



Original Article

Clinical Features, Microbiological Characteristics, and Antibiotic Use in the Treatment of Community-Acquired Pneumonia in Ninh Binh Obstetrics and Pediatrics Hospital

Dong Thi Xuan Phuong¹, Dinh Thi Duong², Nguyen Duy Thanh Huong¹,
Hoang Huong Huyen², Pham Thi Thuy Van¹, Nguyen Tu Son^{1,*}

¹Hanoi University of Pharmacy, 13-15 Le Thanh Tong, Cua Nam, Hanoi, Vietnam

²Vinmec SmartCity, 2A Tay Mo, Tay Mo, Hanoi, Vietnam

Received 9th March 2026

Revised 20th May 2026; Accepted 14th August 2026

Abstract: *Background:* To analyze the clinical and microbiological characteristics as well as antibiotic usage in the treatment of community-acquired pneumonia (CAP) in pediatric patients at Ninh Binh Obstetrics and Pediatrics Hospital discharged between January 1, 2022, and November 30, 2022. *Methods:* A cross-sectional descriptive study using retrospective medical record data. *Results:* A total of 199 hospitalized children were included, with infants aged 2–<12 months accounting for 59.8% of cases. Severe pneumonia was observed in 39.7% of patients. The rate of bacterial culture testing was low (37.7%), with a positive rate of 25.3%. The most common pathogens identified were *Streptococcus pneumoniae* (31.6%), *Haemophilus influenzae* (21.1%), and *Moraxella catarrhalis* (21.1%). The most frequently used antibiotics were third-generation cephalosporins (29.4%), macrolides (26.5%), and penicillins (26.2%). Empirical combination therapy was used in 11.5% of cases, and 28.6% of patients required antibiotic regimen adjustments. *Conclusion:* Third-generation cephalosporins were the most prescribed antibiotics. Over one-third of hospitalized patients had severe pneumonia, while the bacterial culture testing rate remained low (37.7%). These findings indicate a need to enhance microbiological testing and strengthen antibiotic stewardship to optimize treatment outcomes.

Keywords: third-generation cephalosporins, antibiotics, community-acquired pneumonia (CAP), pediatrics.

* Corresponding author.

E-mail address: sonnt@hup.edu.vn

<https://doi.org/10.25073/2588-1132/vnumps.4932>

1. Introduction

Community-acquired pneumonia (CAP) is one of the leading causes of morbidity and mortality among children under five years of age worldwide, particularly in low- and middle-income countries. According to the World Health Organization (WHO), pneumonia accounts for approximately 15% of all deaths in children under five, equivalent to more than 800,000 cases each year [1, 2]. Despite improvements in immunization, nutritional care, and access to healthcare, CAP remains a major burden on health systems, especially in the context of rising antimicrobial resistance [1, 2]. In Vietnam, CAP continues to be one of the most common causes of pediatric hospital admissions. While the treatment of CAP relies mainly on antibiotic therapy, the overuse and inappropriate use of antibiotics in both community and healthcare settings remain serious concerns [3-5]. This situation not only reduces the effectiveness of treatment but also contributes to the spread of antimicrobial resistance—one of the most serious challenges in modern medicine [2]. In addition, the diagnosis and identification of causative pathogens in pediatric community-acquired pneumonia (CAP) remain challenging. Most current treatment regimens are still empirically based due to limitations in microbiological testing, particularly at provincial and district-level hospitals [6, 7, 8]. Meanwhile, data on microbiological characteristics and antibiotic use patterns at these facilities remain limited, posing challenges for developing treatment guidelines tailored to local practice. Ninh Binh Obstetrics and Pediatrics Hospital is a provincial-level specialty hospital that treats thousands of pediatric patients each year. However, no study has yet been conducted to describe the clinical features, microbiology, and antibiotic use in the management of pediatric CAP at this hospital. Therefore, this study was carried out to describe the clinical characteristics, identify selected microbiological pathogens, and analyze the current patterns of antibiotic use in the treatment of community-acquired pneumonia among

hospitalized children at Ninh Binh Obstetrics and Pediatrics Hospital. The findings are expected to provide practical evidence to support the development of appropriate treatment guidelines, improve therapeutic outcomes, and reduce the risk of antimicrobial resistance at the local level.

2. Methods

Study design: a retrospective cross – sectional study.

Study population: Pediatric patients diagnosed with CAP and hospitalized at Ninh Binh Obstetrics and Pediatrics Hospital, who were discharged between January 1, 2022 and November 30, 2022.

Sample size: A total sampling method was applied, including all pediatric patients who met the inclusion and exclusion criteria.

Inclusion criteria: i) Medical records with ICD-10 code J18.0, with the admission diagnosis of pneumonia; and ii) The patient must have received an indication for antibiotic therapy within 48 hours after hospital admission.

Exclusion criteria: i) Medical records inaccessible; ii) Confirmed diagnosis other than pneumonia within the first 48 hours of hospital admission; iii) Length of hospital stay less than 3 days; iv) Presence of infectious diseases involving other organ systems (e.g., urinary tract, muscle, bone, joints, etc.), except for other respiratory tract infections, which were not excluded; and v) Early-onset neonatal infections.

Data collection: A total of 916 medical records were retrieved through the hospital's electronic system and medical record archive. After applying the inclusion and exclusion criteria, 199 records were eligible and included in the study. Data was retrospectively collected from patients' medical records using a standardized data collection form, which comprised demographic characteristics (age, sex), comorbidities, clinical features of CAP, bacterial culture results, and information on antibiotic use.

Study Outcomes: The study focused on three main domains. First, clinical characteristics were assessed, including the distribution of CAP severity and the frequency of presenting clinical symptoms. Second, microbiological characteristics were evaluated, comprising the proportion of patients undergoing bacterial culture, the distribution of specimen types, the positivity rate of cultures, and the antimicrobial resistance patterns of isolated pathogens. Third, antibiotic use was analyzed with regard to empirical antibiotic regimens initially prescribed and subsequent modifications of empirical therapy during hospitalization.

Data analysis: Data were entered and analyzed using Microsoft Excel 2016. Categorical variables were summarized as frequencies and percentages. Continuous variables were expressed as mean and standard deviation if normal distribution, or as median

and interquartile range if the distribution was non-normal.

3. Results

3.1. Clinical Characteristics

Among 199 pediatric patients with CAP, infants aged 2-<12 months accounted for the highest proportion (59.8%), while children over 5 years represented the lowest proportion (2.5%), with a decreasing trend by age group. The male-to-female ratio was 1.1:1, and 139 out of 199 children had 1–3 comorbidities at admission for CAP. The majority of hospital stays lasted 7–10 days (57.8%), and the cure rate was the highest outcome (94.5%). These findings are summarized in Table 1.

Table 1. Baseline characteristics in the study population

Characteristics		Total (n = 199)	
		Number	Percentage (%)
Gender	Male	106	53.3
	Female	93	46.7
Age group	< 2 months	7	3.5
	2 - < 12 months	119	59.8
	1-5 years	68	34.2
	>5 years	5	2.5
Number of comorbidities	0	60	30.2
	≥1	139	69.8
Types of comorbidities	Anemia	68	48.9
	Other gastrointestinal diseases	28	20.1
	Acute suppurative otitis media	18	12.9
	Suspected acute bronchial asthma attack/asthma	14	10.1
	Other comorbidities	6	4.3
	Acute bronchiolitis	5	3.6
Length of hospital stay	< 5 days	6	3.0
	5 - < 7 days	25	12.6
	7 - ≤ 10 days	115	57.8
	>10 days	53	26.6
Treatment outcomes	Complete cure	188	94.5
	Improvement	10	5.0
	No improvement	0	0.0
	Worsen	1	0.5

Among the 199 study patients, severe CAP accounted for 39.7%. The most common clinical symptoms observed were tachypnea or dyspnea

(73.9%) and chest indrawing (76.4%). No patients presented with convulsions, coma, or irritability (Table 2).

Table 2. Clinical characteristics of patients with CAP in the study.

Clinical characteristics		Total (n = 199)	
		Frequency	Percentage (%)
Severity	Moderate CAP	120	60.3
	Severe CAP	79	39.7
Common symptoms	Breathing (tachypnea or dyspnea)	147	73.9
	Rales	78	39.2
	Nasal flaring	79	39.7
	Chest indrawing	152	76.4
	Cyanosis	65	32.7
	Convulsion or coma	0	0
	Mild irritability or danger signs	0	0

3.2. Microbiological Characteristics

Among 199 pediatric patients admitted with CAP, 75 specimens were sent for microbiological testing, of which 19 were positive (25.3%). A total of 64 specimens were

collected prior to antibiotic administration. The majority of specimens were nasopharyngeal swabs (62.7%), followed by sputum samples (34.7%) and blood samples (2.6%). The bacterial isolates obtained from the 19 positive specimens (25.3%) are illustrated in the following figure.

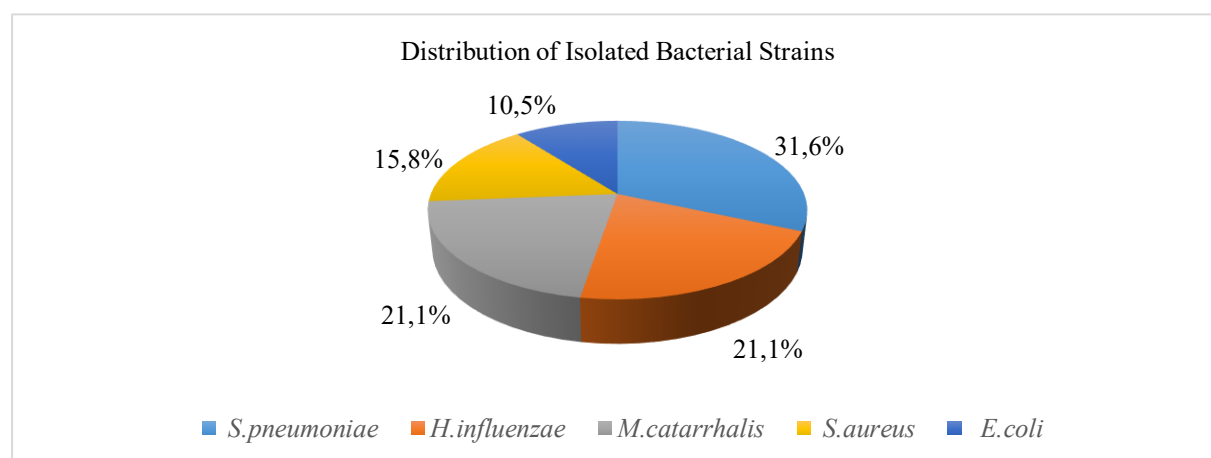


Figure 1. Distribution of Isolated Bacterial Strains (n = 19).

Antibiotic susceptibility testing showed that *S. pneumoniae* exhibited high resistance rates to amoxicillin (80.2%), erythromycin (64.6%), and clarithromycin (76.0%) and was the most multidrug-resistant pathogen identified. These resistance rates were calculated using the total number of *S. pneumoniae*-positive isolates as the denominator.

3.3. Empirical Antibiotic Uses

Among the 199 pediatric patients enrolled in the study, 54.3% had received antibiotics prior to hospital admission. In total, 278 antibiotic prescriptions were recorded for these patients, covering six major classes (penicillins, glycopeptides, cephalosporins, macrolides,

aminoglycosides, and quinolones). The most commonly used classes were third-generation cephalosporins (29.4%), macrolides (26.5%), and penicillins (26.2%). The three most

frequently prescribed antibiotics were azithromycin (18.7%), gentamicin (16.9%), and amoxicillin/sulbactam (16.9%).

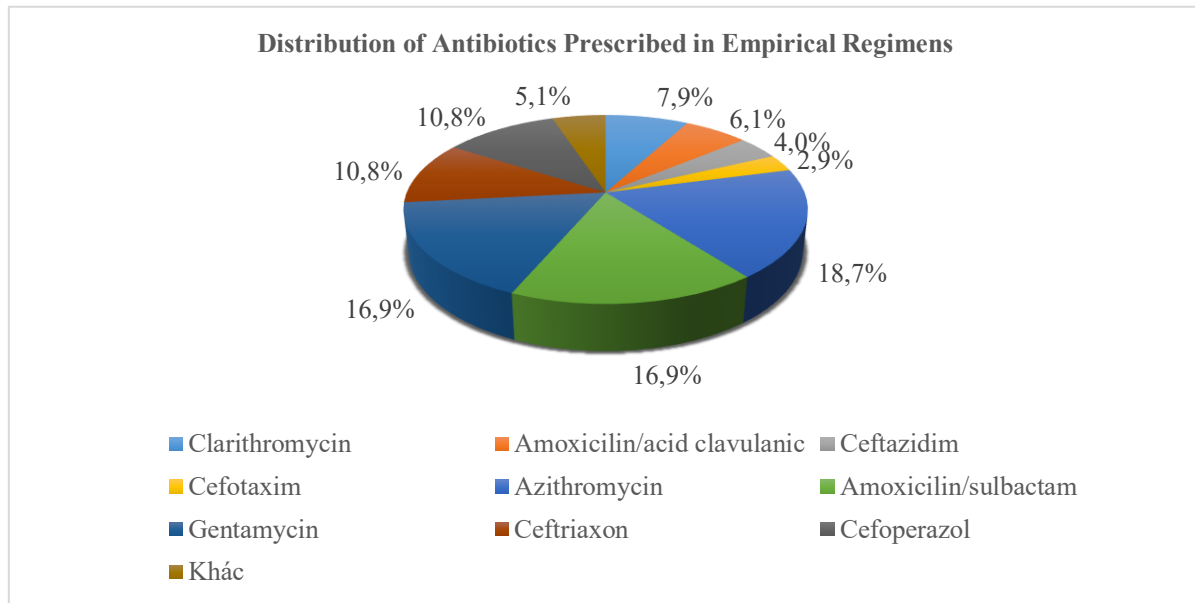


Figure 2. Distribution of Antibiotics Prescribed in Empirical Regimens.

At hospital admission, ten empirical pneumonia treatment regimens were identified, including six monotherapy regimens and four combination regimens. The majority of patients received monotherapy (88.5%), while

combination therapy accounted for 11.5%. Among the monotherapy regimens, the most common were third-generation cephalosporins (32.7%) and penicillins combined with beta-lactamase inhibitors (29.6%) (Table 3).

Table 3. Empirical Treatment Regimens for Pneumonia at Hospital Admission

Regimen	Moderate CAP		Severe CAP	
	n=120	Percentage (%)	n=79	Percentage (%)
Monotherapy	n=112	56.3	n=64	32.2
Penicillin/beta-lactamase inhibitors	41	20.6	18	9.0
Penicillin	1	0.5	0	0.0
Third-generation cephalosporin	25	12.6	40	20.1
Macrolide	38	19.1	4	2.0
Glycopeptide	0	0.0	1	0.5
Aminoglycoside	7	3.5	1	0.5
Combination therapy	n=8	4.0	n=15	7.5
Third-generation cephalosporin+Macrolide	1	0.5	2	1.0
Third-generation cephalosporin+Aminoglycoside	0	0.0	7	3.5
Penicillin/ beta-lactamase inhibitor + Macrolide	5	2.5	3	1.5
Penicillin/ beta-lactamase inhibitor + Aminoglycoside	2	1.0	3	1.5
Total	120	60.3	79	39.7

Among 57 medical records with changes in treatment regimens (28.6%), one patient required two regimen changes (1.8%). The most common reason for modification was suspected drug allergy (29.8%), followed by clinical improvement (26.3%). Other reasons were

distributed at relatively similar proportions. The most frequent type of modification was a change in the antibiotic agent (either within the same class or across different classes), accounting for 49.1% (Table 4).

Table 4. Characteristics of regimen modifications during treatment

Characteristics of regimen modifications		Total (N = 57)	
		Frequency	Percentage (%)
Reason of regimen modifications	Suspected drug allergy in the patient (e.g., rash, tachycardia, hypotension, swelling of lips or eyes, etc.)	17	29.8
	Improved symptoms	15	26.3
	Unimproved symptoms	12	21.1
	According to antibiotic susceptibility testing	10	17.5
	Drug shortage	1	1.8
Types of regimen modifications	Change to another antibiotic class	27	47.3
	Stop an antibiotic	18	31.6
	Addition of another antibiotic	11	19.3
	Change to an antibiotic in the same class	1	1.8

4. Discussions

4.1. Clinical Characteristics

Regarding the general characteristics of the pediatric patients in this study, the highest prevalence of pneumonia was observed in children aged 2–12 months (59.8%), with a decreasing trend by age, and the lowest in children over 5 years (2.5%). This finding is consistent with the results of Luu Thi Thuy Duong and Khong Thi Ngoc Mai (64.9% in children aged 6–12 months and 35.1% in those aged 12–36 months) [9], and Nguyen Thi Truc Linh (53.3% in children aged 2–12 months) [10], reflecting the association between disease prevalence and the immature immune response of younger children. The male-to-female ratio was 1.1:1. However, in terms of disease severity, with 60.3% classified as pneumonia and 39.7% as severe pneumonia, and no cases of very severe pneumonia, our findings differ from those of Luu Thi Thuy Duong and Khong Thi Ngoc Mai (49.4% pneumonia, 50.6% severe pneumonia) [9] at Thai Nguyen Central Hospital, and Ngo Anh Vinh and Mai Thi Le Quyen (25.6%

pneumonia, 74.4% severe pneumonia) [11] at Ha Tinh General Hospital.

Comorbidities were present in 69.8% of patients, most commonly anemia (48.9%), gastrointestinal disorders (20.1%), otitis media (12.9%), and bronchial asthma (10.1%). The most frequent clinical symptoms included tachypnea (73.9%), chest indrawing (76.4%), nasal flaring (39.7%), and lung rales (39.2%). These results differ from several previous studies. Specifically, Luu Thi Thuy Duong and Khong Thi Ngoc Mai reported a similar proportion of tachypnea (73%) but a much higher rate of rales (91.4%) [9], while Ngo Anh Vinh and Mai Thi Le Quyen observed tachypnea in 100% and rales in 96.2% of cases [11]. Thus, the lower frequency of symptoms in our study may be attributable to differences in the timing of assessment, disease severity, or methods of clinical evaluation across healthcare settings.

With regard to treatment outcomes, the cure rate was 94.5%, higher than that reported by Nguyen Thanh Hai et al., (60.0% cured, 38.6% improved, 1.4% unchanged) [6] and Nguyen Van Tuan (20.0% cured, 72.5% improved, 7.5%

transferred to ICU) [12]. The relatively high success rate in this study may be explained by several factors: most patients had pneumonia ranging from mild to severe, with no cases of very severe pneumonia; the provincial hospital setting ensured adequate facilities and drug availability; and rational antibiotic use combined with timely regimen adjustments according to clinical progression likely contributed substantially. Overall, treatment outcomes are strongly influenced by disease severity, the availability of therapeutic resources, and clinical practices in antibiotic prescribing.

4.2. Microbiological Characteristics

Microbiological testing plays an important role in identifying causative pathogens and guiding effective antibiotic strategies; however, the testing rate in this study remained low (37.7%), with only 25.3% of specimens yielding positive results. This reflects the general situation in many provincial hospitals in Vietnam, similar to the study by Nguyen Thanh Hai et al., which reported a bacterial culture rate of 6% with 7.7% positive results at Nghe An Obstetrics and Pediatrics Hospital [6]. This may be explained by the fact that microbiological testing is often reserved for severe cases or patients not responding to initial therapy, and by limitations in standardized microbiology workflows and laboratory capacity in routine clinical practice. The most common pathogens isolated were *Streptococcus pneumoniae* (31.6%), *Haemophilus influenzae* (21.1%), and *Moraxella catarrhalis* (21.1%). These bacteria are widely recognized in the literature as leading causes of pediatric CAP, and our findings are consistent with other studies. For example, Bui Anh Son et al. reported pathogen identification in 32.1% of cases, with *S. pneumoniae* accounting for 22.4% [8], whereas higher proportions were observed in the study by Do Ngoc Quynh and Nguyen Thanh Trung, in which *S. pneumoniae* represented 55.3% and *H. influenzae* 23.5% [13]. Such differences may be attributable to the timing of specimen collection, diagnostic techniques, or prior antibiotic use

before hospitalization, which reduces bacterial isolation rates.

Regarding antimicrobial resistance, *S. pneumoniae* demonstrated high resistance to amoxicillin (80.2%), erythromycin (64.6%), and clarithromycin (76.0%), and was the most multidrug-resistant pathogen in this study. This finding highlights inappropriate antibiotic use in the community and reflects the rising trend of antimicrobial resistance. Compared with the study at Thai Nguyen Central Hospital (2019–2020), resistance levels of *S. pneumoniae* in our study were somewhat lower, but still alarming: erythromycin resistance (98.6%), clindamycin (95.8%), and cefotaxime (41.7%). In addition, *H. influenzae* in that study showed very high resistance rates to ampicillin and cephalosporins (91.7–95.8%) [7]. Although the resistance rates observed in our study have not reached such critical levels, the increasing resistance to beta-lactams and macrolides is evident and aligns with the overall national trend in Vietnam.

4.3. Analysis of Antibiotic Use in the Treatment of Pediatric CAP

More than half of the patients (54.3%) had received antibiotics prior to hospital admission, mostly through self-medication, reflecting inappropriate community use and its contribution to antimicrobial resistance. This rate is comparable to findings by Tran Thi Kieu Anh and Nguyen Van Tuan (51.1%) [14] and Nguyen Thanh Hai (47.0%) [6], but lower than that of Pham Xuan Phuc (70.0%) [15], possibly due to reluctance to seek hospital care and the ease of antibiotic access at pharmacies.

In our study, third-generation cephalosporins were the most frequently prescribed class (29.4%), mainly ceftriaxone and cefoperazone, consistent with previous reports (44.4% [14], 46.4% [6]) but at a lower proportion. Macrolides ranked second (26.5%), much higher than reported by Nguyen Thanh Hai (1.3%) [6] and Nguyen Thi Truc Linh (2.4%) [10]. Differences may relate to allergy history or local formulary availability.

A total of ten empirical regimens were identified at admission, with monotherapy predominating (88.5%). The most common regimens were third-generation cephalosporins (32.7%) and penicillins combined with beta-lactamase inhibitors (29.6%), consistent with previous studies [6, 10, 14]. This highlights the continued reliance on empirical prescribing practices.

Regimen modification occurred in 57 patients (28.6%), higher than the 6.4% reported by Nguyen Thanh Hai [6]. The most frequent reason was suspected allergy (29.8%), and nearly half of modifications (49.1%) involved switching agents, commonly to macrolides or aminoglycosides. One case required two changes due to drug shortage, reflecting logistical challenges.

Overall, these findings emphasize the need to strengthen antibiotic stewardship, restrict community misuse, and update treatment protocols in accordance with national guidelines while adapting to local contexts.

5. Conclusions

In this study of 199 pediatric patients hospitalized with pneumonia at Ninh Binh Obstetrics and Pediatrics Hospital, the disease was most prevalent among infants aged 2–12 months and occurred more frequently in males. *Streptococcus pneumoniae* was identified as the predominant pathogen, demonstrating high resistance rates to amoxicillin, erythromycin, and clarithromycin. The most commonly prescribed antibiotic classes were third-generation cephalosporins, macrolides, and penicillins, with the majority of patients receiving monotherapy. A notable proportion of patients required modification of the initial empirical regimen. These findings underscore the urgent need to optimize antibiotic prescribing practices and to implement stewardship measures aimed at curbing the rise of antimicrobial resistance.

Reference

- [1] World Health Organization, Pocket Book of Hospital Care for Children, WHO Press, Geneva, 2005, <https://www.who.int/publications/i/item/9789241548373> (accessed on: January 10th, 2026).
- [2] World Health Organization, Revised WHO Classification and Treatment of Childhood Pneumonia at Health Facilities, WHO Press, Geneva, 2014, <https://www.who.int/publications/i/item/9789241507813> (accessed on: January 10th, 2026).
- [3] Ministry of Health, Guidelines for Antibiotic Use, Medical Publishing House, Hanoi, 2015 (in Vietnamese).
- [4] Ministry of Health, Guidelines for the Management of Community-Acquired Pneumonia in Children (Issued under Decision 101/QĐ-KCB dated 09/01/2014), Ministry of Health, Hanoi, 2014 (in Vietnamese).
- [5] Ninh Binh Obstetrics and Pediatrics Hospital, Diagnosis and Treatment Protocol for Pneumonia in Children at Ninh Binh Obstetrics and Pediatrics Hospital, Ninh Binh, 2022 (in Vietnamese).
- [6] N. T. Hai, D.N. Ha, L. C. Thanh, N. T. V. Anh, N. V. Hung, C. T. N. Giao, Current Status of Antibiotic Use in the Treatment of Community-acquired Pneumonia in Children Aged 2 Months to 5 Years at Nghe An Obstetrics and Pediatrics Hospital in 2022, Journal of 108 – Clinical Medicine and Pharmacy, Vol. 18, Special Issue, 2023, <https://doi.org/10.52389/ydls.v18idbv.1981> (in Vietnamese).
- [7] D. T. H. Ngoc, K. T. N. Mai, L.T. K. Dung, Etiology and Antibiotic Resistance Level of Bacteria Causing Pneumonia in Children Aged 2 Months to 5 Years at Thai Nguyen Central General Hospital in 2019–2020, Journal of Preventive Medicine, Vol. 30, No. 6, 2021, pp. 9-16, <https://doi.org/10.51403/0868-2836/2020/172> (in Vietnamese).
- [8] B. A. Son, N. T. D. Thuy, N. T. T. Hang, Clinical, Microbiological Characteristics and Treatment Outcomes of Pneumonia with Vancomycin Use in Children at Nghe An Obstetrics and Pediatrics Hospital, Vietnamese Journal of Medicine, Vol. 528, No. 1, 2023, <https://doi.org/10.51298/vmj.v528i1.6047> (in Vietnamese).
- [9] L. T. T. Duong, K. T. N. Mai, Clinical and Subclinical Characteristics and Factors Associated with the Severity of Pneumonia in Children Aged

- 2–36 Months at Thai Nguyen Central Hospital, TNU Journal of Science and Technology, Vol. 207, No. 14, 2019, pp. 67-72, <https://jst.tnu.edu.vn/jst/article/view/1878/pdf>. (in Vietnamese).
- [10] N. T. T. Linh, N. T. L. Tuyen, N. T. Huy, Current Situation of Antibiotic Use in the Treatment of Community-Acquired Pneumonia in Children under 5 Years Old at Can Tho Children's Hospital in 2019–2020, Can Tho Journal of Medicine and Pharmacy, Vol. 37, 2021, pp. 41-47, <https://tapchi.ctump.edu.vn/index.php/ctump/article/view/1045> (accessed on: January 10th, 2026) (in Vietnamese).
- [11] N. A. Vinh, M. T. L. Quyen, Some Clinical and Paraclinical Features and Factors Associated with the Severity of Pneumonia in Children Under 5 Years Old at Ha Tinh City General Hospital, Vietnam Journal of Medicine, Vol. 533, Vol. 2, 2023, <https://doi.org/10.51298/vmj.v533i2.7921> (in Vietnamese).
- [12] N. V. Tuan, Study on the Current Situation of Antibiotic Use in the Treatment of Community-acquired Pneumonia at Nghe An General Friendship Hospital, Vietnam Medical Journal, Vol. 505, No. 2, 2021, <https://doi.org/10.51298/vmj.v505i2.1142> (in Vietnamese).
- [13] D. N. Quynh, N. T. Trung, Etiological Agents of Pneumonia In Children Aged 2 Months to 5 Years at Thai Nguyen Central General Hospital, Vietnam Journal of Medicine, Vol. 2, pp. 225-228, <https://doi.org/10.51298/vmj.v505i2.1131> (in Vietnamese).
- [14] T. K. A. Tran, N. V. Tuan, Study on the Current Situation of Antibiotic Use in the Treatment of Pneumonia in Children Aged 2 Months to 5 Years at Nghe An Obstetrics and Pediatrics Hospital in 2021, Vietnam Journal of Medicine, Vol. 505, No. 1, 2021, <https://doi.org/10.51298/vmj.v505i1.1071> (in Vietnamese).
- [15] P. X. Phuc, Survey on Antibiotic Use in the Treatment of Pneumonia in Children Under 6 Years Old at Quang Ninh Provincial General Hospital, Specialist Level 1 Thesis in Pharmacy, Hanoi University of Pharmacy, 2013 (in Vietnamese).
- [16] M. Harris, J. Clark., N. Coote , P. Fletcher, A. Harnden, M. McKean, A. Thomson, British Thoracic Society Guidelines for the Management of Community-acquired Pneumonia in Children, Thorax, Vol. 66. Suppl. 2, 2011, pp. ii1-ii23, <https://doi.org/10.1136/thoraxjnl-2011-200598>.
- [17] J. S. Bradley, C. L. Byington, S. S. Shah, B. Alverson, E. R. Carter, C. Harrison, S. L. Kaplan, S. E. Mace, G. H. McCracken, M. R. Moore, S. D. St Peter, J. A. Stockwell, D. S. Swanson, The Management of Mommunity-acquired Pneumonia in Infants and Children Older than 3 Months of Age: Clinical Practice Guidelines by the Pediatric Infectious Diseases Society and the Infectious Diseases Society of America, Clinical Infectious Diseases, Vol. 53, No. 7, 2011, pp. e25-e76, <https://doi.org/10.1093/cid/cir531>.
- [18] Children's Hospital No. 2, Pediatric Treatment Protocol, Medical Publishing House, Ho Chi Minh City, 2016 (in Vietnamese).
- [19] Ministry of Health, Guidelines for Diagnosis and Treatment of Common Pediatric Diseases (Issued under Decision No. 3312/QĐ-BYT dated 07/08/2015), Ministry of Health, Hanoi, 2015 (in Vietnamese).
- [20] Ministry of Health, National Pharmacopoeia of Vietnam, Medical Publishing House, Hanoi, 2018 (in Vietnamese)