

Integration of the Biofire FilmArray Pneumonia Panel into an Established Antimicrobial Stewardship Program for Critically Ill Children with Severe Community-Acquired Pneumonia: A Real-World Study

Jorge Reyes-Chacón

jorgereyes83@gmail.com

Central University of Ecuador

Daniel Romero-Alvarez

Universidad Internacional SEK

Ariana Alomoto

Central University of Ecuador

Santiago Escalante

Pontificia Universidad Católica del Ecuador

Rosa Ávila

Hospital General del Sur de Quito, IESS

Diego Sánchez

Hospital General del Sur de Quito, IESS

Ana Valdivieso

Hospital General del Sur de Quito, IESS

Luiggi Heredia

Universidad de Las Américas

Juan Ignacio Gaviria

Hospital General del Sur de Quito, IESS

Daniel Garzón

Universidad San Francisco de Quito

Research Article

Keywords: BioFire FilmArray Pneumonia Panel, antimicrobial stewardship program, children, severe community-acquired pneumonia

Posted Date: September 25th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10923248/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.
[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Background:

Severe community-acquired pneumonia (sCAP) is a major cause of morbidity and mortality in children. We assessed the impact of incorporating the BioFire FilmArray Pneumonia Panel (BFPP) into an established antimicrobial stewardship program (ASP) on antimicrobial prescriptions in children with sCAP admitted to the pediatric intensive care unit (PICU).

Methods:

We conducted a retrospective observational study before and after the study in children with sCAP in the PICU. Controls were enrolled before ASP and BFPP implementation, whereas cases were enrolled after their implementation. The primary outcomes of empirical antibiotic therapy include escalation and de-escalation, the antimicrobial spectrum index (ASI), and the mean length of stay (mLOS).

Results:

We included 254 children with sCAP (n = 131 controls and n = 123 cases). Following ASP implementation, the proportion of patients who did not receive empiric antibiotics increased from 12.2% to 26.8%. However, the percentage of patients prescribed clarithromycin decreased from 70.4% to 4.4%. After BFPP implementation, empiric antibiotic therapy remained unchanged in 69 of 123 children (56.1%) and was modified in 54 (43.9%), including antibiotic initiation in 29 (23.6%), the use of broader-spectrum antibiotics or the addition of one or more agents in 11 (8.9%), and de-escalation in 14 (11.4%). The mean ASI decreased from 8.7 to 6.4 after ASP initiation, with a minimal change to 6.6 following BFPP integration. The mLOS was 4.36 days in the controls versus 4.86 days in the cases. The most common pathogens detected were *H. influenzae*, *S. pneumoniae*, *M. catarrhalis*, *S. aureus*, rhinovirus/enterovirus, adenovirus, parainfluenza virus, and respiratory syncytial virus.

Conclusions:

BFPP extends antimicrobial stewardship beyond de-escalation by supporting appropriate empiric therapy and preserving reductions in the antimicrobial spectrum without adversely affecting clinical outcomes.

INTRODUCTION

Community-acquired pneumonia (CAP) remains a major cause of pediatric hospitalization and mortality worldwide, particularly among children younger than 5 years (1). In 2019, CAP accounted for an estimated 740,000 deaths among children under five years of age (2). Although identifying the etiology

of pediatric CAP for definitive therapy remains clinically challenging, advances in conventional microbiology and molecular diagnostics have enhanced pathogen identification, particularly for respiratory viruses—such as respiratory syncytial virus, rhinovirus, and influenza A/B—as well as fastidious bacterial pathogens, including *Haemophilus influenzae* and *Streptococcus pneumoniae* (3–5). Currently, several rapid multiplex real-time polymerase chain reaction (PCR) assays cleared by the U.S. Food and Drug Administration (FDA) enable the simultaneous detection of viral and bacterial respiratory pathogens—including clinically relevant antimicrobial resistance determinants—from upper and lower respiratory samples within approximately one hour. This improves timely targeted therapy and antimicrobial stewardship programs (ASPs) (6). Among these assays, the BioFire FilmArray Pneumonia Panel (BFPP) identifies 27 clinically relevant pathogens (n = 15 typical bacteria, n = 3 atypical bacteria, and n = 8 viruses) along with seven antibiotic resistance genes from upper and lower respiratory samples with results available within approximately one hour (7).

ASP is a key strategy for optimizing antimicrobial use and improving clinical outcomes in pediatric populations, primarily through core interventions such as standardized clinical pathways and prospective audits with feedback (8). While ASPs consistently reduce antimicrobial consumption in general pediatric wards (9), their implementation in pediatric intensive care units (PICUs) remains heterogeneous, with substantial variation in antimicrobial stewardship interventions, outcome measures, and evaluation metrics used, limiting robust evaluations of their effectiveness (10). Considering that the BFPP has shown promising results in optimizing CAP management (11), evidence regarding its integration into ASPs for children with sCAP in the PICU has not been systematically evaluated.

We evaluated the impact of integrating the BFPP into an established PICU ASP on antibiotic prescription, the antimicrobial spectrum index (ASI), and the mean length of stay (MLOS) in children with sCAP.

METHODS

Study design and population

We conducted an observational, retrospective, case–control study in a 400-bed public hospital in Quito, Ecuador. This study enrolled children aged 1 month to 18 years admitted to the PICU for sCAP management. Diagnosis was established on the basis of clinical criteria, including fever, tachypnea, tachycardia, hypoxemia, mechanical ventilation requirement, and signs of poor peripheral perfusion. Children admitted in 2019, before ASP implementation, served as the control group. In contrast, the case group included children admitted in 2023, after the ASP was established and the BFPP became available. We selected patients from 2019 and 2023 to minimize bias related to the increased incidence of sCAP during the COVID-19 pandemic. Patients with pleural effusion were excluded.

Antimicrobial Stewardship Program and Molecular Testing

ASP activities based on institutional sCAP guidelines were integrated into the PICU, and the principal activities included prospective audits and feedback of empirical or definitive antibiotic prescriptions. These activities were subsequently complemented by the introduction of BFPP testing, which was performed on induced sputum or tracheal aspirate samples collected at admission and processed 24/7 in the microbiology laboratory. The laboratory technicians received specific training to rapidly process and report samples within two hours of receipt, whereas the PICU physicians were trained in the interpretation of BFPP findings.

The BFPP detects 23 pathogens, including eight viruses (adenovirus, coronavirus, human metapneumovirus, human rhinovirus, influenza A, influenza B, parainfluenza virus, and respiratory syncytial virus (RSV), 15 bacteria (*Acinetobacter calcoaceticus baumannii* complex, *Enterobacter cloacae* complex, *Escherichia coli*, *Haemophilus influenzae*, *Klebsiella aerogenes*, *Klebsiella oxytoca*, *Klebsiella pneumoniae* group, *Moraxella catarrhalis*, *Proteus* spp., *Pseudomonas aeruginosa*, *Serratia marcescens*, *S. aureus*, *Streptococcus agalactiae*, *S. pneumoniae*, and *Streptococcus pyogenes*), three atypical bacteria, *Chlamydia pneumoniae*, *Legionella pneumophila*, and *Mycoplasma pneumoniae*), and seven antibiotic resistance genes (*bla*_{CTX-M}, *bla*_{IMP}, *bla*_{KPC}, *bla*_{NDM}, *bla*_{OXA-48-LIKE}, *bla*_{VIM}, and *mecA/C-MREJ*).

Data collection and metrics

All study variables were extracted from medical records. The primary outcomes included empiric antibiotic therapy prescribed at PICU admission in both the case and control groups. Among the children in the case group, targeted antibiotic therapy was also evaluated and defined as the regimen prescribed 12 hours after the BFPP results became available. Changes in therapy were categorized as follows: (a) de-escalation, defined as switching to a narrower-spectrum antimicrobial regimen or discontinuing antimicrobial therapy when clinically appropriate; (b) escalation, defined as broadening the antimicrobial spectrum, adding one or more antimicrobial agents, or initiating a new antimicrobial regimen; or c) no change (12).

The antibiotic spectrum index (ASI) developed by Gerber et al. was used to quantify the antimicrobial spectrum, assigning weighted scores (numeric values) to antimicrobial agents according to their spectrum against different pathogens (13). In both groups, the mean ASI values were calculated for empirical antibiotic therapy initiated at PICU admission. In the case group, the ASI values were recalculated for targeted antibiotic therapy prescribed 12 hours after the BFPP results became available in the medical records. The secondary variables included length of hospital stay (LOS) and patient characteristics, including age, sex, comorbidities, and microorganisms detected by the BFPP.

Statistical analyses were performed via Microsoft Excel. Continuous variables are presented as the means or medians (interquartile ranges), as appropriate, whereas categorical variables are summarized as frequencies and percentages. The LOS in the PICU between the case and control groups was determined via the Mann–Whitney U test.

The ASI was analyzed as a continuous outcome. Multivariable linear regression models were used to evaluate the independent associations between the integration of BFPP into an ASP and ASI after adjustment for age, sex, and LOS. The results are presented as β coefficients with 95% confidence intervals (CIs) for linear regression. A two-sided p value < 0.05 was considered statistically significant.

RESULTS

A total of 254 children with sCAP were included (controls, $n = 131$; cases, $n = 123$), with a mean age of approximately three years in both groups. The mean LOS in the PICU was 4.36 days for controls and 4.86 days for cases (Mann–Whitney U test; $U = 6064.5$, $p = 0.00068$). The overall mortality rate was 2.29% in the control group and 1.63% in the case group ($p = 0.57$), as shown in Table 1.

Table 1
Demographics of the studied population. A total of 254 patients were included in the analysis, with 131 controls and 123 cases. Patients were categorized according to gender and age. Sd: standard deviation.

Gender		Control 2019 n = 131 (%)	Cases 2023 n = 123 (%)
	Female	63 (48.092)	65 (52.846)
	Male	68 (51.908)	58 (47.154)
Age (years)	Under 1	47 (35.878)	21 (17.073)
	1 to 5	55 (41.985)	77 (62.602)
	5 to 10	23 (17.557)	20 (16.260)
	10 to 18	6 (4.580)	5 (4.065)
	Average age	3.001 (sd: 3.436)	3.548 (sd: 3.152)
Other pathologies		46 (35.115)	15 (12.195)
Stay in ICU (Days)		4.366 (sd: 3.959)**	4.862 (sd: 2.962)*
Mortality		3 (2.290)	2 (1.626)**
* $p = 0.00068$.			
** $p = 0.57$			

BFPP detected at least one pathogen (virus or bacteria) in 122/123 (99.2%) samples. The most frequently detected bacteria were *H. influenzae* ($n = 87$, 70.7%), *S. pneumoniae* ($n = 66$, 53.8%), *M. catarrhalis* ($n = 46$, 37.3%), and *S. aureus* ($n = 45$, 36.5%). Among the viral pathogens, human rhinovirus/enterovirus was the most prevalent ($n = 90$, 73.1%), followed by adenovirus ($n = 45$, 36.5%), parainfluenza virus ($n = 35$, 28.4%), and RSV ($n = 30$, 24.3%). The *mecA/C-MREJ* resistance determinant was identified in 13/45 *S. aureus*-positive samples (28.9%). Table 2.

Table 2

Microorganisms and antibiotic resistance genes detected by Biofire FilmArray Pneumonia Panel (BFPP). The most common pathogens detected were *H. influenzae*, *S. pneumoniae*, *M. catarrhalis*, *S. aureus*, human rhinovirus-enterovirus, and adenovirus in induced sputum samples from children with sCAP.

Microorganism or antibiotic resistance gene detected	Number	percentaje
<i>Haemophilus influenzae</i>	87	70.731
<i>Streptococcus pneumoniae</i>	66	53.658
<i>Moraxella catarrhalis</i>	46	37.398
<i>Staphylococcus aureus</i>	45	36.583
<i>Escherichia coli</i>	4	3.252
<i>Klebsiella pneumoniae</i>	4	3.252
<i>Klebsiella oxytoca</i>	2	1.626
<i>Enterobacter cloacae complex</i>	1	0.813
<i>Acinetobacter calcoaceticus-baumannii</i>	1	0.813
Atypical bacteria	n	%
<i>Chlamydia pneumoniae</i>	1	0.813
Viruses	n	%
Human rhinovirus - enterovirus	90	73.170
Adenovirus	45	36.585
Parainfluenza virus	35	28.455
Respiratory syncytial virus	30	24.390
Influenza A	21	17.073
Human metapneumovirus	14	11.382
Coronavirus	12	9.756
Influenza B	1	0.813
Resistance genes	n	%
* <i>mecA/C</i> and <i>MREJ</i>	13	10.569
** <i>bla</i> _{CTX-M}	4	3.252
Not detected	1	0.813
	1	0

nfections were present in 118 of 123 samples (95.9%), predominantly involving virus–bacterium combinations. The most frequent coinfections were human rhinovirus/enterovirus with *H. influenzae*, *S. pneumoniae*, *M. catarrhalis*, or *S. aureus*. Adenovirus, RSV, and parainfluenza virus were detected in a smaller subset of samples. Among the bacterial–bacterial coinfections, *H. influenzae* in combination with *S. pneumoniae* was the most prevalent combination (n = 44/87, 50.6%), followed by *M. catarrhalis* in combination with *S. pneumoniae* or *S. aureus*. Table 3.

Table 3

Coinfections detected by the BioFire FilmArray Pneumonia Panel (BFPP). Bacterial–viral coinfections are presented in a correlogram illustrating the frequency and percentage of each microbial association.

*Percentages are calculated based on the total number of samples in each column.

Haemophilus influenzae	<i>Haemophilus influenzae</i> n = 87 (%)	<i>Streptococcus pneumoniae</i> n = 66 (%)	<i>Moraxella catarrhalis</i> n = 46 (%)	<i>Staphylococcus aureus</i> n = 45 (%)
	-	-	-	-
Streptococcus pneumoniae	44 (50.5)	-	-	-
Moraxella catarrhalis	32 (36.7)	29 (43.9)	-	-
Staphylococcus aureus	32 (36.7)	28 (42.4)	20 (43.4)	-
Human rinovirus-enterovirus	68 (78.1)	48 (72.7)	33 (71.7)	36 (80)
Adenovirus	39 (44.8)	25 (37.8)	20 (43.478)	15 (33.3)
Parainfluenza	20 (22.9)	19 (28.7)	18 (39.1)	12 (26.6)
Respiratory syncytial virus	19 (21.8)	21 (31.8)	15 (32.6)	9 (20)

ASP intervention resulted in a greater proportion of patients without empiric antibiotic therapy (n = 33/123; 26.8%) than did the control (n = 16/131; 12.2%), representing an absolute difference of 14.6 percentage points. Among the 115/131 (87.8%) control patients receiving empiric antibiotic prescriptions, 81/115 (70.4%) included clarithromycin, either as monotherapy or in combination with ceftriaxone or ampicillin–sulbactam. In contrast, ASP activities markedly reduced the number of clarithromycin prescriptions to 4/90 (4.4%) children, with a corresponding increase in the use of ampicillin–sulbactam (43/90, 47.7%) and ceftriaxone (n = 27/90, 30%) as monotherapies.

Following the BFPP implementation, empirical antibiotic regimens were modified in 54 children (43.9%): antibiotic therapy was initiated in 29 (23.6%), broader-spectrum antibiotics or the addition of one or more

antibiotics was used in 11 (8.9%), and de-escalation was used in 14 (11.4%) children. In contrast, empirical antimicrobial regimens remained unchanged in 69 children (56.1%) (Fig. 1; Table 4).

Table 4

Antibiotic prescription based on Biofire FilmArray Pneumonia Panel (BFPP) results. De-escalation was defined as a switch to narrower-spectrum therapy or treatment discontinuation, while escalation was defined as broadening of antimicrobial coverage, addition of one or more agents, or initiation of antimicrobial therapy.

Antibiotic prescriptions after BFPP results	Number (%)
No change	69 (56.1)**
Change	
De-escalation	14 (11.4)*
Escalation	
Use of broader-spectrum antibiotic or the addition of one or more antibiotics	11 (8.9)
Initiation of antimicrobial therapy.	29 (23.6)
Total	123 (100)
*Antibiotics were discontinued in one patient	
** Antibiotic therapy was not initiated in four patients.	

ASP implementation reduced the ASI from 8.7 in the control group to 6.4 in the case group ($P < 0.001$). After adjustment for age, sex, and length of stay, ASP implementation was independently associated with a 2.71-point reduction in ASI compared with the control group (95% CI, -3.46 – -1.96 ; $p < 0.001$). Interestingly, therapeutic decision-making on the basis of the BFPP results did not influence the ASI value, which remained at 6.6 (Fig. 2).

DISCUSSION

Our study provides real-world evidence that the clinical utility of BFPP extends beyond antibiotic de-escalation. When incorporated into an established PICU ASP, the BFPP optimized empiric antibiotic prescribing by confirming guideline-concordant empiric therapy and enabling prompt treatment optimization. These prescribing decisions were associated with the sustained use of narrower-spectrum antimicrobial regimens, reflected by a reduced ASI. To our knowledge, this is the first study to report ASI values before and after the integration of rapid molecular pneumonia diagnostics into an ASP, providing preliminary reference data for future stewardship studies in pediatric sCAP.

Our findings highlight three clinically relevant scenarios. First, accumulating evidence suggests that ASP in the PICU reduces the prescription of beta-lactam, glycopeptide, and aminoglycoside antibiotics without compromising clinical outcomes (14, 15). Similarly, in children with sCAP, a previous study reported that ASP implementation was associated with reduced use of cephalosporins, carbapenems,

macrolides, antifungal agents, and linezolid (16). Consistent with these findings, in our cohort, ASP implementation was associated with reduced prescribing of clarithromycin, either as monotherapy or in combination with other antibiotics, while increasing the use of beta-lactam monotherapy. These prescribing patterns were consistent with the low prevalence of atypical bacterial pathogens detected by BFPP. Moreover, before ASP implementation, the mean ASI was 8.7, reflecting the routine use of broader-spectrum empiric regimens in the absence of a structured ASP. Following ASP implementation, the mean ASI decreased to 6.4, which is consistent with adherence to guidelines for empiric antibiotic therapy involving the use of narrower-spectrum antibiotics.

Second, our findings should be interpreted in the context of a recent randomized clinical trial by Chen et al., who assessed the proportion of hospitalized children with infectious pneumonia who experienced any antibiotic change within 72 hours. Compared with standard care alone, the addition of BFPP to standard care did not significantly increase this outcome (51.6% vs. 49.4%). However, secondary outcomes included greater pathogen-directed antimicrobial modifications and antibiotic de-escalation (17). In our cohort, following the introduction of the BFPP into an established ASP for critically ill children with sCAP hospitalized in the PICU, empiric antibiotic therapy, including the initiation of antibiotic therapy, escalation, and de-escalation, was modified for 43.9% of the children. Notably, empirical antibiotic therapy was maintained in 56.1% of the children. Given that the ASP already promoted narrower-spectrum empiric therapy guideline-concordant, the provision of rapid microbiological results from the BFPP may have enabled timely confirmation that the initial regimen remained appropriate, thereby supporting continuation rather than prompting unnecessary change (escalation). This interpretation is supported by the mean ASI, which showed a minimal increase from 6.4 to 6.6 after BFPP integration. Thus, the addition of BFPP did not reverse the reduction in the antimicrobial spectrum achieved by the ASP but rather maintained a relatively narrow-spectrum prescribing strategy. These findings suggest that the stewardship value of BFPP may extend beyond antibiotic modification alone (escalation or de-escalation); its clinical utility may also lie in informing appropriate continuation of empiric therapy according to the microbiological and clinical context in children with sCAP in the PICU.

Third, although the diagnosis of CAP relies on a combination of clinical, radiological, and microbiological findings, pathogen identification remains essential for guiding targeted antibiotic therapy. However, the clinical utility of conventional microbiological tests is limited by their diagnostic performance and prolonged turnaround times, which delay therapeutic decision-making. For example, serological assays for atypical bacteria (e.g., *Mycoplasma* spp.) require either high antibody titers or a significant increase between paired acute and convalescent sera, limiting their value for early clinical management (18, 19). Likewise, pneumococcal urinary antigen testing remains controversial because of its limited specificity (often below 70%), particularly in children with high rates of nasopharyngeal colonization by *S. pneumoniae*, resulting in a high frequency of false-positive results (20). Furthermore, although blood cultures have long been recommended for the recovery of pathogens in CAP, their clinical utility is limited by their low diagnostic yield (approximately 5.14%). Together with the risk of false-positive results and prolonged turnaround times, which are typically 3–5 days for bacterial identification and antimicrobial susceptibility testing, their usefulness for guiding antimicrobial therapy is limited (21). Similarly,

inflammatory biomarkers such as C-reactive protein and procalcitonin have modest diagnostic accuracy for distinguishing bacterial from viral CAP in children (22), highlighting the need for improved diagnostic strategies.

The BFPP integrates a rapid turnaround time (approximately 2 hours), a fully automated multiplex platform, and excellent diagnostic performance (sensitivity and specificity > 94%). Its high discriminatory capacity between infected and non-infected samples is supported by a pooled log diagnostic odds ratio of 6.35 (23, 24). Consequently, its integration into ASP is recommended to accelerate pathogen identification and facilitate the timely transition from empirical to targeted therapy. In our study, BFPP predominantly identified common respiratory pathogens, such as *S. pneumoniae*, *H. influenzae*, *M. catarrhalis*, *S. aureus*, human rhinovirus/enterovirus, adenovirus, and parainfluenza virus, which accounted for 92% of all positive detections in children with sCAP. Conversely, atypical pathogens are uncommon, with only a single detection of *C. pneumoniae*. This contrasts with previous studies reporting a prevalence of 3.6% for *M. pneumoniae* and 2.7% for *C. pneumoniae* (25). Although this low yield may suggest a limited role for atypical pathogens in sCAP within our setting, it should be interpreted with caution given potential variations in local epidemiology, study populations, diagnostic methods, and prior macrolide exposure (26). Finally, co-detection occurred in 89% of the children. Previous studies have proposed that viral–bacterial coinfections carry a worse prognosis than either single viral infections or viral coinfections do, leading to higher white blood cell counts, radiographic consolidation, parapneumonic effusions, a greater need for pediatric intensive care and mechanical ventilation, and an extended length of stay (27), providing a potential tool for decision-making and prognosis.

Our findings must be interpreted in light of several limitations; although a statistically significant difference in LOS was observed between cases and controls (4.4 vs. 4.8), LOS in critical care settings is influenced by multiple clinical and organizational factors. Furthermore, the relatively small sample size (n = 254) and the single-center design, despite being conducted in a tertiary 400-bed hospital, limit the external validity of our findings. Nevertheless, to our knowledge, comparable studies have not previously been conducted; therefore, our results may provide a preliminary framework for future multicenter investigations.

CONCLUSIONS

The implementation of BFPP in combination with an ASP was associated with improved antibiotic prescription in children with sCAP. In our cohort, the most frequently detected pathogens were *H. influenzae*, *S. pneumoniae*, and viral–bacterial coinfections. The ASP strategy, which prioritized the thoughtful use of macrolides and promoted early pathogen identification, facilitated appropriate therapeutic decisions, including targeted escalation or maintenance of therapy when indicated. Furthermore, the identification of an ASI value of 6.6 represents a relevant benchmark for future studies evaluating the antibiotic spectrum as an early indicator of disease severity in PICUs operating under ASP strategies.

Declarations

Funding

The authors declare that this study was entirely self-funded and received no financial support from external agencies, whether public, commercial or nonprofit. The authors are solely responsible for the study design, data collection, analysis, interpretation, and manuscript preparation.

Data availability:

The data supporting the findings of this study are not publicly available because they contain confidential patient information. The datasets are securely maintained by the investigators and may be made available from the corresponding author upon reasonable request, subject to institutional approval and applicable ethical and confidentiality requirements.

Conflicts of interest

JR-Ch reports having served as a consultant for bioMérieux and having received grant funding from Pfizer outside the submitted work. The other authors have no conflicts of interest to declare.

Ethics approval statement

This study, with codes 2023–031 M, was approved by the Research Ethics Committee on Human Subjects (CEISH) of Universidad San Francisco de Quito-Ecuador in 2023. In compliance with the Declaration of Helsinki, an anonymized database was created by the statistical department of the Hospital General IESS Sur de Quito using data from electronic health records (EHRs). The analysis was performed exclusively on this dataset, and none of the authors knew any identity details of the patients, ensuring that patient re-identification was not possible; for this reason, parental consent was not required by the CEISH.

Author Contributions

All the authors made a significant contribution to the work reported, whether in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; agreed on the journal to which the article has been submitted; and agreed to be accountable for all aspects of the work.

Clinical trial number: not applicable

References

1. Smith DK, Kuckel DP, Recidoro AM. Community-Acquired Pneumonia in Children: Rapid Evidence Review. *Am Fam Physician*. 2021 Dec 1;104(6):618-625. PMID: 34913645.

2. Roh EJ, Shi JY, Chung EH. Epidemiology and surveillance implications of community-acquired pneumonia in children. *Clin Exp Pediatr*. 2022 65:563–73. 10.3345/cep.2022.0037
3. Pratt TG, Abdalla T, Richmond PC, et al. Prevalence of respiratory viruses in community-acquired pneumonia in children: a systematic review and meta-analysis. *Lancet Child Adolesc Health* 2022;6(8):555–570. [https://doi.org/10.1016/S2352-4642\(22\)00092-X](https://doi.org/10.1016/S2352-4642(22)00092-X)
4. Von Mollendorf C, Berger D, Gwee A, Duke T, et al. Aetiology of childhood pneumonia in low- and middle-income countries in the era of vaccination: a systematic review. *J Glob Health* 2022;23:10009. <https://doi.org/10.7189/JOGH.12.10009>
5. Rueda ZV, Aguilar Y, Maya MA, et al. Etiology and the challenge of diagnostic testing of community-acquired pneumonia in children and adolescents. *BMC Pediatr* 2022 Mar 31;22(1):169. <https://doi.org/10.1186/s12887-022-03235-z>
6. Pickens C. POINT: Should Multiplex Molecular Panels Be Performed on All Patients With Community Acquired Pneumonia? Yes
CHEST 2024;167 (1):24 – 27 <https://doi.org/10.1016/j.chest.2024.08.052>
7. Kosai K, Akamatsu N, Ota K, et al. BioFire FilmArray Pneumonia Panel enhances detection of pathogens and antimicrobial resistance in lower respiratory tract specimens. *Ann Clin Microbiol Antimicrob* 2022; 4;21(1):24. <https://doi.org/10.1186/s12941-022-00512-8>
8. Hwang S, Kwon K T. Core Elements for Successful Implementation of Antimicrobial Stewardship Programs. *Infect Chemother* 2021; 53 (3):421. <https://doi.org/10.3947/IC.2021.0093>.
9. Donà D, Barbieri E, Daverio M, et al. Implementation and impact of pediatric antimicrobial stewardship programs: a systematic scoping review. *Antimicrob Resist Infect Control* 2020; 9(1):3. <https://doi.org/10.1186/s13756-019-0659-3>
10. Liberati C, Brigadoi G, Barbieri E, et al. Antimicrobial Stewardship Programs in Pediatric Intensive Care Units: A Systematic Scoping Review. *Antibiotics*. 2025; 14(2):130. <https://doi.org/10.3390/antibiotics14020130>
11. Markussen DL, Serigstad S, Ritz C, Knoop ST, et al. Diagnostic Stewardship in Community-Acquired Pneumonia With Syndromic Molecular Testing: A Randomized Clinical Trial. *JAMA Netw Open*. 2024 Mar 4;7(3):E240830. <https://doi.org/10.1001/jamanetworkopen.2024.0830>
12. Ohji G, Doi A, Yamamoto S, Iwata K. Is de-escalation of antimicrobials effective? A systematic review and meta-analysis. *Int J Infect Dis*. 2016 Aug;49:71-9. <https://doi.org/10.1016/j.ijid.2016.06.002>
13. Gerber JS, Hersh AL, Kronman MP, Newland JG, Ross RK, Metjian TA. Development and Application of an Antibiotic Spectrum Index for Benchmarking Antibiotic Selection Patterns Across Hospitals. *Infect Control Hosp Epidemiol* 2017; 38 (8): 993–997. <https://doi.org/10.1017/ICE.2017.94>.
14. Wassef, M, Sayed, A, Aziz A, Meligy B, Halim A. Implementation and evaluation of antimicrobial stewardship program in medical icu in cairo university specialized pediatric hospital. *Open Access Maced. J. Med. Sci*. 2020; 8:716–722.

15. Liberati C, Brigadoi G, Gres E, et al. Revisiting antimicrobial stewardship in the intensive care unit: insights from an unconventional approach. *J Hosp Infect* 2025; 160, 53-59
16. Fan C, Yang M, Mao Y, Fang B, He Y, Li R et al. Effect of Antimicrobial Stewardship 2018 on severe pneumonia with bacterial infection in paediatric intensive care units. *J Glob Antimicrob Resist*. 2024 Mar;36:444-452. doi: 10.1016/j.jgar.2023.10.017. Epub 2023 Nov 5.
17. Chen J, Wang J, Zhou Y. et al. Impact of a multiplex respiratory PCR panel on antibiotic stewardship in hospitalized pediatric pneumonia: a randomized clinical trial. *Eur J Pediatr* 2026;185:497 <https://doi.org/10.1007/s00431-026-07168-y>
18. Wang K, Gill P, Perera R, Thomson A, Mant D, Harnden A. Clinical symptoms and signs for the diagnosis of *Mycoplasma pneumoniae* in children and adolescents with community-acquired pneumonia. *Cochrane Database Syst Rev* 2012; 10. <https://doi.org/10.1002/14651858.CD009175.pub2>
19. Shim JY. Current Perspectives on Atypical Pneumonia in Children. *Clin Exp Pediatr* 2020; 63 (12): 469. <https://doi.org/10.3345/CEP.2019.00360>.
20. Ambroggio L, Grant LR, Cotter JM, et al. Urinary pneumococcal serotype detection among children with and without community-acquired pneumonia. *BMC Infect Dis*. 2025 Aug 7;25(1):995. <https://doi.org/10.1186/s12879-025-11384-6>
21. Iroh Tam PY, Bernstein E, Ma X, Ferrieri P. Blood culture in evaluation of pediatric community-acquired pneumonia: a systematic review and meta-analysis. *Hosp pediatr*. 2015; 5(6): 324-336. <https://doi.org/10.1542/hpeds.2014-0138>
22. Gunaratnam LC, Robinson JL, Hawkes MT. Systematic Review and Meta-Analysis of Diagnostic Biomarkers for Pediatric Pneumonia. *J Pediatric Infect Dis Soc* 2021; 10(9):891–900. <https://doi.org/10.1093/jpids/piab043>
23. Moy AC, Kimmoun A, Merkling T, et al. Performance evaluation of a PCR panel (FilmArray® Pneumonia Plus) for detection of respiratory bacterial pathogens in respiratory specimens: A systematic review and meta-analysis. *Anaesth Crit Care Pain Med*. 2023; 42(6):101300. <https://doi.org/10.1016/j.accpm.2023.101300>
24. Sogaard KK, Hinic V, Goldenberger D, et al. Evaluation of the clinical relevance of the Biofire® FilmArray pneumonia panel among hospitalized patients. *Infection*. 2024; 52(1):173-181. <https://doi.org/10.1007/s15010-023-02080-1>
25. Gentile A, Bardach A, Ciapponi, A, et al. Epidemiology of community-acquired pneumonia in children of Latin America and the Caribbean: a systematic review and meta-analysis. *Int J Infect Dis* 2012; 16(1): e5-e15. <https://doi.org/10.1016/j.ijid.2011.09.013>
26. Zewdie S, Kassa AA, Bizuneh MM, Tesfaye TC, Yayehrad AT. Antibiotic use without prescription among children aged under 5 years in low- and middle-income countries: a systematic review and meta-analysis. *JAC Antimicrob Resist*. 2025; 7(3):dlaf093. <https://doi.org/10.1093/jacamr/dlaf093>

Figures

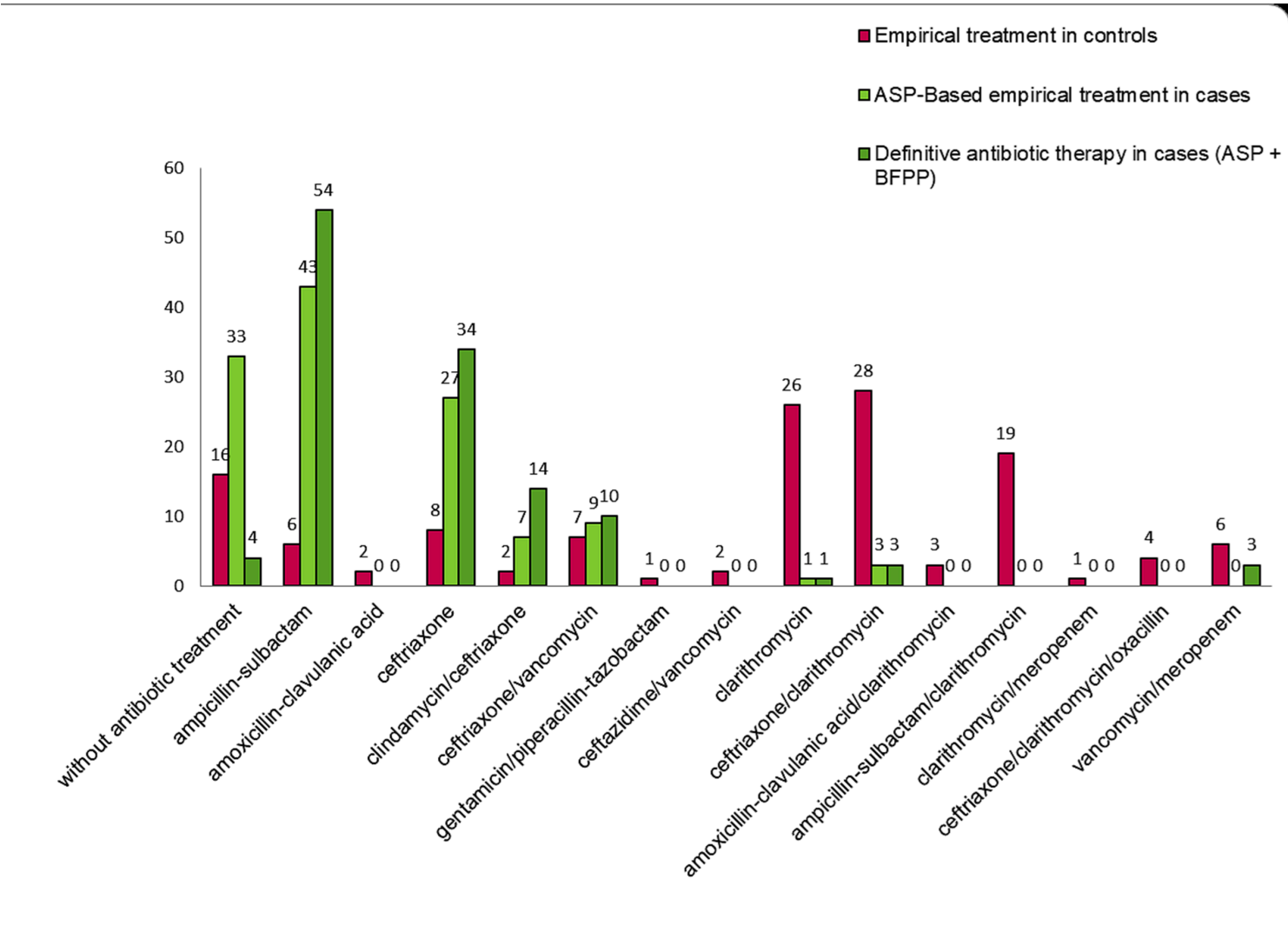


Figure 1

Antibiotic treatment prescribed during the study

For 2019, antibiotic treatment included antibiotics prescribed 24 hours after the patient entered the pediatric intensive care unit (PICU, purple). For 2023, the bars represent antibiotics prescribed 12 hours after the Biofire FilmArray Pneumonia Panel (BFPP) result (green).

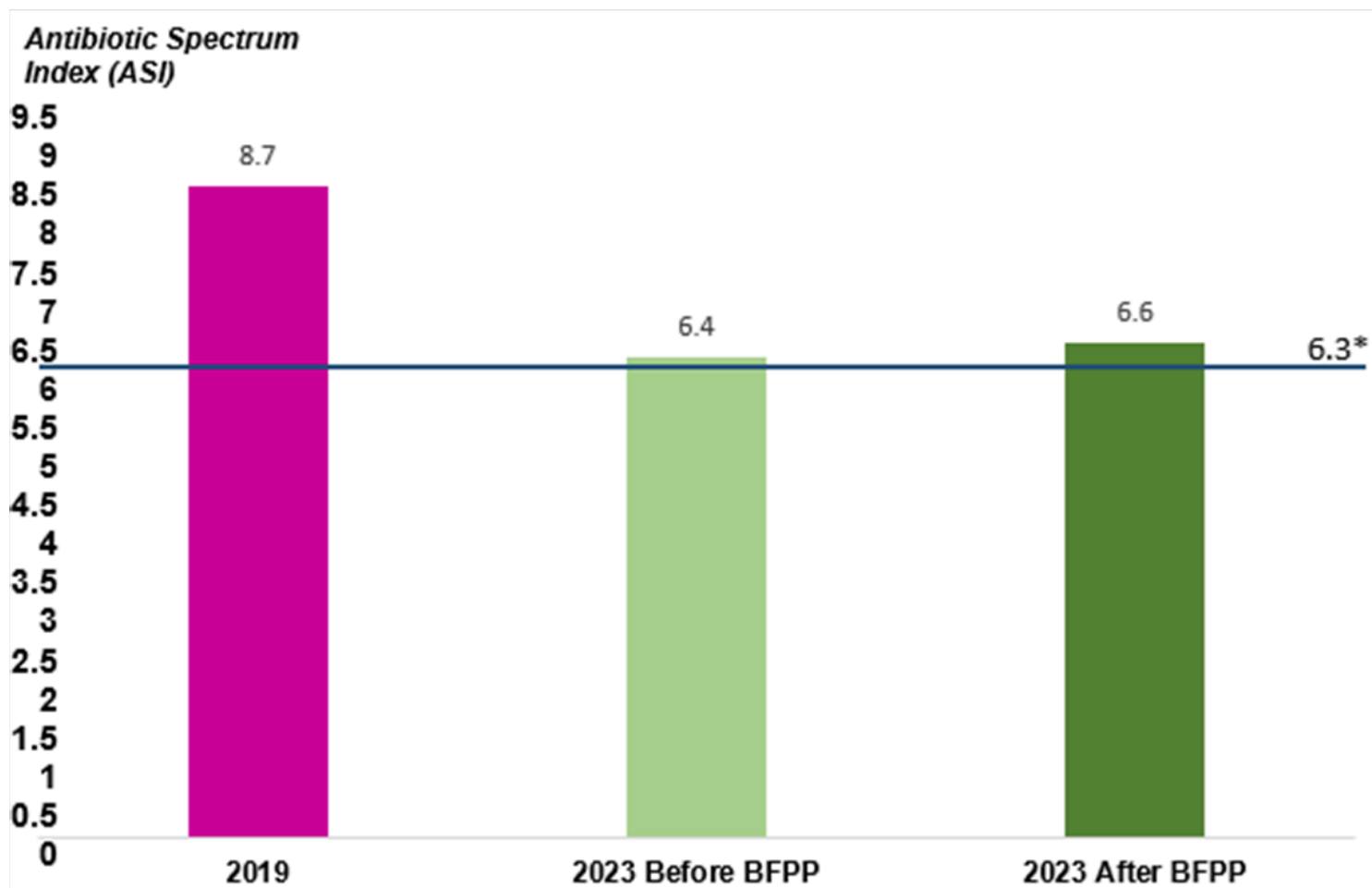


Figure 2

The antibiotic spectrum index (ASI) was calculated for cases and controls.

Comparison of average ASI values for controls (2019) and cases (2023). For 2023, the ASI was compared before (light green) and after (green) the implementation of the Biofire FilmArray Pneumonia Panel (BFPP).

*The value of 6.3 is the ASI calculated according to Gerber et al. (2017) for community-acquired pneumonia (CAP).