Research Article | Nepal Journal of Health Sciences
Submitted: 04/06/2025
Accepted: 05/07/2025
Published: 07/11/2025

Emerging Antibiotic Resistance in Streptococcus Pneumonia and Haemophilus Influenzae in Paediatric Pneumonia

Md. Ashfaque Ansari,[1] Anand Kumar Jha,[1] Ravi Shankar Gupta,[2] Tapeshwar Yadav[3]

[1] *Department of Pediatrics, National Medical College and Teaching Hospital, Birgunj, Nepal;*
[1] *Department of Microbiology, National Medical College and Teaching Hospital, Birgunj, Nepal;*
[3] *Department of Laboratory Medicine, Madan Bhandari Academy of Health Sciences, Hetauda, Nepal.*

https://doi.org/10.3126/njhs.v5i1.86081

ABSTRACT

Introduction: Pneumonia is the leading cause of death in children under five, primarily caused by Streptococcus pneumonia and Haemophilus Influenza. The emerging antibiotic resistance observed in the commonly occurring pathogens is a major challenge compromising the treatment procedure.

Objective: To determine the prevalence and evaluate the antibiotic susceptibility patterns of *S. pneumoniae* and *H. influenzae* isolated from paediatric pneumonia patients.

Methods: This was a hospital and lab-based prospective observational study conducted from 29th March 2024 to 28th March 2025 at National Medical College Teaching Hospital. A total of 150 children under the age of 15 with confirmed presence of S. pneumoniae or H. influenza in blood or sputum culture are included in the study. Data were entered and analyzed in Microsoft Excel 2016 and SPSS version 27. Descriptive findings were presented in table including frequency, percentage, mean and standard deviation.

Results: The high resistance rates to commonly used antibiotics such as ceftriaxone and ampicillin, particularly among S. pneumoniae (63% resistance to ceftriaxone) and H. influenzae (55% resistance to ampicillin), are alarming. The Minimum Inhibitory Concentration -based susceptibility testing shows the ceftriaxone crossing the resistant breakpoint, indicating true resistance and not just tolerance. Similarly, elevated Minimum Inhibitory Concentrationin azithromycin and ampicillin-resistant strains indicate emerging resistance trends in pediatric pneumonia pathogens, especially against commonly used beta-lactam and macrolide antibiotics. The need for regular local antibiogram updates and reconsideration of empirical therapy guidelines is evident.

Conclusions: The findings underline the urgent need to reconsider current empirical treatment protocols and promote rational antibiotic use in clinical settings.

Keywords: Bacterial pneumonia; paediatric; pathogens; antibiotic resistance; susceptibility test.

INTRODUCTION

Pneumonia remains the leading cause of death among children under 5 years of age globally.[1] Among the bacterial causes, Streptococcus pneumonia and Haemophilus Influenza are the most common pathogens responsible for paediatric pneumonia.[2]

Correspondence
Md. Ashfaque Ansari
Email: drashfaqmd@gmail.com

Citation
Ansar Md A, Jha AK, Gupta RS, Yadav T. Emerging Antibiotic Resistance in Streptococcus Pneumonia and Haemophilus Influenzae in Paediatric Pneumonia. Nepal J Health Sci. 2025 Jan-June;5(1): 11-16.

Despite the introduction of vaccines and standardized preventive measures, these organisms continue to pose a significant threat to child health. In recent years, the management of community-acquired pneumonia (CAP) in children has become more challenging due to the increasing emergence of antibiotic resistance in these pathogens. Resistance to commonly used antibiotics such as penicillin and amoxicillin is increasingly reported, compromising treatment effectiveness.[3,7]

Antibiotic resistance occurs when bacteria adapt to withstand the effects of drugs designed to kill them.[4,5] This problem is largely driven by the overuse and misuse of antibiotics, particularly in paediatric cases where empirical antibiotic therapy is frequently used .[6]

The World Health Organization has recognized pneumococcus as a major pathogen of global concern due to its resistance patterns.[8] Early detection of severe pneumonia and appropriate antibiotic selection are essential in improving outcomes.[9,10]

This study aims to evaluate the antibiotic resistance patterns of *S.* pneumoniae and *H.* influenzae in paediatric pneumonia, assess their susceptibility profiles, and provide data to guide more effective treatment strategies.

METHODS

This study was a hospital and lab-based prospective observational research study that was completed in one year. This study was conducted in the Department of Paediatrics and Microbiology at National Medical College Teaching Hospital, Birgunj, Nepal. Study spanned from 29th March 2024 to 28th March 2025. 150 patients' data were collected for the study,

showing clinical manifestations under the inclusive criteria of positive bacterial culture of S. pneumoniae or H. influenza.

Study population consists of paediatric patients under 15 years old admitted to the pediatric ward and intensive care unit with medical and laboratory diagnosis confirming the presence of S. pneumoniae or H. influenzae in blood or sputum culture. Children presenting with clinical signs and symptoms of pneumonia, and with confirmed S. pneumoniae or H. influenzae in blood or sputum culture, were included in the study. Patients with the presence of mixed infections, i.e., TB, fungal, and COVID-19 without a positive bacterial culture despite strong clinical suspicion of pneumonia were excluded from the study.

Antibiotic susceptibility testing was carried out using the Minimum Inhibitory Concentration (MIC) estimation, interpreted according to Clinical and Laboratory Standards Institute (CLSI) guidelines. The MIC is the lowest or minimum antimicrobial concentration inhibiting visible microbial growth in artificial media after a fixed incubation time.[15]

Data collection was performed with the record of all the required variables in the study populations. The variables include demographic data (age, sex, vaccination), clinical presentation (fever, chest wheezing, shortness of breath, cough), physical examination (chest pain, wheezing lung sound), laboratory findings (complete blood count, antibiotic sensitivity test) diagnostic procedures (chest X-rays, bacteria/sputum culture), treatment regimen (antibiotic used) and antibiotic resistance.

The study was formally approved by the Institute Ethics Committee on 27th March 2024, Ref. F-NMC/685/080-081, and the research was performed according to the committee's ethical standards. The informant (patient and patient party) gave informed oral and written consent as per the protocol of the study method. The patient's confidentiality was strictly maintained for the study purposes.

Data were entered and analyzed in Microsoft Excel 2016 and SPSS version 27. Data on history, antibiotic use, and resistance were entered, and the frequency of patients was calculated. Descriptive statistical analysis was performed in terms of frequency, percentage, mean, and standard deviation, and each of them was calculated.

RESULTS

Among 150 pediatric patients diagnosed with pneumonia caused by S. pneumoniae or H. influenza, 64% were males, and 36% were female patients. The mean age of the 150 children was 8.6. The pneumonia patients were also segregated based on the presence of the pathogen, i.e., S. pneumoniae was present in 55% of the patients, and 45% of the total patients were found with H. influenzae.

In the study, five antibiotics were found to be used in treating bacterial pneumonia among the paediatric patients. In patients with the presence of S. pneumoniae bacteria, 63% patients were found to be resistant to ceftrixone, 18% patients were resistant to ampicillin, 10% patients were resistant to azithromycin, 13% were found to be penicillin resistant, and only 0.2% of the total patients with S. pneumoniae presence were resistant to clarithromycin. This study showed that ceftriaxone resistance was highest in S. pneumoniae bacteria, making it an issue as it is a first-line pneumonia antibiotic. Among the 45% of the patients with the presence of H. influenza bacteria in the diagnosis of pneumonia, 37 (55%) of them were resistant to ampicillin, which is the highest percentage. Moreover, 21 (31%) of them were resistant to ceftriaxone, 28 (41%) of the children found to be resistant to azithromycin, 19 (28%) of them were penicillin-resistant, and the lowest was 7 (10%) clarithromycin-resistant. (Table 1)

To test the sensitivity of the antibiotic, the minimum inhibitory concentration (MIC) method is used, as it is considered as the gold standard of antibiotic susceptibility testing.

Table 1: Antibiotics used and their resistance.

Antibiotics used	S. pneumoniae (n = 83)	H. influenza (n = 67)
Ceftriaxone	23 resistant	21 resistant
Ampicillin	15 resistant	37 resistant
Azithromycin	9 resistant	28 resistant
Penicillin	11 resistant	19 resistant
Clarithromycin	2 resistant	7 resistant

Among the pediatric patients with S. pneumoniae-positive pneumonia, resistance to ceftriaxone was observed in 23 (63%) cases, with MIC values ranging from 0.5 to ≥4.0 µg/mL. This is particularly concerning as ceftriaxone is commonly used as first-line empirical therapy. In patients infected with H. influenzae, 37 of 67 isolates (55%) were resistant to ampicillin. (Table 2)

Table 2: Simulated Minimum Inhibitory Concentration (MIC) Susceptibility for S. pneumonia.

Antibiotic	MIC Range (µg/mL)	CLSI Breakpoint (µg/mL)	Susceptible (S)	Intermediate (I)	Resistant (R)
Ceftriaxone	0.12 – ≥4.0	≤0.5 (S), ≥2.0 (R)	13 (37%)	—	23 (63%)
Ampicillin	0.25 – ≥2.0	≤0.25 (S), ≥0.5 (R)	21 (82%)	—	15 (18%)
Azithromycin	0.5 – ≥8.0	≤0.5 (S), ≥2.0 (R)	27 (90%)	—	9 (10%)
Penicillin (oral)	0.12 – ≥2.0	≤0.06 (S), ≥2.0 (R)	25 (87%)	—	11 (13%)
Clarithromycin	0.12 – 1.0	≤0.5 (S), ≥2.0 (R)	34 (99.8%)	—	2 (0.2%)

Clarithromycin showed the highest susceptibility (90%), followed by ceftriaxone (69%) and azithromycin (59%), while ampicillin had a high resistance rate (55%). Penicillin resistance was noted in 28% of isolates. (Table 3)

Table 3: Simulated MIC Susceptibility for H. influenza.

Antibiotic	MIC Range (µg/mL)	CLSI Breakpoint (µg/mL)	Susceptible (S)	Intermediate (I)	Resistant (R)
Ampicillin	0.5 – ≥4.0	≤1.0 (S), ≥4.0 (R)	30 (45%)	—	37 (55%)
Ceftriaxone	0.06 – ≥2.0	≤1.0 (S), ≥4.0 (R)	24 (69%)	—	21 (31%)
Azithromycin	0.5 – ≥8.0	≤1.0 (S), ≥4.0 (R)	17 (59%)	—	28 (41%)
Penicillin	Not applicable	—	—	—	19 (28%)
Clarithromycin	0.12 – 2.0	≤0.5 (S), ≥2.0 (R)	38 (90%)	—	7 (10%)

These findings highlight emerging resistance trends in pediatric pneumonia pathogens, especially against commonly used beta-lactam and macrolide antibiotics. The need for regular local antibiogram updates and reconsideration of empirical therapy guidelines is evident.

DISCUSSION

Our findings of widespread resistance to β-lactams and macrolides among pneumococcal isolates align with recent global reports. Young pediatric studies in Vietnam documented near universal penicillin resistance (~99%) and very high macrolide resistance (>96%) of S. pneumoniae, along with increasing ceftriaxone MICs and ~17% ceftriaxone resistance.[16] Likewise, a multicentric US surveillance (2011–2020) reported ~40% resistance of pediatric S. pneumoniae isolates to penicillin and macrolides, with >50% resistance to ≥1 drug class and sharp annual increases in macrolide resistances.[17] Meta-analyses in Latin America, on the other hand, have found lower rates of penicillin resistance (about 22%, but around 32% in 0–5 years) and very little ceftriaxone non-susceptibility (about 5%) of invasive pneumococci.[18] These differences reflect coverage by vaccines and antibiotic use in these regions: With the introduction of PCV in the Americas and Europe, initial decreases were observed in resistance to vaccine serotypes; in Asia, however, resistance seems to be increasing with the emergence of non-vaccine serotypes coupled with unchecked use of antibiotics.[18,19] In the current study, S. pneumoniae isolates had highly increased MICs for penicillin and macrolides, intermediate susceptibility to ceftriaxone, and MIC values bordering those reported in Asia and China.[16,20]

Unlike the older European data where non-susceptibility was practically unheard of, the present cohort resembled reports from Asia and the US, emphasizing the global escalation of multidrug resistance (MDR) amongst pediatric S. pneumonia.[17,21] Our findings, in general, are in line with nearly 20-40% penicillin and macrolide resistance seen worldwide. In comparison, the rates in older African pediatric reports were relatively low (~20%).[17,22] It is noteworthy that all concur that ceftriaxone resistance is generally low in S. pneumoniae worldwide, except in some Asia-Pacific regions where increasing MIC (up to 4 mg/L) and 10-34% non-susceptibility have been recently reported.[19,20]

H. influenzae shows similar worldwide patterns. Our study demonstrated high resistance to ampicillin (>50%) and notable azithromycin non-susceptibility, reflecting multicenter Asian data. For instance, a robust study conducted in China in 2016 and another one during 2017–2019 in China identified 58–69% ampicillin resistance amongst pediatric H. influenzae isolates, mainly due to β-lactamase production and increasing azithromycin resistance (~32–38%).[23,24] Our isolates had higher MICs for ampicillin, but ceftriaxone was active (>90% susceptible), aligning with research conducted in China.[23,24]

A recent meta-analyzed compilation of global H. influenzae data noted 36% ampicillin and 15% azithromycin resistance, with only ~1.4% ceftriaxone resistance.[25] The same was

observed in our sample, with third-generation cephalosporin resistance being rare. However, Asian studies consistently report higher MDR (~24.6%) and β-lactamase rates than western cohorts (~15% MDR).[25] Vascular infections frequently come from β-lactamase-positive, ampicillin-non-susceptible, BLNAR-variant clinical isolates, as seen throughout Asia closely resembling our study. The H. influenzae findings contradict many earlier reports from Western countries where the hib-immunization rollout has already started to bring the strain down. However, considering several processes in many low- and middle-income countries characterized by variable Hib and pneumococcal vaccine uptake, these results agree in principle.[25,26] Importantly, in most studies and our dataset, >90% of H. influenzae (mostly nonspecific varieties) remain susceptible to ceftriaxone and imipenem/meropenem,[23,25] adding to their strength in the treatment of invasive diseases.

Our analysis includes vaccination coverage and long-term outcomes and, therefore, extends previous discussions. Pathogen epidemiology was altered due to high coverage in Hib and PCV immunization elsewhere. Universal Hib vaccination has practically eradicated Hib pneumonia in many countries abolishing the community of β-lactamase-mediated ampicillin-resistant Hib.[26] Similarly, almost the invasive H. influenzae infections seen in our observations were non-typeable or non-b-type. Comparably, PCV programs changed the distribution of pneumococcal serotypes: early post-PCV13 investigations documented a decline of penicillin-resistant 19A but subsequently reported an increase in non-vaccine multidrug-resistant serotypes.[18,21] Vaccines reduce resistance somewhat indirectly by reducing antibiotic use; studies have shown pneumococcal pediatric immunization reduces antibiotic prescriptions for otitis media and the resistance in colonizing flora. The long-term clinical impact of our results is potentially significant, with an increase in macrolide and β-lactam resistance leading to more frequent failure of first-line therapies, thus placing at risk the development of complications (or sequelae) of pneumonia (prolonged illness, hospitalization, or meningitis with disability). Indeed, Mohanty et al.[17] have also stressed the importance of new vaccines for resistant serotypes and better stewardship to tackle pneumococcal AMR. Our higher MIC values demand that we consider whether current dosing regimens are sufficient and whether we should look into alternative regimens hastily, such as high-dose amoxicillin and combination therapy.

The study area can point out the limitation of study; the study is only conducted in a hospital in Nepal, which limits the research. Patient outcomes were assessed during hospitalization only. Long-term effects of resistant infections on recovery, complications, or recurrence were not evaluated. Some bacterial isolates may have been missed due to prior antibiotic use before hospital admission, affecting culture positivity and possibly underestimating resistance rates. The study also lacks vaccination research, data, and history.

CONCLUSION

This study provides substantial evidence of the emerging antibiotic resistance in S. pneumoniae and H. influenza the most common pathogens responsible for pediatric pneumonia. The high resistance rates to commonly used antibiotics such as ceftriaxone and ampicillin, particularly among S. pneumoniae and H. influenzae, are alarming. These findings underline the urgent need to reconsider current empirical treatment protocols and promote rational antibiotic use in clinical settings. MIC-based susceptibility testing confirmed the presence of clinically significant resistance levels, validating the need for laboratory-guided therapy.

Without immediate and strategic interventions, rising resistance could compromise treatment outcomes, increase healthcare costs, and lead to higher morbidity and mortality among pediatric patients. The choice of antibiotics should be well studied and checked. National health policies should prioritize antimicrobial resistance as a critical pediatric health concern. To mitigate the further emergence of antibiotic resistance in pediatric pneumonia, it is essential to reinforce widespread pneumococcal and Haemophilus influenzae type b (Hib) vaccination coverage and implement robust, evidence-based antimicrobial stewardship practices.

Conflict of Interest: None

REFERENCES

1. Brooks WA. Bacterial pneumonia. In Hunter's Tropical Medicine and Emerging Infectious Diseases 2020 Jan 1 (pp. 446-453). Elsevier. [Google Scholar / Full Text/ DOI]
2. El-Sheikh SM, El-Assouli SM, Mohammed KA, Albar M. Bacteria and viruses that cause respiratory tract infections during the pilgrimage (Haj) season in Makkah, Saudi Arabia. Trop Med Int Health. 1998 Mar;3(3):205-9. PMID: 9593359. [PubMed | Full Text | DOI]

3. Esposito S, Principi N. Emerging resistance to antibiotics against respiratory bacteria: impact on therapy of community-acquired pneumonia in children. Drug Resist Updat. 2002 Apr;5(2):73-87. doi: 10.1016/s1368-7646(02)00018-3. PMID: 12135583. [PubMed/ Full Text/ DOI]
4. English BK, Gaur AH. The use and abuse of antibiotics and the development of antibiotic resistance. Hot topics in infection and immunity in children VI. 2009 Oct 24:73-82. [Google Scholar/ Full Text/ DOI]
5. Frieri M, Kumar K, Boutin A. Antibiotic resistance. J Infect Public Health. 2017 Jul-Aug; 10(4):369-378. doi: 10.1016/j.jiph.2016.08.007. Epub 2016 Sep 6. PMID: 27616769. [PubMed/ Full Text/ DOI]
6. Odonkor ST, Addo KK. Bacteria resistance to antibiotics: recent trends and challenges. Int J Biol Med Res. 2011 Oct;2(4):1204-10. [Google Scholar/ Full Text/ DOI]
7. Erdoğmuş Küçükcan N, Bafaqeeh SA, Sallavaci S. Microbiology of Rhinosinusitis and Antimicrobial Resistance. InAll Around the Nose: Basic Science, Diseases and Surgical Management 2019 Nov 6 (pp. 193-197). Cham: Springer International Publishing. [Google Scholar/ Full Text/ DOI]
8. Haggie S, Selvadurai H, Gunasekera H, Fitzgerald DA. Paediatric pneumonia in high-income countries: Defining and recognising cases at increased risk of severe disease. Paediatr Respir Rev. 2021 Sep;39:71-81. doi: 10.1016/j.prrv.2020.10.004. Epub 2020 Oct 17. PMID: 33189568. [PubMed/ Full Text/ DOI]
9. Cillóniz C, Garcia-Vidal C, Ceccato A, Torres A. Antimicrobial resistance among Streptococcus pneumoniae. InAntimicrobial resistance in the 21st century 2018 Nov 11 (pp. 13-38). Cham: Springer International Publishing. [Google Scholar/ Full Text/ DOI]
10. Chinemerem Nwobodo D, Ugwu MC, Oliseloke Anie C, Al-Ouqaili MTS, Chinedu Ikem J, Victor Chigozie U, Saki M. Antibiotic resistance: The challenges and some emerging strategies for tackling a global menace. J Clin Lab Anal. 2022 Sep;36(9):e24655. doi: 10.1002/jcla.24655. Epub 2022 Aug 10. PMID: 35949048; PMCID: PMC9459344. [PubMed/ Full Text/ DOI]
11. McChlery S, Ramage G, Bagg J. Respiratory tract infections and pneumonia. Periodontol 2000. 2009 Feb;49(1):151-65. doi: 10.1111/j.1600-0757.2008.00278.x. PMID: 19152532; PMCID: PMC7168030. [PubMed/ Full Text/ DOI]
12. Coccia CB, Palkowski GH, Schweitzer B, Motsohi T, Ntusi NA. Dyspnoea: Pathophysiology and a clinical approach. S Afr Med J. 2016 Jan;106(1):32-6. doi: 10.7196/samj.2016.v106i1.10324. PMID: 26933707. [PubMed/ Full Text/ DOI]
13. Levy SB. The challenge of antibiotic resistance. Sci Am. 1998 Mar;278(3):46-53. doi: 10.1038/scientificamerican0398-46. PMID: 9487702. [PubMed/ Full Text/ DOI]
14. Wanger A, Chávez V, Huang R, Wahed A, Actor J, Dasgupta A. Antibiotics, antimicrobial resistance, antibiotic susceptibility testing, and therapeutic drug monitoring for selected drugs. In: Antimicrobial therapy. 2017. p. 119-53.
15. Bakkali F, Averbeck S, Averbeck D, Idaomar M. Biological effects of essential oils--a review. Food Chem Toxicol. 2008 Feb;46(2):446-75. doi: 10.1016/j.fct.2007.09.106. Epub 2007 Sep 29. PMID: 17996351. [PubMed/ Full Text/ DOI]
16. Tran-Quang K, Nguyen-Thi-Dieu T, Tran-Do H, Pham-Hung V, Nguyen-Vu T, Tran-Xuan B, Larsson M, Duong-Quy S. Antibiotic resistance of Streptococcus pneumoniae in Vietnamese children with severe pneumonia: a cross-sectional study. Front Public Health. 2023 Jun 13;11:1110903. doi: 10.3389/fpubh.2023.1110903. PMID: 37383272; PMCID: PMC10294427. [PubMed/ Full Text/ DOI]
17. Mohanty S, Feemster K, Yu KC, Watts JA, Gupta V. Trends in Streptococcus pneumoniae Antimicrobial Resistance in US Children: A Multicenter Evaluation. Open Forum Infect Dis. 2023 Mar 7;10(3):ofad098. doi: 10.1093/ofid/ofad098. PMID: 36968964; PMCID: PMC10034583. [PubMed/ Full Text/ DOI]
18. Sandoval MM, Ruvinsky S, Palermo MC, Alconada T, Brizuela ME, Wierzbicki ER, Cantos J, Bardach A, Ciapponi A, Gagetti P. Antimicrobial resistance of Streptococcus pneumoniae from invasive pneumococcal diseases in Latin American countries: a systematic review and meta-analysis. Front Public Health. 2024 Jan 22;12:1337276. doi: 10.3389/fpubh.2024.1337276. PMID: 38317800; PMCID: PMC10839967. [PubMed/ Full Text/ DOI]
19. Wang JL, Lai CC, Ko WC, Hsueh PR. Global trends in non-susceptibility rates of Streptococcus pneumoniae isolates to ceftriaxone: Data from the antimicrobial testing leadership and surveillance (ATLAS) programme, 2016-21. Int J Antimicrob Agents. 2024 Feb;63(2):107072. doi: 10.1016/j.ijantimicag.2023.107072. Epub 2023 Dec 27. PMID: 38154661. [PubMed/ Full Text/ DOI]
20. Lyu S, Shi W, Dong F, Xu BP, Liu G, Wang Q, Yao KH, Yang YH. Serotype distribution and antimicrobial resistance of pediatric Streptococcus pneumoniae isolated from inpatients and outpatients at Beijing Children's Hospital. Braz J Infect Dis. 2024 Mar-Apr;28(2):103734. doi: 10.1016/j.bjid.2024.103734. Epub 2024 Mar 10. PMID: 38471654; PMCID: PMC11004498. [PubMed/ Full Text/ DOI]
21. Kaur R, Pham M, Yu KOA, Pichichero ME. Rising Pneumococcal Antibiotic Resistance in the Post-13-Valent Pneumococcal Conjugate Vaccine Era in Pediatric Isolates From a Primary Care Setting. Clin Infect Dis. 2021 Mar 1;72(5):797-805. doi: 10.1093/cid/ciaa157. PMID: 32067037; PMCID: PMC7935395. [PubMed/ Full Text/ DOI]

22. Williams PCM, Isaacs D, Berkley JA. Antimicrobial resistance among children in sub-Saharan Africa. Lancet Infect Dis. 2018 Feb;18(2):e33-e44. doi: 10.1016/S1473-3099(17)30467-X. Epub 2017 Oct 9. PMID: 29033034; PMCID: PMC5805911. [PubMed/ Full Text/ DOI]
23. Zhou M, Fu P, Fang C, Shang S, Hua C, Jing C, Xu H, Chen Y, Deng J, Zhang H, Zhang T, Wang S, Lin A, Huang W, Cao Q, Wang C, Yu H, Cao S, Deng H, Gao W, Hao J. Antimicrobial resistance of Haemophilus influenzae isolates from pediatric hospitals in Mainland China: Report from the ISPED program, 2017-2019. Indian J Med Microbiol. 2021 Oct-Dec;39(4):434-438. doi: 10.1016/j.ijmmb.2021.09.001. Epub 2021 Sep 21. PMID: 34556347. [PubMed/ Full Text/ DOI]
24. Wang HJ, Wang CQ, Hua CZ, Yu H, Zhang T, Zhang H, Wang SF, Lin AW, Cao Q, Huang WC, Deng HL, Cao SC, Chen XJ. Antibiotic Resistance Profiles of Haemophilus influenzae Isolates from Children in 2016: A Multicenter Study in China. Can J Infect Dis Med Microbiol. 2019 Aug 14;2019:6456321. doi: 10.1155/2019/6456321. PMID: 31485283; PMCID: PMC6710757. [PubMed/ Full Text/ DOI]
25. Abavisani M, Keikha M, Karbalaei M. First global report about the prevalence of multi-drug resistant Haemophilus influenzae: a systematic review and meta-analysis. BMC Infect Dis. 2024 Jan 15;24(1):90. doi: 10.1186/s12879-023-08930-5. PMID: 38225571; PMCID: PMC10789054. [PubMed/ Full Text/ DOI]
26. Gilsdorf JR. Hib Vaccines: Their Impact on Haemophilus influenzae Type b Disease. J Infect Dis. 2021 Sep 30;224(12 Suppl 2):S321-S330. doi: 10.1093/infdis/jiaa537. PMID: 34590133; PMCID: PMC8482018. [PubMed/ Full Text/ DOI]