobacterium tuberculosis* and *Streptococcus pneumoniae* has not been widely reported. The simultaneous occurrence of both infections leads to delayed diagnosis and inadequate treatment [11,12]. Co-infection of pneumonia and tuberculosis in infected persons with streptococcal pneumonia as a prior infection could give rise to difficulties in the management of health problems if tuberculosis is diagnosed alone [10]. *Streptococcus pneumoniae* has therefore been reported as the most common agent of pneumonia especially in tuberculosis cases and the leading cause of more than 60% of bacterial pneumonia in adults which usually leads to hospitalization [10, 13].

The Centre for Disease Control (CDC) [14,15] reported that those who are at the risk of pneumococcal infection include people with tuberculosis infection. Exposure results in approximately 10% of such persons developing active tuberculosis with such presentation as coughing, fever, weakness, and loss of weight [16]. With this percentage of individuals developing active disease, about 1.5 million TB deaths cases occur worldwide each year making it a leading cause of death from an infectious agent apart from Human Immuno-deficiency virus (HIV) [17]. Furthermore, a serious problem is the emergence of multi-drug-resistant *Mycobacterium tuberculosis* strains in a number of countries. In Nigeria, reports of multi-drug resistant TB are on a steady increase likely due to the increasing accessibility to Xpert MTB/Rif assay [16].

Disease caused by both *Mycobacterium tuberculosis* and *Streptococcus pneumoniae* is a major health problem in Nigeria, and co-infection with these two diseases conditions has not been widely reported. Some individuals show drug resistance to not just one antibiotic but multiple antibiotics. The antimicrobial resistance profile of *Mycobacterium tuberculosis* and *Streptococcus pneumoniae* will help determine the drug of choice for treatment. Therefore, the aim of this study was to determine the prevalence of *Mycobacterium tuberculosis* and *Streptococcus pneumoniae* co-infection and resistance of *Mycobacterium tuberculosis* and *Streptococcus pneumoniae* among patients with pulmonary infections.

Materials and Methods

Study area and study population

The study area for the present study is Makurdi Benue State, Nigeria. Makurdi is a cosmopolitan city located in the middle belt region of Nigeria. Makurdi has an annual rainfall of 1200mm and a maximum temperature of 33.4^{o}C. The inclusion criteria for the study population were patients attending the Chest Clinics at the Health facilities in

Makurdi, (Benue State University Teaching Hospital and Federal Medical Centre Makurdi) Benue State, Nigeria and diagnosed by consultant physicians with broncho-pulmonary disorders. The Exclusion criteria comprise patients with symptoms not related to pulmonary infections. Patients who were positive for *Mycobacterium tuberculosis* and *Streptococcus pneumoniae* were managed and treated by the physicians in these hospitals.

Sample size and sample size determination

This was obtained using Thrushfield's (2005) method as reported by **Enitan et al.** [18]. The sample size was determined on the basis of 23.1% prevalence by **Ihongbe et al.** [3]. Hence, 273 clinical samples were collected from pulmonary patients attending Tertiary Health Facilities in Makurdi, Benue state.

Ethical clearance

Ethical clearance indicating approval for this study was obtained from the Ethical committee of Benue State University Teaching Hospital, Makurdi, Nigeria (Reference number: BSUTH/CMAC/HREC/101/V.I/143). The consent of the patients to participate in this study was also obtained.

Sample collection

Five millilitres (5ml) of sputum samples from consenting patients were collected into properly labelled sputum containers between July to September 2019. Sampling was done during each sampling period and the necessary precautionary information was given to patients.

Specimen processing and analysis

1. GeneXpert

GeneXpert system (Cepheid) is a semi-quantitative, nested real-time PCR in-vitro diagnostic test for the detection of *Mycobacterium tuberculosis* complex DNA in sputum samples and Rifampin-resistance associated mutations of the rpoB gene in sputum samples were used following the manufacturer's instruction in the GeneXpertMTB/Rif manual.

A total of 273 sputum samples were screened for *Mycobacterium tuberculosis*. This was done according to the method described in the GeneXpertMTB/Rif manual. GeneXpertMTB/Rif reagent sample diluent was added to one out of the two sputum specimen in a ratio of 2:1 and was shaken vigorously 10-20 times and then incubated for 5 minutes at room temperature. It was shaken vigorously again 20 times and incubated for another 10minutes. Using a sterile transfer pipette, 2ml of the liquified specimen was dispensed into the cartridges. The cartridge barcode was scanned using a barcode scanner. The cartridge was then loaded into the available module to run. The GeneXpert machine then integrated and automated sample processing, nucleic acid amplification, and detection of the target sequences.

2. Culture of sputum sample/isolation of *Streptococcus pneumoniae*

Five millilitres (5 ml) of sputum sample were taken from each patient and washed (the purulent part) with 5ml of sterile physiological saline. The washed sputum was inoculated using a sterile wire loop onto blood and chocolate agar, while an optochin disc was added to the blood and chocolate agar plates inside the area of the second spread. The blood agar plate was incubated aerobically while the chocolate agar plate was incubated in an atmosphere that was enriched with CO_2 at 37^0C for 24 hours [19]. The organism was isolated by culturing using an enriched medium with 5% sheep blood and chocolate agar [19]. Alpha-haemolytic colonies on blood agar and chocolate agar were considered for confirmation.

Identification of *Streptococcus pneumoniae*

1. Gram-staining technique

Gram-staining was performed following standard procedures [20].

2. Catalase test

A colony was taken with a loop that is sterile and mixed with a drop of 3 % hydrogen peroxide (H_2O_2) on a slide. Effervescence caused by the liberation of Oxygen as gas bubbles showed a positive test for catalase production by the bacterium while a negative test was indicated by the absence of the effervescence [20].

3. Optochin test

A disc of 5 μg of optochin (Oxoid) was placed on the inoculated blood agar (Blood-Based Agar, Himedia) plate and chocolate agar (Blood-Based Agar, Himedia) plate and was incubated aerobically and under an increased carbon dioxide atmosphere respectively for presumptive identification of *Streptococcus pneumoniae*. Alpha hemolytic streptococci strains that were susceptible or sensitive to optochin were considered for further tests [20] .

4. Bile solubility test

Many colonies of the organism were emulsified in a tube that contained 2ml of physiological saline to make the suspension turbid [20]. The suspension

was transferred into two tubes. Two drops of sodium deoxycholate reagent were added to one of the tubes and mixed. To the other tube, 2 drops of sterile distilled water were added and mixed. The tubes were incubated at 37^0C for 10-15 minutes. Clearing of turbidity was observed for the tube that contained sodium deoxycholate, indicating that *Streptococcus pneumoniae* was present [20].

Antimicrobial susceptibility profile for *Streptococcus pneumoniae*

Mueller-Hinton Agar (Himedia) supplemented with 5% sheep blood, prepared according to manufacturer's instructions was allowed to cool to room temperature and 20ml was dispensed into Petri dishes. Suspensions of *Streptococcus pneumoniae* in 2ml saline were mixed and brought to 0.5 Mcfarland standard. Plates were inoculated with a suspension of *Streptococcus pneumoniae* using sterile swabs. Seven antibiotics namely amoxycillin (10µg), amoxillin/clavulanic acid (30µg), ceptriaxone (30µg), trimethoprim/sulphamethoxazole (25µg), ciprofloxacin (5µg), erythromycin (15 µg) and vancomycin (30µg) were used for this study. Each antibiotic disk was placed on each plate and incubated aerobically and anaerobically at 370C overnight. Zones of inhibitions were measured using a ruler and reported as resistant, intermediate or sensitive according to CLSI guidelines [20].

Statistical analysis

Data were analyzed using Chi-Square calculator (https://www.socscistatistics.com/tests/chisquare2/default2.aspx). Relationships between categorical variables were assessed using the Chi-square test of independence and a *p*-value of ≤ 0.05 was considered statistically significant.

Results

Table 1 shows the occurrence of *Mycobacterium tuberculosis, Streptococcus pneumoniae* and their co-infections in Relation to Age and gender. Based on gender distribution, 160(58.6%) of them were females while the remaining 113(41.4%) were males. On the basis of age distribution, participants within the age range of 30-39 years had the highest *Mycobacterium tuberculosis* infection, 4(3.5%), followed by 20-29 years and 40-49 years, 2(1.8%), and the lowest *Mycobacterium tuberculosis* infection was among age groups of 10-19 and >60 years with 1(0.9%) positive case each. *Streptococcus pneumoniae* infections were reported within the age range of 30-39 years as 2(1.8%) and 1(0.9%) among males while females within the age groups 30-39, 40 – 49 and 50-59 years had the highest occurrence, 2(1.3%) each while age group of 10-19 years had the lowest occurrence of 1(0.6%). Co-infections of *Mycobacterium tuberculosis* and *Streptococcus pneumoniae* were recorded in 1(0.9%) case within the age groups of 20-29 years and 30-39 years among males while 1.0(0.6%) was recorded among females. The monthly occurrence of these pathogens and their co-infection status is shown in **table (2)**. The occurrence of *Mycobacterium tuberculosis* was highest in the month of July, 9 (7.10%) and lowest in the month of August, 5(1.6%). There was no case established in the month of September 0(0.0%). The occurrence of *Streptococcus pneumoniae* infection was highest in the month of September, 3(7.9%), followed by the month of August, 6(5.5%) and lowest in July, 2(1.6%). The only co-infections of *Mycobacterium tuberculosis* and *Streptococcus pneumoniae* occurred in August, 3(2.8%). Rifampicin resistance was only observed in males within the age range of 40-49 years 1(0.9%) as presented in **table (3)**. The antibiotic susceptibility pattern of *Streptococcus pneumoniae* shows that amoxicillin/clavulanic acid and ceftriaxone were the most sensitive with zero percent (0.0%) resistance while most of the organisms were resistant to trimethoprim/sulphamethoxazole, amoxycillin, ciprofloxacin, erythromycin and vancomycin as shown in **table (4).** The percentage susceptibilities of the 11 isolates, namely; Isolates1 to 11 (IS1-IS11) screened indicated that 6 were susceptible to 85.7% of the drugs, 1 susceptible to 71.4% while 4 were susceptibility to 57.1% of the antibiotics tested.

A chi-square test of independence was performed to examine the relationship between variables (age, sex, month of sampling) and the occurrence of *Mycobacterium tuberculosis, Streptococcus pneumoniae* or their co-infections. There was no significant association ($p>0.05$) between the variables analyzed and the occurrence of mono or co-infections.

Table 1. Occurrence of *Mycobacterium tuberculosis*, *Streptococcus pneumoniae* and their co-infections in relation to age and sex among patients attending tertiary health facilities in Makurdi, Nigeria.

Age (Years)	Number of samples analyzed		Number (%) positive for *M. tuberculosis*		χ^2,	***p-value***	Number (%) positive for *Streptococcus pneumoniae*		χ^2,	***p-value***	Number (%)positive for *M. tuberculosis* and *S. pneumoniae*		χ^2,	***p-value***
	Male	**Female**	**Male**	**Female**			**Male**	**Female**			**Male**	**Female**		
0-9	3	7	0(0.0)	0(0.0)	*4.20, 0.37*		0(0.0)	0(0.0)	3.1, 0.54		0(0.0)	0.0(0.0)	4.2, 1.33	
10-19	13	7	1(0.9)	0(0.0)			0(0.0)	0(0.0)			0(0.0)	0.0(0.0)		
20-29	14	31	2(1.8)	0(0.0)			1(0.9)	1(0.6)			1(0.9)	0.0(0.0)		
30-39	20	23	4(3.5)	2(1.3)			2(1.8)	2(1.3)			1(0.9)	1.0(0.6)		
40-49	15	28	2(1.8)	1(0.6)			1(0.9)	2(1.3)			0(0.0)	0.0(0.0)		
50-59	17	15	0(0.0)	0(0.0)			0(0.0)	2(1.3)			0(0.0)	0.0(0.0)		
60-69	13	22	1(0.9)	0(0.0)			0(0.0)	0(0.0)			0(0.0)	0.0(0.0)		
≥ 70	18	27	1(0.9)	0(0.0)			0(0.0)	0(0.0)			0(0.0)	0.0(0.0)		
TOTAL	113	160	11(0.00)	3(0.0)			4(0.04)	7(0.04)			2(0.02)	1(0.01)		

Table 2. Monthly occurrence of *Mycobacterium tuberculosis, Streptococcus pneumoniae* and their co-infections among patients attending tertiary health facilities in Makurdi, Nigeria.

Month/year	Number of Samples Analysed	Number (%)Positive for *M. tuberculosis*	χ^2	***p-*,value**	Number (%)Positive for *S. pneumoniae*	χ^2	***p-*,value**	Number (%)Positive for *M. tuberculosis and S. pneumoniae*	χ^2	***p-*,value**
July, 2019	126	9(7.1)	3.2,	0.20	2(1.6)	4.2,	1.33	0(0.0)	4.5,	0.10
Aug, 2019	109	5(1.6)			6(5.5)			3(2.8)		
Sept, 2019	38	0(0.0)			3(7.9)			0(0.0)		
Total	273	14(5.1)			11(4.0)			3(1.1)		

Table 3. Occurrence of rifampicin resistant *Mycobacterium tuberculosis* in relation to age and sex among patients attending tertiary health facilities in Makurdi, Nigeria.

Age (Years)	Number of samples analyzed		Number (%) of rifampicin resistant *M. tuberculosis*		χ^2	***p-value***
	Male	**Female**	**Male**	**Female**		
0-9	3	7	0 (0.0)	0(0.0)	2.7	0.59
10-19	13	7	0 (0.0)	0(0.0)		
20-29	14	31	0 (0.0)	0(0.0)		
30-39	20	23	0 (0.0)	0(0.0)		
40-49	15	28	1(0.9)	0(0.0)		
50-59	17	15	0 (0.0)	0(0.0)		
60-69	13	22	0 (0.0)	0(0.0)		
≥ 70	18	27	0 (0.0)	0(0.0)		
TOTAL	113	160	1(0.01)	0(0.0)		

Table 4. Antibiotic susceptibility profile of *Streptococcus pneumoniae* among patients attending tertiary health facilities in Makurdi, Nigeria.

Isolates	Zones of inhibition (mm) of the antibiotics used in the study							% Susceptibility of each Isolate
	AMX	AMC	CTX	TMP	CIP	ERY	VAN	
	SD = ≥21	SD = ≥25	SD = ≥20	SD = ≥18	SD = ≥21	SD = ≥23	SD = ≥28	
IS1	S (26)	S(27)	S(22)	S(20)	R (17)	S (24)	S(30)	85.7
IS2	S(25)	S(25)	S(21)	R(16)	S(22)	S(27)	S(31)	85.7
IS3	R(15)	S(28)	S(23)	R(12)	S(24)	S(26)	R(25)	57.1
IS4	S(28)	S(27)	S(22)	R(17)	R(19)	R(21)	S(28)	57.1
IS5	S(26)	S(29)	S(24)	S(21)	R(18)	S(25)	R(20)	71.4
IS6	R(20)	S(26)	S(21)	S(19)	S(22)	R(22)	R(27)	57.1
IS7	S(23)	S(27)	S(26)	R(16)	S(25)	S(24)	S(33)	85.7
IS8	S(22)	S(26)	S(24)	S(20)	S(24)	S(27)	R(26)	85.7
IS9	S(21)	S(30)	S(20)	R(17)	S(21)	S(28)	S(29)	85.7
IS10	R(19)	S(28)	S(23)	S(23)	R(20)	S(27)	R(13)	57.1
IS11	S (28)	S(27)	S(24)	R(14)	S(30)	S(26)	S(28)	85.7

AMX= Amoxycillin; AMX= Amoxicillin/clavulanic acid, CTX = Ceftriaxone, TMP = Trimethoprim, CIP = Ciprofloxacin, ERY = Erythromycin, VAN = Vancomycin, SD= Standard Diameter, IS=Isolate number.

Discussion

Streptococcus pneumoniae and *Mycobacterium tuberculosis* are major organisms implicated in co-infections, especially in immunosuppressed pulmonary patients. Tuberculosis is a leading cause of morbidity and mortality across the globe especially in developing countries including Nigeria [21]. *Streptococcus pneumoniae* is one of the most common etiologic agents of bacterial pneumonia accounting for about 60 % of pneumonia caused by bacteria in adults requiring hospitalisation [4, 13].

This study examined the co-infection status and resistance of *Mycobacterium tuberculosis* and *Streptococcus pneumoniae* among suspected patients with pulmonary infections attending tertiary health facilities in Makurdi. A percentage occurrence of 5.13% for *Mycobacterium tuberculosis* mono-infection, 4.03% *Streptococcus pneumoniae* mono-infection and 1.10% for *Mycobacterium tuberculosis* and *Streptococcus pneumonia* co-infections among 273 participants in the study was established.

The decrease in the percentage occurrence of mono-infection of *Mycobacterium tuberculosis* (5.13 %) is lower than the occurrence rate of (24.6%) and (21.5%) reported in previous studies [18]. This is probably due to the immunocompromised state of the HIV-infected individuals in the previous study. In addition, it may likely be a result of much awareness and the fact that the work was done in Makurdi, Nigeria; an urban area with a good ventilation system that reduces the rate of transmission. The occurrence rate of 1(1.10%) of Rifampicin resistance as observed in this study was lower compared to 2(3.8%) in previous studies [18]. The occurrence was also low due to awareness and free access to diagnosis and management of tuberculosis employing the Direct Observed Therapy method (DOT) through the support of non-governmental organizations and other supporting partners. The prevalence of *Streptococcus pneumoniae* from the research carried out indicated a low occurrence rate compared to other studies with a percentage occurrence of 6.4% reported by [13] and 8.8 % by [18] in previous studies. The pneumococcal bacteria are transmitted through inhalation and mostly during the harmattan season (a period of elevated temperatures and increased concentrations of airborne dust), which might account for the low occurrence rate since the work was done during the rainy season between June and September [22].

Furthermore, the occurrence of *Streptococcus pneumoniae* and *Mycobacterium tuberculosis* co-infections of (1.10 %) is lower than the occurrence rate of 2.7 % and 44.1% in previous research works [13]. This could also be due to the level of awareness and increasing access to diagnosis and management of the infections.

The antibiotic susceptibility pattern of the 11 isolates of *Streptococcus pneumoniae* that was isolated from the sputum of suspected pulmonary infection individuals reveals amoxicillin/clavulanic acid and ceftriaxone had 100% sensitivity while trimethoprim/sulphamethoxazole, 6 (54.55 %) had the lowest sensitivity followed by vancomycin 5 (45.45 %). This disagrees with the report by **Enitan et al.** [18] who reported that trimethoprim/sulphamethoxazole was the antibiotic with the most antibacterial activity on the *Streptococcus pneumoniae* isolates and was also *least* sensitive to amoxycillin. A pathogen can be described as resistant to the antimicrobial agent when the disease it is responsible for will not show any response to treatment when using a given drug, while a pathogen is described as susceptible or sensitive to a particular drug when the disease it causes responds to treatment with that drug [21]. Pneumococcal pneumonia dual infection with tuberculosis in a patient can result in the patient progressing from asymptomatic tuberculosis to symptomatic tuberculosis, especially if the pneumococcal pneumonia infection is undetected [12]. A causative agent of undetected co-infection could lead to resistance to antibiotics after it is exposed for too long to antibiotics that are used in the treatment of the other infection that was detected, although, occurring together [23]. This is seen in co-infections involving HIV and *Mycobacterium tuberculosis* [24]. Prolonged exposure to antibiotics is capable of causing the development of drug resistance in organisms [3]. Although the co-infection rate of *Streptococcus pneumoniae* and *Mycobacterium tuberculosis* is low, these pathogens are the major cause of morbidity and mortality, hence further work or research is needed to determine the preventive measures for *Streptococcus pneumoniae* and *Mycobacterium tuberculosis* infection in pulmonary patients.

Conclusion

This research work indicated *that Streptococcus pneumoniae* and *Mycobacterium tuberculosis* co-infection exist though the occurrence rate is low among pulmonary infection suspects with an occurrence rate of 1.10%. Considering the sensitivity pattern of each locality, the results of the present study showed different patterns from other areas in Nigeria. Therefore, early detection and proper management must be observed with serious public enlightenment efforts to eradicate the danger of co-infection among patients suspected of pulmonary infections.

Acknowledgement

We sincerely appreciate Benue State University Teaching Hospital for providing conducive laboratory space for the experimental work.

Conflict of interest

We declare that we have no conflict of interest.

Financial disclosures: nothing to declare.

References

1- **Chang AB, Chang CC, O'Grady K, Torzillo, PJ.** Lower respiratory tract infections. Pediatric Clinics North America Journal 2009; 56: 1303–1321.

2- **Stralin K.** Usefulness of aetiological tests for guiding antibiotic therapy in community-acquired pneumonia. International Journal Antimicrobial Agents 2008; 31: 3–11.

3- **Ihongbe J, Agwu F, Inyang, N.** Pneumococcal pneumonia complicates presentation of pulmonary tuberculosis and pseudomembranous candidiasis, predictive of unknown HIV infection in Ekpoma Nigeria. The Internet Journal of Microbiology 2007; 5(2): 67-70.

4- **Torres A, Cilloniz C, Niederman MS, Menéndez R, Chalmers JD, Wunderink RG, et al.** T. Pneumonia. Nat. Rev. Dis. Primers 2021; 7: 25.

5- **GBD.** Lower Respiratory Infections Collaborators. 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 2016. Lancet Infect. Dis 2018; 18: 1191–1210.

6- **GBD.** Diseases and Injuries Collaborators. Global burden of 369 diseases and injuries in 204 countries and territories, 1990-2019: A systematic analysis for the Global Burden of

Disease Study 2019. Lancet 2020. 396: 1204–1222.

7- **Alene KA, Wangdi K, Clements A.C.A.** Impact of the COVID-19 Pandemic on Tuberculosis Control: An Overview. Trop Med. Infect. Dis 2020; 5: 123.

8- **Migliori GB, Thong PM, Akkerman O, Alffenaar JW, Álvarez-Navascués F, Assao-Neino MM, et al.** Worldwide Effects of Coronavirus Disease Pandemic on Tuberculosis Services, January-April 2020. Emerg. Infect. Dis 2020; 26: 2709–2712.

9- **Nikolayevskyy V, Holicka Y, van Soolingen D, van der Werf MJ, Ködmön C, Surkova E, et al.** Impact of the COVID-19 pandemic on tuberculosis laboratory services in Europe. Eur. Respir. J 2021; 57: 2003890.

10- **Herffelfinger JD, Dowell SF, Jorgensen JH.** Management of community acquired pneumonia in the era of Pneumococcus resistance. Achieve infectious Medicine 2000; 160: 1399-1408.

11- **Anshum A, Uma M, Riyaz PM, Mantha S.** Tuberculosis coinfection: A case study. Lung of India 2015; 32 (2):172-174.

12- **Jolobe OMP.** Dual Infection In Tuberculosis With Pneumonia. International Journal of Medecine 2018; 111:349.

13- **Agwu E, Ohihion AA, Agba MI, Okogun, GRA, Okodua M, et al.** Incidence of Streptococcus pneumoniae. Infections among Patients Attending Tuberculosis Clinics in Ekpoma, Nigeria. Shiraz Electronic Medical Journal 2006; 7 (1): 13-15.

14- **Centers for Disease Control and Prevention, (CDC)**. Pneumococcal diseases: Symptoms and Complications. 2017. Available at: https://www.cdc.gov/pneumococcal/about/symptoms-complications.html. C:\Users\Sarah\Desktop\msc final\Streptococcus pneumoniae - Wikipedia.htm - cite_ref-22. Accessed May 14, 2022

15- **Centers for Disease Control and Prevention, (CDC).** Pneumococcal diseases. Symptoms and Complications. 2002. https://www.cdc.gov/pneumococcal/about/symptoms-complications.html. C:\Users\Sarah\Desktop\msc final\Streptococcus pneumoniae - Wikipedia.htm - cite_ref-22 Accessed May 14, 2022.

16- **World Health Organization (WHO).** Global Tuberculosis Control Report. Available at: https://www.iom.int/sites/g/files/tmzbdl486/files/documents/Global-TB-Report-2020.pdf. Accessed June 9, 2022.

17- **Raviglione MC.** Reichand Hershfield's Tuberculosis: A comprehensive international approach. (3rd Ed), New York, 2006: Information healthcare USA, Incorporation.

18- **Enitan S. Adekunbi O. Ihongbe J. Olumide A.** Prevalence of Streptococcus Pneumoniae and Mycobacterium tuberculosis co-infection among HIV infected Adult Patients on HAART in Ogun state, Nigeria. International Journal of Virology and AIDS 2019; 6:048.

19- **Cheesbrough M.** District Laboratory Practice in Tropical Countries. (2nd Edition), Cambridge University Press, Cambridge, UK, 2006.

20- **Clinical and laboratory standard institute (CLSI).** Performance standard for antimicrobial susceptibility test: sixteenth information supplement. Clinical Laboratory Standard Institute Document M100-S16, 2017. (ISBN 1-56238-588-7) Wayne, PA: CLSI.

21- **World Health Organization (WHO).** Global Tuberculosis Control Report. World Health Organization. 2011. Available at:

http://apps.who.int/iris/hande/10665/44728 Vii. Pg 246. ISBN 9789241564380.

22-Jusot JF, Neill DR, Waters EM, Bangert M, Collins M, Bricio Moreno L, et al. Airborne dust and high temperatures are risk factors for invasive bacterial disease. J Allergy Clin Immunol 2017;139(3):977-986.

23-Ruthie B., **Birger R.D., Kouyos J. E**. The potential impact of coinfection on antimicrobial chemotherapy and drug resistance. Trends in Microbiology 2015, 23(11):742.

24-Pawlowski A, Marianne J, Markus S, Martin ER. Tuberculosis and HIV coinfection. Plos Pathogen 2012;e1002464.

Isaac AM, Nfongeh JF, Agabi YA, Uneze S, Abba PO, Danjuma E, Udeogu KE, Cosmas NT, Anejo-Okopi JA, Mawak JD. Co-infections and antimicrobial resistance profile of *Mycobacterium tuberculosis* and *Streptococcus pneumoniae* among patients with pulmonary infections attending tertiary health facilities in Makurdi, Nigeria Microbes Infect Dis 2023; 4(2): 497-505.