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Antibiotic therapy of community-acquired pneumonia in children of different age groups: outcomes of a multidisciplinary team approach (a retrospective analysis)

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Abstract: *Community-acquired pneumonia in children is a common infectious disease associated with a risk of severe complications. Optimisation of antimicrobial therapy is a key task, particularly with the involvement of a clinical pharmacist. The aim of this study was to evaluate the effectiveness of a multidisciplinary team, with a focus on the role of the clinical pharmacist in rationalising antimicrobial therapy for paediatric community-acquired pneumonia. A retrospective analysis of 90 cases of community-acquired pneumonia treatment in children was conducted at a clinic where a multidisciplinary team operates within the infection control unit. The analysis included the frequency of antibiotic prescriptions (considering the AWaRe classification), duration of therapy, and routes of administration of antimicrobials. Statistical analysis was performed using the χ^2 and t-test. The most frequently prescribed agents were cefotaxime (55.1%) and macrolides (24.4%). In the older age group, antibiotic combinations were more commonly used, which was associated with a significantly higher days of treatment burden ($p<0.005$). Reserve group antibiotics were not used. In 36.7% of cases, antibiotics were administered orally. The involvement of a multidisciplinary team, particularly a clinical pharmacist, contributes to improving the quality of antimicrobial therapy, minimising the unjustified use of broad-spectrum antibiotics, and ensuring adherence to the AWaRe principles and WHO recommendations.*

Keywords: Community-Acquired Pneumonia, Antimicrobial Stewardship, Pharmacists, Humans, Child.

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Introduction

The incidence of community-acquired pneumonia (CAP) remains high [1]. In children, CAP is one of the leading causes of mortality [2,3], particularly in those under 5 years of age [4], accounting for 20% of deaths in this group [5]. Approximately 14.5% of children with CAP require admission to the intensive care unit [6].

The most common pathogens of CAP in children are viruses; therefore, not every patient with non-severe CAP without risk factors requires antibiotic treatment. In such cases, a "watchful waiting" approach without antibiotics is recommended. This strategy helps to reduce adverse effects, treatment costs, and the spread of antimicrobial resistance [1]. However, a considerable proportion of pediatric CAP cases have a bacterial etiology, or bacterial superinfection may develop, in which case antibiotic therapy remains the cornerstone of etiological treatment.

It is well established that *S. pneumoniae*, the leading causative agent of CAP [7], is also the major contributor to years of life lost associated with or driven by antimicrobial resistance [8]. Therefore, timely and adequate antibacterial therapy in children with CAP is of utmost importance. On the other hand, aggressive antibiotic therapy may cause adverse reactions and carries the risk of promoting antimicrobial resistance.

To optimise antimicrobial therapy in healthcare facilities, infection control units are established, within which multidisciplinary teams operate. According to the Order of the Ministry of Health of Ukraine No. 1614 dated August 2, 2021, these teams must include a clinical pharmacist, who serves as the coordinator of the antimicrobial stewardship program [9]. The role of the clinical pharmacist in antimicrobial management has been widely discussed [10,11]. Pharmacist recommendations have been shown to reduce the duration of antimicrobial therapy for pneumonia [12–14]. Pharmacist involvement has also contributed to reducing the use of broad-spectrum antimicrobials [15]. Antimicrobial stewardship in the management of children with CAP includes educational programs, monitoring and reporting of antibiotic use and resistance, periodic audits with feedback, and pre-authorization procedures [16].

Aim

The aim of the research was to assess the impact of a multidisciplinary team (paediatricians, paediatric infectious disease specialists, and clinical pharmacists) on optimising antimicrobial therapy for paediatric community-acquired pneumonia.

Materials and Methods

The study was conducted at the Non-Commercial Enterprise "Kyiv City Children's Clinical Hospital No. 2," where in 2022 an infection control unit was established and local treatment protocols for infectious diseases were developed, including a local protocol for the management of community-acquired pneumonia in accordance with the clinical guideline "Community-acquired pneumonia in children" [17], WHO recommendations [18], and the national standard of care "Rational use of antibacterial and antifungal medicines for therapeutic and prophylactic purposes" [19].

A retrospective analysis was conducted on the use of antimicrobial agents in children with CAP who received inpatient treatment between January 1, 2025, and March 31, 2025. In total, 90 children (46 girls and 44 boys) aged 7 months to 17 years (mean age 8.36 ± 5.15 years) were treated for community-acquired pneumonia. Among them, 33 children were under 5 years of age (18 girls and 15 boys), and 57 were older than 5 years (28 girls and 29 boys).

Table 1. Demographic characteristics of the study population by age and sex

Age of children	Girls	Boys	Overall
≤5 years	18	15	33
>5 years	28	29	57
Total	46	44	90

Statistical analysis was performed using Microsoft Excel 365. Quantitative variables were described using the mean (M) and standard deviation (SD). The χ^2 (chi-square) test was used to compare frequencies, and the Student's

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t-test was applied to assess the significance of differences between mean values. Differences were considered statistically significant at $p < 0.05$. To evaluate antimicrobial burden, the days of therapy (DOT) metric was used.

Results

In total, 127 antimicrobial prescriptions were made for 90 patients. Most frequently (Fig. 1), children were empirically prescribed the third-generation intravenous cephalosporin cefotaxime (55.1%), often in combination with oral macrolides, clarithromycin (16.5%) or azithromycin (7.9%). Aminopenicillins, mostly in combination with β-lactamase inhibitors, were used less frequently (ampicillin/sulbactam in 7.9%, amoxicillin/clavulanate in 5.5%, and amoxicillin in 3.9%). Only three children (2.4%) older than 8 years received doxycycline, and one infant (0.8%) received cefpodoxime.

Combination therapy (two antimicrobial agents, mostly cefotaxime with clarithromycin, azithromycin, or doxycycline) was observed in 27 patients (47.4%) in the older age group and 5 patients (15.1%) in the younger age group, with the difference being statistically significant ($p < 0.005$). Consequently, antimicrobial burden, measured as days of therapy (DOT), was significantly higher in older children (10.44 ± 4.56 days vs. 8.03 ± 3.23 days; $p < 0.005$).

According to the data presented in Table 2, younger children more frequently received ampicillin/sulbactam (19.5% vs. 2.3%; $p < 0.05$), whereas older children were significantly more often prescribed cefotaxime (61.6% vs. 41.5%; $p < 0.05$). Azithromycin and doxycycline were prescribed exclusively to older children.

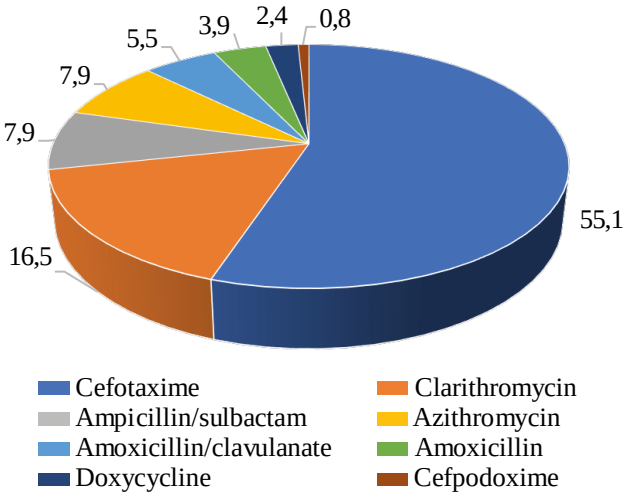

Figure 1. Proportion of antimicrobial agents prescribed to children with community-acquired pneumonia

Table 3 shows the features of the use of antimicrobial agents according to the AWaRe classification. No drugs from the Reserve group were used at all.

In older children, Watch group antibiotics were predominantly used (90.7%), whereas in younger children, Access group antibiotics (both protected and unprotected aminopenicillins) were used in 41.5% of cases, with the difference being statistically significant ($p < 0.001$).

Table 2. Use of antimicrobial agents in children of different age groups

Antimicrobial agent	Age of children					
	≤5 years		>5 years		Overall	
	Abs.	%	Abs.	%	Abs.	%
Amoxicillin	4	9.8	1	1.2	5	3.9
Amoxicillin/clavulanate	5	12.2	2	2.3	7	5.5
Ampicillin/sulbactam	8	19.5*	2	2.3	10	7.9
Doxycycline	0	0.0	3	3.5	3	2.4
Azithromycin	0	0.0	10	11.6	10	7.9
Clarithromycin	6	14.6	15	17.5	21	16.5
Cefotaxime	17	41.5	53	61.6*	70	55.1
Cefpodoxime	1	2.4	0	0.0	1	0.8
Total	**41**	**100.0**	**86**	**100.0**	**127**	**100.0**

An asterisk (*) indicates a significant difference ($p<0.05$)

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Table 3. Use of antimicrobial agents in children of different age groups according to the AWaRe classification

Groups of antimicrobial agents according to AWaRe classification	Age of children					
	≤5 years		>5 years		Overall	
	Abs.	%	Abs.	%	Abs.	%
Access group	17	41.5*	8	9.3	25	19.7
Watch group	24	58.5	78	90.7*	102	80.3
Reserve group	0	0.0	0	0.0	0	0.0
Total	**41**	**100.0**	**86**	**100.0**	**127**	**100.0**

An asterisk (*) indicates a significant difference ($p<0.05$)

Table 4. Route of administration of antimicrobial agents in children of different age groups

Route of administration of antimicrobial agents	Age of children					
	≤5 years		>5 years		Overall	
	Abs.	%	Abs.	%	Abs.	%
Parenteral	163	61.5	381	64.0	544	63.3
Oral	102	38.5	214	36.0	316	36.7
Total	**265**	**100.0**	**595**	**100.0**	**860**	**100.0**

No significant differences were observed in the route of administration of antimicrobial agents between age groups. In two-thirds of cases, drugs were administered intravenously, while in the remaining cases they were given orally.

The duration of antimicrobial therapy for community-acquired pneumonia in older patients was on average 6.89 ± 1.74 days, and in younger patients 6.58 ± 1.57 days.

Thus, the presence of a multidisciplinary team in the clinic contributed to the fact that, according to our 3-month retrospective audit, Reserve group antimicrobials were not used in the treatment of children with CAP.

Beta-lactam antibiotics of third-generation cephalosporins, protected and unprotected aminopenicillins were predominantly used, consistent with the main causative pathogen (*S. pneumoniae*). In cases with suspected atypical pneumonia (mainly in older children), macrolides (clarithromycin or azithromycin) or the tetracycline antibiotic doxycycline were prescribed in combination with beta-lactams.

Discussion

The results of other researchers indicate that mycoplasma pneumonia is detected in 7.4% of children with CAP, more frequently in older children with a mean age of 8.8 years [20]. It should be noted that macrolide resistance of *Mycoplasma* remains high. However, *M. pneumoniae* still demonstrates good *in vitro* susceptibility to second-line antibiotics such as tetracyclines, which makes them an effective treatment option for patients with initial treatment failure when macrolides are used [21].

The low consumption of Access group antibiotics in Ukraine is a widespread problem [22]. The activities of a multidisciplinary team help overcome barriers in physicians' acceptance of pharmacists' recommendations for optimising antimicrobial therapy, particularly in minimising the use of Reserve group antibiotics [23].

The success of therapy in children with community-acquired pneumonia, along with the minimal antimicrobial burden that reduces the risks of adverse drug reactions, drug-drug interactions, and the development of antibiotic resistance, was largely ensured by the activities of the multidisciplinary team. In particular, the clinical pharmacist was involved in the development of local protocols, the pre-authorization procedure, and the monitoring of antimicrobial prescriptions. According to other

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researchers, pharmacist-initiated interventions contributed to reducing antimicrobial use and preventing adverse drug reactions, with a relatively high level of physician acceptance [24]. The pharmacist participates in antibiotic selection and proposes dosing regimens for paediatric pneumonia [25,26]. Other studies indicate that clinicians generally respond positively to pharmacists' recommendations for CAP treatment, especially regarding the switch from intravenous to oral antibiotic administration, while being less receptive to restrictions on antibiotic use [27]. Evidence also shows that caregivers of children with pneumonia accept pharmacists' recommendations for optimising antimicrobial therapy [10]. Prolonged antimicrobial treatment remains a common practice [28]. This retrospective analysis has several limitations, namely a relatively small sample size and the absence of an assessment of the effectiveness of such antimicrobial stewardship interventions, specifically, a prospective audit with feedback. Future research should focus on evaluating the impact of prospective pharmaceutical consultations on the duration of antimicrobial therapy, the number of days of antibiotic use, and related outcomes.

Conclusions

The analysis of medical records conducted within this retrospective study demonstrated the effectiveness of a multidisciplinary team, including a clinical pharmacist, in the management of children with community-acquired pneumonia. All patients received antimicrobial therapy in accordance with current standards; reserve group antibiotics were not used; therapy was not associated with dose-dependent adverse effects; the average duration of antimicrobial treatment was approximately 7 days; and in one-third of cases, antibiotics were administered orally. These findings highlight the important role of the clinical pharmacist in rationalising antibiotic therapy and improving the quality of medical care for children with CAP.

Financing

This study received no external funding.

Conflict of interests

This publication does not cause any conflict between the authors, has not been and will not be the subject of commercial interest or remuneration in any form.

AI Disclosure

The authors used ChatGPT for language editing of the English text. The authors reviewed and verified all AI-generated content to ensure accuracy and integrity.

Consent to publication

All authors have read the text of the article and gave consent to its publication.

Author Contributions (CRediT taxonomy)

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Антибіотикотерапія негоспітальної пневмонії у дітей різних вікових груп: результати діяльності мультидисциплінарної команди (ретроспективний аналіз)

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Анотація: *негоспітальна пневмонія у дітей є поширеним інфекційним захворюванням із ризиком розвитку тяжких ускладнень. Оптимізація антимікробної терапії є ключовим завданням, зокрема із залученням клінічного фармацевта. Метою цього дослідження було оцінити ефективність роботи мультидисциплінарної команди, зокрема участь клінічного фармацевта, у раціоналізації антимікробної терапії негоспітальної пневмонії у дітей. У дослідженні проведено ретроспективний аналіз 90 випадків лікування негоспітальної пневмонії у дітей у клініці, в якій функціонує мультидисциплінарна команда на базі відділення інфекційного контролю. Аналізували частоту призначень антибіотиків, в т.ч. із урахуванням класифікації AWaRe, тривалість терапії, шляхи введення антимікробних препаратів. Статистичну обробку здійснено з використанням χ^2 та t-критерію. Найчастіше призначались цефотаксим (55,1%) та макроліди (24,4%). У старшій віковій групі частіше застосовували комбінації антибіотиків, що супроводжувалось достовірно вищим навантаженням кількості днів терапії ($p<0,005$). Препарати групи резерву не використовувались. У 36,7% випадків антибіотики призначались перорально. Участь мультидисциплінарної команди, зокрема клінічного фармацевта, сприяє підвищенню якості антимікробної терапії, мінімізації необґрунтованого використання антибіотиків широкого спектра, дотриманню принципів AWaRe та рекомендацій ВООЗ.*

Ключові слова: негоспітальна пневмонія, адміністрування антимікробних препаратів, фармацевти, люди, дитина