ORIGINAL ARTICLE

CONTENTS

# Rational treatment of mild to moderate community-acquired pneumonia in previously healthy children

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## ABSTRACT

**Aim:** To analyze the features of antibacterial treatment in children hospitalized for community-acquired pneumonia and the potential influence of dysbiosis.
**Materials and Methods:** The work analyzed medical records of 51 children, aged 2 to 13 years, who were hospitalized with community-acquired pneumonia. Clinical symptoms, severity of the course, structure and duration of basic treatment measures, their cost, and signs of dysbiosis were studied in the patients.
**Results:** The average duration of hospital treatment for patients with community-acquired pneumonia was 13.3 ± 0.62 days, with 28 cases lasting between 14 and 30 days. Given the community-acquired nature of the infection, the initial use of cephalosporins was irrational and significantly increased the cost of treatment. After one week, signs of intestinal swelling, increased peristalsis, and unstable defecation, assessed as gut dysbiosis, appeared. Some symptoms, such as irritation in the throat, persistent cough, difficulty clearing mucus, shortness of breath, wheezing, and others, were regarded as signs of respiratory dysbiosis. The use of probiotics was initiated.
**Conclusions:** The study established the irrational use of third- and fourth-generation cephalosporins as first-line antibacterial treatment. Symptoms of intestinal discomfort and manifestations of mucociliary respiratory tract dysfunction should be regarded as gut-lung axis phenomena of dysbiosis.

**KEY WORDS:** community-acquired pneumonia, antibiotic treatment, microbiota, children

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## INTRODUCTION

Community-acquired pneumonia (CAP) among children is a global health problem worldwide and one of the leading causes of hospitalization and mortality [1, 2]. Over the past 20 years, there has been a substantial decrease in the incidence of childhood pneumonia and pneumonia-associated complications [3]. New vaccines against Haemophilus influenzae type b and Streptococcus pneumoniae have contributed to decreases in complicated pneumonia cases and have reduced mortality [4]. Unnecessary hospitalization also represents a significant and potentially avoidable burden on the child, their family, and the healthcare system. Indications for hospitalization of a child with CAP differ significantly depending on the country, region, and hospital. Even after evaluating the prognostic severity of the disease and regional differences in the structure of hospital establishments, the criteria for hospitalization remain inconsistent between outpatient and inpatient institutions. Nevertheless, CAP is still among the leading causes of outpatient visits and hospital admissions [5].

The etiology of CAP in the pediatric population is variable and changes according to factors such as age, disease severity, and place of residence. A high percentage of healthy children are colonized by S. pneumoniae, H. influenzae, or infected by various viruses. Numerous studies have shown that clinical, laboratory, and radiological criteria cannot reliably differentiate between bacterial and viral etiologies in children with CAP [6, 7]. Therefore, treatment decisions should be based on the expected pathogens according to the child's epidemiology and age. However, mixed bacterial-viral and viral infections are common, which complicates pathogen detection and effective treatment. The "gold standard" for determining pneumonia etiology is the detection of respiratory pathogens in specimens taken directly from the lungs via bronchoalveolar lavage, pleural fluid sampling, lung biopsy, or aspiration [8]. However, because these methods are invasive and require anesthesia in children, they are rarely performed in clinical practice [9].

The managing of etiological pneumonia treatment remains a challenge nowadays because the empiric antibiotic therapy is the first step after hospitalization and could be sometimes law effective. S. pneumoniae is the most common cause of CAP in Europe, but underestimation of its sensitivity to widely use antimicrobial medication and use of high and long-lasting treatment

leads to inappropriate results, which exacerbates the problem of resistance to antibiotics [10, 11]. As some cases of CAP in children could be viral, not every patient with non-severe CAP and without risk factors needs to be treated with high and long dose of antibiotics [12, 13]. The optimal duration of antibiotic treatment of children even with known bacterial CAP still remains unclear. Y. Gao et al. (2023) show that shorter-duration, compared with longer-duration antibiotics use, do not appreciably increase mortality and probably have little or no impact on the need for change in antibiotics [14]. This approach will also help reduce side effects, costs, and the development of microbial resistance.

Longer duration of antibiotics treatment influence normal intestinal microbiota with development of different level dysbiosis. Host-microbiota interaction plays fundamental roles in the homeostasis of mucosal immunity [15, 16]. Dysbiosis of intestinal microbiota has various immune changes and many multifactorial diseases. Many years have been considered that the lungs a sterile organ because microbiological culture techniques had shown negative results [17]. Improvement of culture-dependent and independent techniques has facilitated understanding of lung microbiota that not only exists in healthy lung but also play great role in immune responses under both physiological and pathological conditions. Understanding dysbiosis of the respiratory microbiome and altered mucous immunity in patients with different illness holds great promise to develop targeted host-directed immunotherapy to reduce ineffective treatment, to improve patient outcomes [18]. It is now widely accepted that exist a bi-directional gut-lung axis with connections of the intestinal and pulmonary microbiota and that modulation of both microbiota exist in health as in pathological status. Isolated dysbiosis of the respiratory tract occurs when the natural microbial balance of the upper or lower airways is disrupted, often due to antibiotic use, environmental factors, or underlying conditions [19]. This imbalance can increase susceptibility to infections, activate inflammation, alter mucociliary clearance, and cause other respiratory issues.

Chinese investigators D. Yang et al. (2020) discuss the causal roles of pulmonary dysbiosis in disease settings and suggest that the interaction between lung microbiota and the host is critical for establishing immune homeostasis in the lungs [20]. However, what constitutes a "healthy" microbiota remains a topic of active debate. Some authors hypothesize that the use of specific bacterial strains as "probiotics" could have positive effects on host immunity and/or protection against pathogens, potentially benefiting both the treatment of intestinal disorders and pulmonary diseases [21].

## AIM

The study aimed to analyze the features of antibacterial treatment in children, hospitalized for acute community acquired pneumonia and potential dysbiosis influence.

## MATERIALS AND METHODS

The work analyzed medical records of 51 children in age from 2 to 13 years that were in children clinical hospital with mild or moderate CAP. In patients were studied clinical symptoms, severity of course, structure and duration of basic treatment measures, their cost, signs of dysbiosis. Statistical analysis performed by means of Statistica programs (version 5.11, StatSoft Inc.) with calculating mean (M) and its standard error (m). Multivariate cluster analysis was used to analyze the relationship between clinical signs and peculiarities of treatment. A p-value <0,05 was considered as statistically significant.

The study was conducted in accordance with the principles of the World Medical Association`s Declaration of Helsinki «Ethical Principles for Medical Research Involving Human Subjects». Informed consent to participate was obtained from all those included in the study (parents of children or their guardians), which emphasizes the absence of invasive interventions. The study protocol was discussed and approved at a meeting of the Biomedical Ethics Committee of Bukovinian State Medical University.

## RESULTS

The duration of hospital treatment was, on average, 13.3±0.62 days, with subsequent outpatient treatment and rehabilitation. Antibiotics, antipyretics, mucolytics, and, in some cases, antihistamines and corticosteroids were used in the treatment. In 28 cases (54.9%), hospitalization lasted from 14 to 30 days. In these patients, after 5-7 days of illness, body temperature was normal or subfebrile, with low levels of intoxication and only slight fatigue or general weakness.

According to clinical recommendations, Amoxicillin should be the starting antibiotic for the treatment of CAP in previously healthy children. However, in our study, it was used in only one child (Fig. 1). The first line of antibacterial treatment was primarily based on third- and fourth-generation cephalosporins. The most expensive medication in the treatment was antibiotics, while the least expensive were the antipyretics. Given the community-acquired nature of the process, the initial use of cephalosporins was irrational and significantly increased the cost of treatment. The total average cost per case was 2346.9±145.7 UAH (51.2±3.2 EUR).

Starting from the end of the first week, signs of intestinal swelling, increased peristalsis, unstable defecation, and

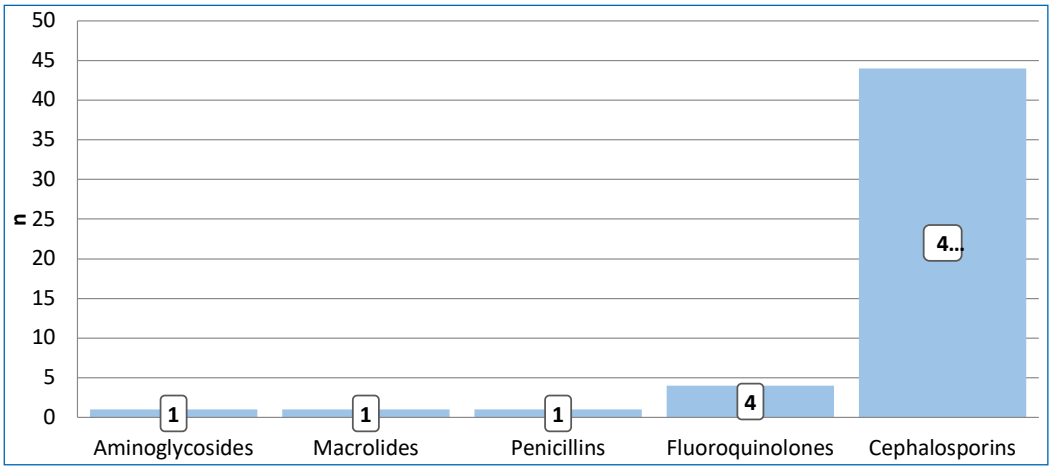


**Fig. 1.** The variants of first line antibacterial treatment (cases [n])

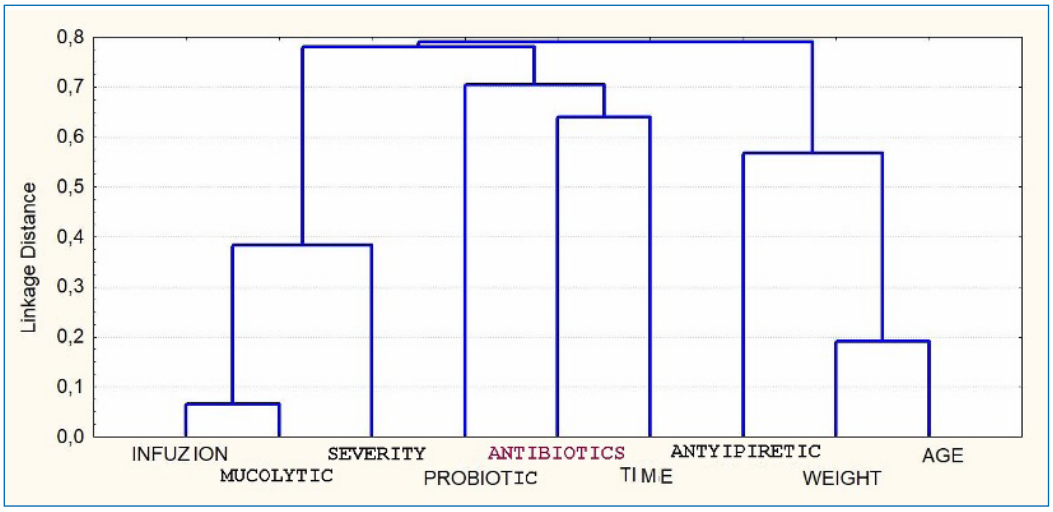


**Fig. 2.** Multivariate cluster analysis of the relationship between patients' indicators and treatment

other symptoms appeared. In all these cases, the symptoms were assessed as gut dysbiosis, and probiotics were prescribed. In this subgroup, some symptoms were noted, which we regarded as respiratory dysbiosis from the upper airways, such as frequent sore throat, persistent symptoms of chronic nasal congestion, postnasal drip, mild pharyngitis, and dryness or irritation in the throat. From the lower respiratory tract, symptoms mostly included persistent cough (dry or with minimal mucus secretion), difficulty clearing mucus, shortness of breath, or wheezing. These symptoms were assessed as dysbiosis of the respiratory tract, where the natural microbial balance of the upper or lower airways is disrupted. In all these cases, antibiotic use lasted more than two weeks, with a switch to another drug from the same group in the second line.

Multivariate cluster analysis of the relationship between clinical signs and treatment patterns revealed three distinct groups (Fig. 2). In the middle group, prolonged antibacterial treatment was associated with the use of probiotics. This suggests that prolonged use of antibiotics induces dysbiosis phenomena in the bi-directional gut-lung axis, linking the intestinal and pulmonary clinical symptoms.

## DISCUSSION

There are a lot of last days investigations which show a high effectiveness of short course of antibiotics use. A. Dinh et al. (2021) in double-blind, randomized, placebo-controlled, non-inferiority have compared 5 days versus 10 days and 3 versus 7 days of antibiotic treatment of children with CAP and reported that shorter duration was not inferior or even superior to longer duration use [22]. The similar result was shown by Canadian authors from McMaster University and University of Ottawa [23, 24]. Authors also indicated on absents symptoms of dysbiosis in short course treatment. Other data was presented by J. Bielicki et al. (2021) as results of a multicenter, randomized, blinded, placebo-controlled trial with Amoxicillin monotherapy comparing total daily dose and duration (3 or 7 days) for treatment of childhood CAP [25]. It was conducted in many hospitals in the UK and Ireland and in this investigation was noted that disease severity at enrollment was not significantly different among children from each clinical. In treatment analysis was showed noninferiority for lower dose and shorter duration (shorter vs longer). There was no significant association between dose or duration of amoxicillin and severity of cough symptoms. From the other side, patients hospitalized with

pneumonia often receive excess antibiotic therapy [26]. Excess antibiotic treatment was associated with patient-reported adverse events [19]. Intravenous antibiotics play a critical role in clinical care, particularly for severe bacterial pneumonia. However, the inability of antibiotics to reach target tissues causes serious side effects, including liver and kidney damage, intestinal dysbiosis, cause gastrointestinal infections. The gut microbiota plays a vital role in the development of protecting against severe course of respiratory diseases like pneumonia. It was demonstrated the existence of the gut-lung axis and the interaction between the gut and the lung, which is related to the better prognosis for patients. Most of these studies recommended probiotic supplementation of pneumonia treatment moreover, probiotics suppress severe immune responses and inhibit pathologic inflammatory conditions in the body via modulation of immune responses [17, 21, 27].

## CONCLUSIONS

The study established that, despite existing guidelines for the management of CAP in children, there is an irrational use of third- and fourth-generation cephalosporins as first-line antibacterial treatment, which should not be initiated at the start of treatment. Regarding the indication for inpatient care, the length of stay and the duration of antibiotic treatment were excessively long. The risks of antimicrobial resistance in these cases are high, and it is advisable to use a shorter duration of antibiotics.

Symptoms of intestinal discomfort and manifestations of mucociliary respiratory tract function deterioration should be regarded as phenomena of dysbiosis within the gut-lung axis. Compared with research on gut microbiota, our understanding of lung microbiota is still limited, and a number of conceptual questions remain to be answered.

## REFERENCES


1. Florin TA, Tancredi DJ, Ambroggio L et al. Predicting severe pneumonia in the emergency department: a global study of the Pediatric Emergency Research Networks (PERN)-study protocol. BMJ Open. 2020;10(12):e041093. doi: 10.1136/bmjopen-2020-041093. DOI
2. Chen L, Miao C, Chen Y et al. Age-specific risk factors of severe pneumonia among pediatric patients hospitalized with community-acquired pneumonia. Ital J Pediatr. 2021;47(1):100. doi: 10.1186/s13052-021-01042-3. DOI
3. Tannous R, Haddad RN, Torbey PH. Management of Community-Acquired Pneumonia in Pediatrics: Adherence to Clinical Guidelines. Front Pediatr. 2020;8:302. doi: 10.3389/fped.2020.00302. DOI
4. Carter A, Msemburi W, Sim SY et al. Modeling the impact of vaccination for the immunization Agenda 2030: Deaths averted due to vaccination against 14 pathogens in 194 countries from 2021 to 2030. Vaccine. 2024;42(1):S28-S37. doi: 10.1016/j.vaccine.2023.07.033. DOI
5. Borges J, Rosa MV, Fernandes RM et al. Hospital admissions in children with acute respiratory disease in Portugal. Pulmonology. 2019;25(2):122-125. doi: 10.1016/j.pulmoe.2018.12.004. DOI
6. Tagarro A, Moraleda C, Domínguez-Rodríguez S et al. A Tool to Distinguish Viral From Bacterial Pneumonia. Pediatr Infect Dis J. 2022;41(1):31-36. doi: 10.1097/INF.0000000000003340. DOI
7. Rankin DA, Peetluk LS, Deppen S et al. Diagnostic models predicting paediatric viral acute respiratory infections: a systematic review. BMJ Open. 2023;13(4):e067878. doi: 10.1136/bmjopen-2022-067878. DOI
8. Hogea SP, Tudorache E, Pescaru C et al. Bronchoalveolar lavage: role in the evaluation of pulmonary interstitial disease. Expert Rev Respir Med. 2020;14(11):1117-1130. doi: 10.1080/17476348.2020.1806063. DOI
9. Meyer Sauteur PM. Childhood community-acquired pneumonia. Eur J Pediatr. 2024;183(3):1129-1136. doi: 10.1007/s00431-023-05366-6. DOI
10. Albuhairi S, Farhan MA, Alanazi S et al. Antibiotic Prescribing Patterns for Hospitalized children with Community-Acquired Pneumonia in a Secondary Care Center. J Infect Public Health. 2021;14(8):1035-1041. doi: 10.1016/j.jiph.2021.05.018. DOI
11. Antoon JW, Nian H, Todd J et al. Guideline-Concordant Antibiotic Use in Children With Community-Acquired Pneumonia. Hosp Pediatr. 2025:e2024007994. doi: 10.1542/hpeds.2024-007994. DOI
12. Donà D, Brigadoi G, Grandinetti R et al. Treatment of mild to moderate community-acquired pneumonia in previously healthy children: an Italian intersociety consensus (SIPPS-SIP-SITIP-FIMP-SIAIP-SIMRI-FIMMG-SIMG). Ital J Pediatr. 2024;50(1):217. doi: 10.1186/s13052-024-01786-8. DOI
13. Nascimento-Carvalho CM. Community-acquired pneumonia among children: the latest evidence for an updated management. J Pediatr (Rio J). 2020;96(1):29-38. doi: 10.1016/j.jped.2019.08.003. DOI
14. Gao Y, Liu M, Yang K et al. Shorter Versus Longer-term Antibiotic Treatments for Community-Acquired Pneumonia in Children: A Meta-analysis. Pediatrics. 2023;151(6):e2022060097. doi: 10.1542/peds.2022-060097. DOI
15. Shah T, Baloch Z, Shah Z et al. The Intestinal Microbiota: Impacts of Antibiotics Therapy, Colonization Resistance, and Diseases. Int J Mol Sci. 2021;22(12):6597. doi: 10.3390/ijms22126597. DOI
16. Kwon J, Kong Y, Wade M et al. Gastrointestinal Microbiome Disruption and Antibiotic-Associated Diarrhea in Children Receiving Antibiotic Therapy for Community-Acquired Pneumonia. J Infect Dis. 2022;226(6):1109-1119. doi: 10.1093/infdis/jiac082. DOI

17. Zhou Y, Liu M, Liu K et al. Lung microbiota and potential treatment of respiratory diseases. Microb Pathog. 2023;181:106197. doi: 10.1016/j.micpath.2023.106197. DOI
18. Roquilly A, Torres A, Villadangos JA et al. Pathophysiological role of respiratory dysbiosis in hospital-acquired pneumonia. Lancet Respir Med. 2019;7(8):710-720. doi: 10.1016/S2213-2600(19)30140-7. DOI
19. Fu L, Huo S, Lin P et al. Precise antibiotic delivery to the lung infection microenvironment boosts the treatment of pneumonia with decreased gut dysbiosis. Acta Biomater. 2024;184:352-367. doi: 10.1016/j.actbio.2024.06.026. DOI
20. Yang D, Xing Y, Song X, Qian Y. The impact of lung microbiota dysbiosis on inflammation. Immunology. 2020;159(2):156-166. doi: 10.1111/imm.13139. DOI
21. Baldi S, Fabbrizzi A, Di Gloria L et al. First Exploration of the Altered Microbial Gut-Lung Axis in the Pathogenesis of Human Refractory Chronic Cough. Lung. 2024;202(2):107-118. doi: 10.1007/s00408-024-00681-7. DOI
22. Dinh A, Ropers J, Duran C et al. Discontinuing β-lactam treatment after 3 days for patients with community-acquired pneumonia in non-critical care wards (PTC): a double-blind, randomised, placebo-controlled, non-inferiority trial. Lancet. 2021;397(10280):1195-1203. doi: 10.1016/S0140-6736(21)00313-5. DOI
23. Singla S, Sih K, Goldman RD. Antibiotic treatment duration for community-acquired pneumonia in children. Can Fam Physician. 2023;69(6):400-402. doi: 10.46747/cfp.6906400. DOI
24. Pernica JM, Harman S, Kam AJ et al. Short-course antimicrobial therapy for pediatric community-acquired pneumonia: The SAFER Randomized Clinical Trial. JAMA Pediatr. 2021;175(5):475-482. doi: 10.1001/jamapediatrics.2020.6735. DOI
25. Bielicki JA, Stöhr W, Barratt S et al. Effect of Amoxicillin Dose and Treatment Duration on the Need for Antibiotic Re-treatment in Children With Community-Acquired Pneumonia: The CAP-IT Randomized Clinical Trial. JAMA. 2021;326(17):1713-1724. doi: 10.1001/jama.2021.17843. DOI
26. Vaughn VM, Flanders SA, Snyder A et al. Excess Antibiotic Treatment Duration and Adverse Events in Patients Hospitalized With Pneumonia: A Multihospital Cohort Study. Ann Intern Med. 2019;171(3):153-163. doi: 10.7326/M18-3640. DOI
27. Nayebi A, Navashenaq JG, Soleimani D, Nachvak SM. Probiotic supplementation: A prospective approach in the treatment of COVID-19. Nutr Health. 2022;28(2):163-175. doi: 10.1177/02601060211049631. DOI

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**CONFLICT OF INTEREST**
The Authors declare no conflict of interest

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