



# PREVALENCE AND ANTIBIOTIC SUSCEPTIBILITY OF *S.pneumoniae* AMONG INPATIENTS IN A TERTIARY HOSPITAL IN JALINGO, TARABA STATE

MODESTA IFEOMA MBAH AND CHUKWUEMEKA SAMUEL ODO

Email: [mdduruoha@gmail.com](mailto:mdduruoha@gmail.com)

(Received 3 May 2025; Revision Accepted 27 June 2025)

## ABSTRACT

**Background & Objectives:** *Streptococcus pneumoniae* is a major cause of morbidity and mortality worldwide and poses a heavy burden on the society. This study assessed the prevalence of *Streptococcus pneumoniae* among inpatients in Specialist Hospital Jalingo, Taraba State as well as the antibiotic susceptibility of the isolates.

**Materials and Methods:** Standard procedures were followed in the collection of 106 specimens (sputum, nasal, throat and wound swabs,) from inpatients who had stayed a minimum of 72 hours on admission in the male and female wards of Taraba State Specialist hospital Jalingo, Taraba State. Following the same line. *S. pneumoniae* isolates were identified based on their characteristic alpha haemolysis on blood agar and sensitivity to optochin and bile solubility. Also, antibiotic susceptibility test was performed by Kirby Bauer disk diffusion method for all isolates

**Results:** The prevalence of *S. pneumoniae* among the inpatients was 33.3% while that of males and female were respectively 29.1% and 31.4% ( $p=0.798$ ). However, the prevalence obtained from the sputum, nasal, throat and wound swabs were respectively 51.4%, 7.1%, 34.3% and 4.5% ( $p$  value=0.000). Meanwhile, the prevalence obtained from the age groups: 1-10, 11-20, 21-45, 46-60, 61-75, and >75 years were respectively 58.3%, 14.3%, 19.1%, 18.2%, 54.5% and 54.5% ( $p=0.007$ ). Nevertheless, High resistance was recorded with Amoxicillin (93.8%), Imipenem (85.7%) and Gentamycin (75%) while low resistance was observed with Erythromycin (8.7%), Ciprofloxacin (11.1%) and Azithromycin (18.2%).

**Conclusion:** There was a significant difference in the prevalence of *S.pneumoniae* among inpatients of various ages as well as among specimens used in the detection. The specimen influenced the prevalence in both male and female. However, the influence due to the specimen was only among those aged 21-45. On the other hand, the prevalence of *S.pneumoniae* among females was not influenced by age whereas among males it was. Nevertheless, multidrug resistance strains were also obtained.

**KEYWORDS:** Age, Gender, Prevalence, Specimen, *Streptococcus pneumoniae*

## INTRODUCTION

*Streptococcus pneumoniae* is a major cause of morbidity and mortality worldwide (Subramanian *et al.*, 2019). It is one of the normal flora of the upper respiratory tract of humans but the major cause of respiratory infections among the children and the elderly (Sempere *et al.*, 2020). Almost 40%-50% healthy children and 20%-30% of healthy adults are carriers Pre- antibiotics era (Dion *et al.*, 2023), *S. pneumoniae* was estimated to be the cause of 95% of all cases of pneumonia.

Currently, however, *S. pneumoniae* accounts for up to 15% of pneumonia cases in the United States and 27% of cases worldwide (Dion and Ashurst, 2023). In the South East of Nigeria, precisely Abia State, Nwankwo *et al.* (2021) reported that a total of thirty-three (33) *Streptococcus pneumoniae* isolates were recovered from sixty (60) sputum samples from pneumonia patients. In Ogun state, South West Nigeria, 8.8% prevalence was obtained (Samson *et al.*, 2019). However, 29.2% prevalence was reported in North Central Nigeria.

Modesta Ifeoma Mbah, Taraba State University, Jalingo

Chukwuemeka Samuel Odo, Taraba State University, Jalingo

In a state in North East Nigeria (Gombe) the prevalence of 11.7% was recorded among children 3-24 months while 22.6% was obtained in a study conducted in Bauchi, North East Nigeria, among children 0-5 years (Ali *et al.*, 2023). There is limited data on the prevalence of *S. pneumoniae* in Maiduguri, Yobe and Taraba states (all in North East Nigeria). Hence, the need for this study in Jalingo, Taraba State.

Pneumococci are spread via direct contact with secretions from carriers, via saliva, or inhaled via an aerosol, where they colonize the nasopharynx (Hyams *et al.*, 2010). Infection hardly occurs unless a patient has predisposing risk factors, a bolus of infectious cells, or colonization with a particularly virulent strain of *S. pneumoniae* (Dion *et al.*, 2023). Other risk factors include hospitalization, jails and overcrowded rooms, age, cigarette smoking and respiratory tract infections (Butler *et al.*, 2010; Dion *et al.*, 2023). Good nutrition and environmental factors and none attendance of Day Care decrease the spread of the disease. People at risk include the elderly (more than 65 years old), children younger than two years, people with underlying lung disease, alcoholics with chronic kidney and liver diseases (Dion *et al.*, 2023). Aside pneumonia, it (*S. pneumoniae*) can cause diseases such as conjunctivitis, otitis media sinusitis acute exacerbations of chronic bronchitis, meningitis, cardiac infections (eg endocarditis) (Iyer, 2025).

Some of the studies on the prevalence of *S. pneumoniae* revealed thus: According to Nwankwo *et al.*, 2021, a total of thirty-three (33) *Streptococcus pneumoniae* isolates were recovered from sixty (60) sputum samples from pneumonia patients' in a hospital in Abia state Nigeria. Meanwhile, Ali *et al.*, 2023, reported a prevalence of 22.0% among under five years old children in Toro General hospital Bauchi State Nigeria.

Nevertheless, there is paucity of data on the prevalence of *S. pneumoniae* among inpatients. Therefore, this study is to bridge the gap by studying the prevalence and antibiotic susceptibility of *S. pneumoniae* among inpatients in a tertiary hospital in Jalingo.

## METHODOLOGY

This was a hospital based study involving inpatients that were hospitalised for a minimum of 72 hours. Following the ethical clearance from Taraba state specialist hospital, oral informed consent of the patients was obtained thereafter, specimens were collected.

**Sample Collection:** Patients were given sterile wide mouthed jars to collect the sputum. Instructions were given to them on how to collect it. The nasal and wound swabs were collected using a standard rotating technique with the help of a premoistened sterile cotton swab while the throat swab was collected by instructing the patient to open the mouth wide and sticking the tongue out as the swab was rubbed several times across the back of the throat behind the arch. Contact with the tonsils were ensured while contact with the tongue and cheeks were avoided. All swabs were immediately inserted into different sample bottles and taken to the Lab which is in the hospital.

**Culturing of Specimen and Identification of *S.pneumoniae*:** Specimen were cultured on blood and chocolate agar plates and incubated in carbondioxide enriched atmosphere at 37° C for 24 hours.. Presumptive identification of *S.pneumoniae* was done using colony morphology, Gram staining, biochemical tests and the alpha haemolytic characteristics. Also done were the Optochin sensitivity and bile solubility tests. The antimicrobial susceptibility test was done following standard procedure while using the Kirby-Bauer disc diffusion method. The antibiotic discs used were obtained from the

OPTUN Laboratories Nigeria Limited and are as follows: Rocephin(25mg), Peflacin(30µg), Streptomycin(30µg), Amoxacillin(30µg), Ceftriaxone(30µg), Ofloxacin(10µg), Imipenem(10µg), Cefuroxime(30µg), Azithromycin(12µg), Augmentin(30µg), Erythromycin(10µg) and Gentamycin(10µg). The demographic characteristics were obtained through interview.

**Statistical Analysis:** IBM Statistical package for Social Science version 25 was utilized for statistical analysis; descriptive statistics (frequency and percentage) was used while inferential statistics (Chi square test) was used to determine the association that existed among the variables at alpha level 0.05.

## RESULTS

The highest prevalence of *S.pneumoniae* was obtained among the age group 1-10 years old, closely followed by the age groups 65-75 and >75 years old while the least was obtained from the age group 11-20 years old. However, the prevalence among the age group 1-10 years old was 58.3% and 61-75 and >75 years old were separately 54.5% while the least was among the age group 11-20 years old ( $p=0.007$ ). However, the prevalence was higher among females compared to males. It was 31.4% and 29.1% ( $p=0.798$ ). Meanwhile, the prevalence obtained from sputums was the highest and least from the wounds. However, it was 51.4% and 4.5% ( $p<0.001$ ) respectively from sputums and wounds as presented in Table 1 below.

**Table 1:** Prevalence of *S.pneumoniae* among inpatients in Specialist Hospital, Jalingo

Characteristics	Categories	Presence of <i>Streptococcus pneumoniae</i>		P value
		No	Yes	
Age	1-10	5(46.7%)	7(58.3%)	0.007
	11-20	12(85.7%)	2(14.3%)	
	21-45	38(86.9%)	9(19.1%)	
	46-60	9(81.8%)	2(18.2%)	
	61-75	5(45.5%)	6(54.5%)	
	> 75	5(45.5%)	6(54.5%)	
Gender	Female	35(68.6%)	16(31.4%)	0.798
	Male	39(70.9%)	16(29.1%)	
Specimen	Nasal	13(92.9%)	1(7.1%)	0.001
	Sputum	17(48.6%)	18(51.4%)	
	Throat	23(65.7%)	12(34.3%)	
	Wound	21(95.5%)	1(4.5%)	

The prevalence of *S.pneumoniae* obtained from the Nasal, throat, wound swabs and sputum was only significant among the age group 21-45 years old ( $p=0.012$ ). However, *S.pneumoniae* was obtained mainly from the sputums and throat swabs. Though, it

was obtained only from the nasal swabs of patients aged 61-75 years old (25%), among patients older than 75 years old, it was obtained from the wounds as presented in Table 2 below.

**Table 2:** Prevalence of *S.pneumoniae* in the body Sites of Inpatients of Various ages in Specialist Hospital, Jalingo

AGE	SPECIMEN	PRESENCE OF <i>Streptococcus pneumoniae</i>		pvalue
		No	Yes	
1-10	Sputum	1(16.7%)	5(83.3%)	0.079
	Throat Swab	4(66.7%)	2(33.3%)	
11-20	Nasal Swab	3(100%)	0.00	0.405
	Sputum	1(50%)	1(50%)	
	Throat Swab	6(85.7%)	1(14.3%)	
	Wound Swab	2(100%)	0.00	
21-45	Nasal Swab	3(100%)	0.000	0.012
	Sputum	9(56.3%)	7(43.5%)	
	Throat Swab	9(81.8%)	2(18.2%)	
	Wound Swab	17(100%)	0.000	
46-60	Nasal Swab	4(100%)	0.000	0.233
	Sputum	1(100%)	0.000	
	Throat Swab	2(50%)	2(50%)	
	Wound Swab	2(100%)	0.000	
61-75	Nasal Swab	3(75%)	1(25%)	0.255
	Sputum	1(20%)	4(80%)	
	Throat Swab	1(50%)	1(50%)	
>75	Sputum	4(80%)	1(20%)	0.103
	Throat Swab	1(20%)	4(80%)	
	Wound Swab	0.000	1(100%)	
Total	Nasal Swab	13(92.8%)	1(7.1%)	0.000
	Sputum	17(48.6%)	18(51.4%)	
	Throat Swab	23(65.7%)	12(34.3%)	
	Wound Swab	21(95.5%)	1(4.5%)	

Among the female patients, the prevalence of *S.pneumoniae* obtained from the sputum was higher

than the throat swab. It was 52.6% and 33.3% ( $p=0.015$ ) respectively from the sputum and

throat swabs.No *S.pneumoniae* was isolated from the nasal and wound swabs.However,among the male patients,the highest prevalence was obtained from the

sputum and the least from wound swabs.It was 50% and 7.7%(p=0.046) respectively from the sputum and wound swabs as presented in Table 3 below.

**Table 3:** Prevalence of *Streptococcus pneumoniae* in the Body Sites of Male and Female Inpatients in Specialist Hospital, Jalingo

SEX	SPECIMEN	PRESENCE OF <i>S.pneumoniae</i>		pvalue
		NEGATIVE	POSITIVE	
FEMALE	Nasal swab	5(100%)	0.000	0.015
	Sputum	9(47.4%)	10(52.6%)	
	Throat	12(66.7%)	6(33.3%)	
	Wound swab	9(100%)	0.000	
MALE	Nasal Swab	8(88.7%)	1(11.1%)	0.046
	Sputum	8(50%)	8(50%)	
	Throat Swab	11(64.7%)	6(35.3%)	
	Wound Swab	12(92.3%)	1(7.7%)	
TOTAL	Nasal swab	13(92.9%)	1(7.1%)	0.000
	Sputum	17(48.6%)	18(51.4%)	
	Throat swab	23(65.7%)	12(34.3%)	
	Wound swab	21(95.5%)	1(4.5%)	

The highest prevalence of *S.pneumoniae* obtained among female patients was from the age group 61-75 years,closely followed by the age >75 years old and the least was obtained from the age 46-60 years old.The prevalences were respectively 80%,66.7% and 16.7% from those aged 61-75,>75 and 46-60

years old(P=0.073).However, among the males ,the highest and least prevalences were obtained from patients aged 1-10 years old and 21-45 years old and they are respectively 80% and 19%(p=0.042) as presented in Table 4 below.

**Table 4:** Prevalence of *S.pneumoniae* among Male and Female Inpatients of Various ages

SEX	AGE	PRESENCE OF <i>S.pneumoniae</i>		PVALUE
		NO	YES	
FEMALE	1-10	4(57.1%)	3(42.9%)	0.073
	11-20	7(77.8%)	2(22.2%)	
	21-45	17(81%)	4(19.0%)	
	46-60	5(83.3%)	1(16.7%)	
	61-75	1(20%)	4(80%)	
	>75	1(33.3%)	2(66.7%)	
MALE	1-10	1(20%)	4(80%)	0.042
	11-20	5(100%)	0.000	
	21-45	21(80.8%)	5(19.2%)	
	46-60	4(80%)	1(20%)	
	61-75	4(66.7%)	2(33.3%)	
	>75	4(50%)	4(50%)	

TOTAL	1-10	5(44.7%)	7(58.3%)	0.007
	11-20	12(85.7%)	2(14.3%)	
	21-45	38(80.9%)	9(18.1%)	
	46-60	9(31.8%)	2(18.2%)	
	61-75	5(45.5%)	6(54.5%)	

High resistance was obtained in Amoxacillin(93.8%) Imipenem (85.7%) Gentamycin while low resistance was obtained in Azythromycin(18.2%), Erythromycin (8.7%) and Ciprofloxacin(11.1%) as presented in Table 5 below.

## PREVALENCE AND ANTIBIOTIC SUSCEPTIBILITY OF *S.pneumoniae* AMONG INPATIENTS IN A TERTIARY HOSPITAL

819

**Table 5:** The antimicrobial Profile of *S.pneumoniae* Isolated from Inpatients in Specialist Hospital, Jalingo.

ANTIMICROBIALs	RESISTANCE	SENSITIVE
Rocephin(25mg)	4(36.4%)	7(63.6%)
Peflacine(30µg)	8(53.3%)	7(46.7%)
Ciprofloxacin(10µg)	4(11.1%)	32(88.9%)
Streptomycin(30 µg)	7(53.8%)	6(46.2%)
Amoxacillin(30µg)	15(93.8%)	1(6.3%)
Cefriaxone(30 µg)	4(33.3%)	8(66.7%)
Ofloxacin(10 µg)	3(18.8%)	13(81.3%)
Imipenem(10 µg)	12(85.7%)	2(14.3%)
Cefuroxime(30 µg)	5(55.6%)	4(44.4%)
Azythromycin(12µg))	2(18.2%)	9(81.8%)
Augmentin(30µg)	9(56.3%)	7(43.8%)
Erythromycin(10µg)	2(8.7%)	21(91.3%)
Gentamycin(10µg))	12(75%)	4(25%)

## DISCUSSIONS

The highest (58.3%) prevalence of *S.pneumoniae* was obtained among those aged 1-10 years old. This was closely followed by the elderly (aged 61-65 and ≥ 75 years old) (54.5%) while the least (14.3%) was among those aged 11-20 years old (Table 1). The higher prevalence obtained among the elderly and children could be because of lowered immune states of these groups. This observation agrees with the report by Kim *et al.*, (2021). It also agrees with Butler (2010), Dion and Ashurst, (2023) and Nwankwo *et al.*, 2021. that age influences the prevalence of *S.pneumoniae*.

Though not significant, the prevalence of *S.pneumoniae* was higher among females compared to the males (Table 1) and this could be because most women are caregivers to both the elderly and children who are highly susceptible to *S.pneumoniae*. This study agrees with the report of Mekuria *et al.*, (2022) and Samson *et al.*, (2019) that women have higher prevalence of *S.pneumoniae* compared to men. Ali *et al.*, (2023) did not record any significant difference in the prevalence of *S.pneumoniae* based on gender. Nevertheless, a contrary report was given by Nwankwo *et al.*, (2021)-that the prevalence of *S.pneumoniae* was higher among males who had pneumonia compared to their female counterpart. The difference in the observations of the two studies could

be because Nwankwo *et al.*, (2021) limited his studies to only the patients that had pneumoniae and it was not clear whether all the patients they attended to were outpatients or a mix of both out and inpatients., Ali *et al.*, (2023) reported a higher prevalence among males than females less than five years old. The highest prevalence(51.4%) of *S.pneumoniae* was obtained from sputum while the least(7.1%) was from the nasal swabs. That the specimen used for the detection of *S.pneumoniae* is of utmost paramount in the isolation of *S.pneumoniae*, according to this study buttresses earlier reports by Aljicevic *et al.*, (2015) and Kim *et al.*, (2021).

However, the prevalence of the *S.pneumoniae* obtained from throat swab was the highest among the elderly, older than 75 years (Table 2) which is because of their reduced immune state and probably other physiological changes. The observation is also in congruence with the report of Sempere *et al.*, (2020) and Nwankwo *et al.*, (2021).

The prevalence of *S.pneumoniae* obtained from sputum was higher than that obtained from throat swab among the patients aged 1-10. Though the difference was insignificant. The study agrees with a study by Kim *et al.*, (2021). Also among the age group 11-20 and 21-25, it was noticed that the prevalence of *S.pneumoniae* obtained from sputum was higher compared to throat swab. The occurrence of *S.pneumoniae* in wound was a rare occurrence having

being obtained only from one patient, who was older than 75 years (Table 2). The rare occurrence of *S.pneumoniae* in wounds was also reported by Néhémie *et al.*, (2020). Also observed was that the prevalence of *S.pneumoniae* obtained from sputum was the highest among children aged 1-10 and adults 61-75.

The prevalence of *S.pneumoniae* obtained from sputum was slightly higher among females compared to males whereas the prevalence obtained from throat swab was slightly higher among males compared to the females (Table 3). However, among the females and males, the prevalence of *S.pneumoniae* obtained from the sputum was the highest (Table 3). To the best of the knowledge of the authors there was no earlier report where the prevalence of *S.pneumoniae* among male and female inpatients were compared based on the specimen used in the detection of the bacteria.

Age is a significant factor in infection by *S.pneumoniae*.

obtained in this study. This study agrees with Lyu *et al.*, (2024) that *S.pneumoniae* had a high resistant to Imipenem (65.7%). Both this study and Lyu *et al.*, (2024) reported high sensitivity to erythromycin-100% and 91.3% respectively. However, Halala *et al.* (2022) reported 83% sensitivity to Erythromycin. However, Samson *et al.*, (2019) reported 69.5% sensitivity. The differences in the antibiotic sensitivities observed by different authors could have stemmed from the strains prevalent in the region, patients' abuse and misuse of the antibiotics and the availability of the antibiotics to patients. Also, patients' demographics could also be a factor.

### Limitation of the Study

This study did not relate the period of hospitalisation to the prevalence of *S.pneumoniae*.

Female patients 1-10 years old and the elderly (61-75 as well as 75 years old and above) had the highest prevalence of *S.pneumoniae*. Also, among the males, the prevalence of *S.pneumoniae* was highest among Patients aged 1-10 years old and those aged 75 years and above (Table 4). This study buttresses earlier report by Sempere *et al.*, (2020) that age influences the prevalence of *S.pneumoniae*. The prevalence of *S.pneumoniae* followed the same pattern as in males and females: being highest among children aged 1-10 and adults 61 and above (Table 4 and 1) which also agrees with the report by Nwankwo *et al.*, (2021). Nevertheless, there was no study with which to compare the influence of the prevalence of *S.pneumoniae* among males and females based on their ages (to the best of the knowledge of the authors).

From this study, some of the isolates of *S.pneumoniae* were antibiotic resistant. Some of the isolates were highly resistant to some antibiotics such as amoxicillin (93.8%), Imipenem (85.7%) and Gentamycin (75%) and moderately resistant to Peflaxine (53.3%), Streptomycin (53.8%), Cefuroxime (55.6%) and Augmentin (56.3%). This is because some of these drugs especially amoxicillin and gentamycin are more or less 'over the counter drugs', very cheap and widely available. This makes most patients to abuse the drugs which lead to antibiotic resistance. Low resistance was observed in Ciprofloxacin (11.1%), Ofloxacin (18.8%) and Azithromycin (18.2%). Other studies that reported resistance/sensitivity to these antibiotics include: High Sensitivity to Streptomycin was reported by Nwankwo *et al.*, (2021) against the moderate sensitivity obtained in this study. A high resistance to Gentamycin was also reported by Nwankwo *et al.*, (2021) in agreement to that which was obtained in this study. Though Samson *et al.*, (2019) reported a high sensitivity (73.9%) to Gentamycin. He also reported moderate sensitivity to amoxicillin (56.5%) against low sensitivity (6.2%)

### CONCLUSIONS

The prevalence of *S.pneumoniae* is subject to the specimen used for its isolation. Though it is rarely obtained from wounds. It is most likely to be isolated from the sputum compared to the nasal and the throat swabs. Also, age is also a significant factor in the prevalence of *S.pneumoniae* among patients with children younger than ten and the elderly older than 65 being the most susceptible.

### RECOMMENDATIONS

It is recommended that the control of *S.pneumoniae* among inpatients should be by the enlightenment "on the best way to prevent the spread of the pathogen especially through the sputum and mouth" tailored mainly towards children 1-10 and adults 65 years and above. To obtain the best result in trying to detect the pathogen, much attention should be given to the type of specimen used.

**Conflict of Interest:** The authors declare no conflict of Interest

### REFERENCES

- Ali, M., Okojoku, O., Adiekwu, R. and Robinson, J., 2023, Prevalence and serotypes of Streptococcus pneumoniae among under five children attending Toro general hospital, Bauchi State, Nigeria. *Microbes and Infectious Diseases*. 4(2), 468-476. doi: 10.21608/mid.2022.133445.1302
- Aljicevic, M., Karcic, E., Bektas, S. and Karcic, B. 2015. Representation of Streptococcus Pneumoniae in Outpatient Population of Sarajevo Canton. *Journal of the Academy of Medical Sciences in Bosnia and Herzegovina*. 10;69(3):177-180. doi: 10.5455/medarh.2015.69.177-180. PMID: 26261387

- Butler, S.G., Stuart, A., Leng, X., Rees, C., Williamson, J., and Kritchevsky, S.B. 2010. Factors influencing aspiration during swallowing in healthy older adults. *The Laryngoscope* .120(11):2147–2152. doi: 10.1002/lary.21116. [DOI] [PMC free article] [PubMed] [Google Scholar]
- Dion, C.F., John, V. and Ashurst, J.V., 2023, Streptococcus pneumoniae. Cited on August 8, 2023 from <https://www.ncbi.nlm.nih.gov/books/NBK470537/>
- Halala, K.B., Ali, M.M. and Ormago, M.D., 2022, 10.1016/j.bjid.2024.103734. Epub 2024 Mar 10. PMID: 38471654; PMCID: PMC11004498.
- Mekuria, S., Seyoum, A., Ataro, Z., Abebe, T. and Urgessa, K. 2022, Prevalence, Antimicrobial Resistance, and Associated Factors of Streptococcus pneumoniae Colonization Rate among Old-Age Patients with Respiratory Tract Infection Attending Sheikh Hassan Yebere Referral and Karamara General Hospitals, Jijiga, Ethiopia. *Can J Infect Dis Med Microbiol.* 9338251. doi: 10.1155/2022/9338251. PMID: 36193092; PMCID: PMC9525751.
- PREVALENCE AND ANTIBIOTIC SUSCEPTIBILITY OF *S.pneumoniae* AMONG INPATIENTS IN A TERTIARY HOSPITAL** 821
- Prevalence and Multi-Drug Resistance of Streptococcus pneumoniae Infection Among Presumptive Tuberculosis Adult Cases at Dilla University Referral Hospital, Dilla, Ethiopia. *Infect Drug Resist.* 15:5183-5191 <https://doi.org/10.2147/IDR.S375343> <https://www.pharmaceutical-technology.com/data-insights/streptococcal-pneumonia-drugs-in-development/?cf-view&cf-closed>.
- Hyams, C., Camberlein, E., Cohen, J. M., Bax, K. and Brown, J.S., 2010, The Streptococcus pneumoniae capsule inhibits complement activity and neutrophil phagocytosis by multiple mechanisms. *Infection and Immunity*. 78(2):704–715. doi: 10.1128/iai.00881-09. DOI: PMC
- Iyer, U., 2025 Pneumococcal Infections (Streptococcus pneumoniae). Cited in 2025 from <https://emedicine.medscape.com/article/225811-overview>.
- Kim, J.S., Jung, B.K., Kim, J.W. and Kim, G.Y., 2021, Prevalence and Antimicrobial Susceptibility of Streptococcus pneumoniae Isolated from Clinical Samples in the Past 8 Years in Korea. *Biomed Res Int.* 6615334. doi: 10.1155/2021/6615334. PMID: 33997025; PMCID: PMC8099532.
- Lyu, S., Shi, W, Dong, F., Xu, B.P., Liu, G., Wang, Q., Yao, K.H. and Yang, Y.H., 2024 Serotype distribution and antimicrobial resistance of pediatric Streptococcus pneumoniae isolated from inpatients and outpatients at Beijing Children's Hospital. *Braz J Infect Dis.* ;28(2):103734. doi: 10.1155/2022/9338251. PMID: 36193092; PMCID: PMC9525751.
- Maaloum, F., Kabura, S., Zaki, B., Farid, C., Belabbes, H. and Elmdaghri, N., 2020, Surgical wound infection caused by a multi drug resistant Streptococcus pneumoniae Serotype 19A after a total colectomy with ileostomy. *Pan Afr Med J.* 6;35:97. doi: 10.11604/pamj.2020.35.97.19128. PMID: 32636995; PMCID: PMC7320775.
- Nwankwo, I. U., Edward, K. C., Nwoba, C. N. and Ike, M.O., 2021, Prevalence of Streptococcus pneumoniae in Pneumonia Patients that Attend Madonna Catholic Hospital Umuahia, Abia State, Nigeria *South Asian Journal of Research in Microbiology.* 9 (4): 35-43. DOI: 10.9734/sajrm/2021/v9i430216
- Ogoko, N.I., Adabara, N., Shittu, O. and Kuta, F. 2024 Prevalence and Antibiotic Resistance Profile of Streptococcus pneumoniae isolated from Patients attending Selected Federal Hospitals in Parts of North Central Nigeria. *International Journal of Applied biology (IJBAR)* vol 15(1) :43-60
- Samson, E.S., Ajike, A.O., Cletus, I.J., and Olumide, A. O., 2019, 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.* 6(1): DOI: 10.23937/2469-567X/1510048. ISSN: 2469-567X
- Sempere, J., de Miguel, S., González-Camacho, F., Yuste, J. and Domenech, M., 2020, Clinical relevance and molecular pathogenesis of the emerging serotypes 22F and 33F of

*Streptococcus pneumoniae* in Spain.  
Frontiers in Microbiology .11(309) doi:  
10.3389/fmicb.2020.00309.

Subramanian, K., Henriques-Normark, B. and  
Normark, S.,2019, Emerging concepts in the

pathogenesis of the *Streptococcus pneumoniae*: From nasopharyngeal colonizer to intracellular pathogen. Cell Microbiol.. 21(11):e13077. doi: 10.1111/cmi.13077. Epub 2019 Jul 17. PMID: 31251447; PMCID: PMC6899785.