



Published in final edited form as:

Clin Infect Dis. 2025 February 24; 80(2): 263–270. doi:10.1093/cid/ciae593.

Impact of Clinician Feedback Reports on Antibiotic Use in Children Hospitalized With Community-acquired Pneumonia

Kathleen Chiotos^{1,2,3,4}, Lauren Dutcher⁵, Robert W. Grundmeier^{3,6}, Didien Meyahnwi⁴, Ebbing Lautenbach^{5,7,8}, Melinda M. Neuhauser⁹, Lauri A. Hicks⁹, Keith W. Hamilton⁵, Yun Li⁷, Julia E. Szymczak¹⁰, Brandi M. Muller¹⁰, Morgan Congdon^{3,4,6}, Emily Kane^{3,6}, Jessica Hart⁶, Levon Utidjian^{3,6}, Leigh Cressman⁸, Anne Jaskowiak-Barr⁸, Jeffrey S. Gerber^{2,3,4,7}

¹Division of Critical Care Medicine, Department of Anesthesiology and Critical Care, Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, USA

²Division of Infectious Diseases, Department of Pediatrics, Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, USA

³Department of Pediatrics, University of Pennsylvania Perelman School of Medicine, Philadelphia, Pennsylvania, USA

⁴Clinical Futures, Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, USA

⁵Division of Infectious Diseases, Department of Medicine, University of Pennsylvania Perelman School of Medicine, Philadelphia, Pennsylvania, USA

⁶Division of General Pediatrics, Department of Pediatrics, Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, USA

⁷Department of Biostatistics, Epidemiology, and Informatics, University of Pennsylvania Perelman School of Medicine, Philadelphia, Pennsylvania, USA

⁸Center for Clinical Epidemiology and Biostatistics, Perelman School of Medicine, University of Pennsylvania, Philadelphia, Pennsylvania, USA

For commercial re-use, please contact reprints@oup.com for reprints and translation rights for reprints. All other permissions can be obtained through our RightsLink service via the Permissions link on the article page on our site—for further information please contact journals.permissions@oup.com. <https://doi.org/10.1093/cid/ciae593>

Correspondence: K. Chiotos, Department of Anesthesiology and Critical Care Medicine, Children's Hospital of Philadelphia, 3401 Civic Center Blvd, 9th Fl Main Hospital, 9NW29, Philadelphia, PA 19104 (chiotosk@chop.edu); J. S. Gerber, Department of Pediatrics, Roberts Center for Pediatric Research, 2716 South St, Rm 10364, Philadelphia, PA 19146 (gerberj@chop.edu).

Author contributions. K. C. had full access to all of the data and takes responsibility for the integrity of the data and the accuracy of the analysis. Study concept and design: K. C., L. D., R. W. G., E. L., M. M. N., L. A. H., K. W. H., J. E. S., B. M. M., M. C., E. K., J. H., L. U., J. S. G. Acquisition of data and statistical analysis: K. C., R. W. G., D. M., Y. L., J. S. G. Analysis and interpretation of data: K. C., L. D., R. W. G., E. L., M. M. N., L. A. H., K. W. H., L. C., J. S. G. Critical review of manuscript: L. D., R. W. G., E. L., M. M. N., L. A. H., K. W. H., J. E. S., B. M. M., M. C., E. K., J. H., L. U., A. J. B., J. S. G.

Disclaimer. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the U.S. Centers for Disease Control and Prevention (CDC).

Supplementary Data

Supplementary materials are available at *Clinical Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Potential conflicts of interest. The authors: No reported conflicts of interest. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

⁹Division of Healthcare Quality Promotion, National Center for Emerging and Zoonotic Infectious Diseases, U.S. Centers for Disease Control and Prevention, Atlanta, Georgia, USA

¹⁰Division of Epidemiology, University of Utah School of Medicine, Salt Lake City, Utah, USA

Abstract

Background. Feedback reports summarizing clinician performance are effective tools for improving antibiotic use in the ambulatory setting, but the effectiveness of feedback reports in the hospital setting is unknown.

Methods. Quasi-experimental study conducted between December 2021 and November 2023 within a pediatric health system measuring the impact of clinician feedback reports delivered by email and reviewed in a monthly meeting on appropriate antibiotic use in children hospitalized with community-acquired pneumonia (CAP). We used an interrupted time series analysis (ITSA) to estimate the immediate change and change over time in the proportion of CAP encounters adherent to validated metrics of antibiotic choice and duration, then used Poisson regression to estimate intervention effect as a risk ratio (RR).

Results. Preintervention, 213 of 413 (52%) encounters received the appropriate antibiotic choice and duration, which increased to 308 of 387 (80%) postintervention. The ITSA demonstrated an immediate 18% increase in the proportion of CAP encounters receiving both the appropriate antibiotic choice and duration (95% confidence interval [CI]: 3–33%), with no further change over time (–0.3% per month, 95% CI: –2%–2%). In the Poisson model adjusted for age, sex, race, season, site, and intensive care unit admission, the intervention was associated with a 32% increase in the rate of appropriate antibiotic choice and duration (RR 1.32, 95% CI: 1.12–1.56, $P < .01$). No difference in length of stay or revisits were detected postintervention.

Conclusions. The intervention was associated with an increase in clinician adherence to antibiotic choice and duration recommendations for children hospitalized with CAP.

Keywords

community-acquired pneumonia; antimicrobial stewardship; feedback report; audit and feedback; antibiotic

Community-acquired pneumonia (CAP) is among the most common indications for antibiotic treatment in pediatric inpatients [1–3]. Ampicillin is recommended as the first-line treatment for most children hospitalized with non-severe pneumonia [4]. Multiple randomized trials and observational studies have demonstrated that five days of antibiotic treatment is as effective as longer durations for CAP in non-immunocompromised patients who are clinically stable within five days of starting therapy, a recommendation reflected in the 2019 American Thoracic Society/Infectious Diseases Society of America adult CAP guidelines [5–9].

Given the high prevalence of CAP among hospitalized children, ensuring adherence to evidence-based recommendations is a priority for pediatric antimicrobial stewardship programs (ASPs). Several studies have demonstrated the effectiveness of targeted prospective audit with feedback on improving antibiotic use for CAP [10–13]. However,

this requires significant time investment that may not be feasible in all settings. Electronic feedback reports summarizing individual clinician performance are effective tools for improving adherence to evidence-based recommendations for antibiotic use in the outpatient setting, but the role of clinician feedback reports in the inpatient setting is unknown [14–18]. Using previously validated measures of appropriate antibiotic choice and duration derived from electronic health record (EHR) data [19], the objective of this study was to evaluate the effectiveness of clinician feedback reports for improving initial antibiotic choice and total antibiotic duration in children hospitalized with CAP.

METHODS

Study Design

We performed a quasi-experimental study assessing the impact of audit and feedback reports on adherence to antibiotic choice and duration recommendations for CAP between December 2021 and November 2023. This study was approved by the Children's Hospital of Philadelphia Institutional Review Board as exempt research and registered on [clinicaltrials.gov](https://clinicaltrials.gov/ct2/show/study/NCT06027593) (NCT06027593).

Study Setting and Population

This study was conducted in 2 children's hospitals within the same health system, including an approximately 600-bed quaternary care facility and an 80-bed community-based facility. Trainees provide care at the quaternary care facility only, whereas the community-based facility is staffed by attendings and advanced practices providers. All CAP encounters discharged from the general pediatrics clinical services between December 2021 and November 2023 were included. Readmissions for CAP within 30 days of the index visit were excluded. CAP was defined based on an International Classification of Diseases version 10 (ICD-10) diagnosis code for viral or bacterial pneumonia (Supplementary Table 1); an antibiotic administered within 48 hours of admission and continued for at least two consecutive days or, for patients discharged prior to this, a prescription for antibiotics at discharge; and a chest x-ray obtained within 48 hours before or after admission. Requiring both antibiotics and a chest x-ray within 48 hours was intended to increase the specificity of our definition for community onset infections. Patients transferred from hospitals outside of our system, those with complex chronic conditions [20] or chronic pulmonary conditions, pediatric intensive care unit (PICU) stays >48 hours, hospital stays >7 days, those with concurrent infections other than acute otitis media or pharyngitis, and those who died within 48 hours were excluded. Encounters with viral ICD-10 codes were included if they met other criteria to ensure antibiotic choice and duration were evaluated for all patients receiving antibiotics for clinician-diagnosed CAP. This definition of CAP was locally validated in prior work [19].

Electronic Measures of Appropriate Antibiotic Use and Study Outcomes

The primary outcome measure was the proportion of all CAP encounters that received both the appropriate antibiotic choice and duration. Appropriate antibiotic choice and duration were determined using only data from the EHR with no need for manual chart review, with the goal of creating measures that were pragmatic and scalable to a variety of settings.

Appropriate antibiotic choice was defined as administration of amoxicillin or ampicillin within the first 48 hours. If the patient was admitted to the PICU or had a concurrent diagnosis code for empyema or lung abscess, ceftriaxone was also considered appropriate. If the patient had a history of methicillin-resistant *Staphylococcus aureus* (MRSA) infection or colonization within the preceding one year, any anti-MRSA antibiotic was also considered appropriate. For patients with reported β -lactam allergy or β -lactam antibiotic use within the preceding 28 days, any antibiotic was considered appropriate. Finally, azithromycin was considered appropriate if prescribed as monotherapy to a child ≥ 5 years old or with a positive *Mycoplasma pneumoniae* test. Appropriate antibiotic duration was defined as a total antibiotic duration (inpatient and discharge antibiotics) of 6 days or less. Six days was selected as the threshold for the metric to avoid over-penalizing clinicians for excess durations when partial days of treatment were counted as full days in our electronic measure. For patients with a positive blood culture, a positive respiratory culture for *Pseudomonas aeruginosa* or *Staphylococcus aureus*, or a diagnosis code for concurrent empyema, lung abscess, acute otitis media, pharyngitis, or positive *Legionella* testing, any antibiotic duration was considered appropriate (Supplementary Table 2). As a balancing measure, we assessed the frequency of CAP-related revisits to any ambulatory or inpatient location within 28 days of discharge from the index CAP encounter. CAP-related revisits were defined as a visit with a CAP or complicated pneumonia ICD-10 and a new antibiotic prescription for a different antibiotic.

Intervention

The primary strategy used in this intervention was dissemination of an audit and feedback report reflecting adherence to the antibiotic choice and duration measures described above. These measures included aggregated data across the general pediatrics practice group, such that all individuals received the same report summarizing the group's performance for each metric.

Prior to distribution, we performed a rapid user centered design process to optimize the clinician feedback report [21]. This process included four general pediatrics partners and was conducted through 2, 1-hour virtual meetings in September and October of 2022. In October and November 2022, we provided education on the metrics as well as the feedback reports during a series of general pediatrics divisional meetings. We also updated our longstanding CAP guideline to more explicitly align with the metrics presented in the feedback report, although the recommended initial antibiotic choice and duration recommendations were not changed as part of this intervention. Feedback reports were distributed monthly by email during the postintervention period (December 2022 until November 2023) to all general pediatrics attendings, fellows, and advanced practice providers. The metrics were also reviewed briefly during standing monthly QI meetings with the general pediatrics division. These multiple delivery methods were leveraged to maximize clinician interaction with the feedback reports [22]. All CAP encounters that were non-adherent to the antibiotic choice and duration metrics were reviewed by the study team and based on these reviews, recommendations for improving performance were embedded in the feedback report (Figure 1).

Analysis

Demographic and clinical variables of CAP patients were compared in the preintervention (December 2021–November 2022) and postintervention (December 2022–November 2023) periods using χ^2 tests for categorical variables and the Wilcoxon rank sum tests for continuous variables.

We graphically displayed the monthly proportion of CAP encounters adherent to both the antibiotic choice and duration measures. We then conducted interrupted time series analyses using linear regression for the monthly proportion of appropriate antibiotic use. This model included a time-varying indicator variable for the intervention, time in months since study start, and a variable reflecting the interaction between intervention and time in months. The coefficient of the intervention variable reflects the immediate change in the proportion after intervention start, the coefficient of the time variable measures the rate of change in proportion over time, and the coefficient of the interaction term reflects the modifying effect of the intervention on this rate of change over time. As a secondary analysis, antibiotic choice and antibiotic duration were analyzed separately using similar methods.

We then used modified Poisson regression with a robust error variance to evaluate the binary outcome variable of appropriate antibiotic choice and duration on the risk ratio (RR) scale [23]. The model includes a time-varying indicator variable for intervention, which measures the immediate effect of the intervention. The model also includes time in months since study start and postintervention time, with the former measuring the time trend by slope and the latter measuring the modifying effect of the intervention on the time trend. We evaluated several potential confounders including age, sex, race, pediatric intensive care unit (PICU) admission, site, season, β -lactam allergy, and viral diagnosis. Race was included in the model based on prior publications demonstrating an association between race and appropriate antibiotic use [24, 25]. As a secondary analysis, we evaluated the impact of the intervention on antibiotic choice and antibiotic duration in separate modified Poisson regression analyses. We also performed 3 sensitivity analyses: (1) including only patients who received more than 3 days of antibiotics; (2) including only those with bacterial ICD-10 codes; and (3) excluding those with a β -lactam allergy, a positive blood culture, a positive respiratory culture for *P. aeruginosa* or *S. aureus*, and those with otitis media or pharyngitis. Analyses were performed using R statistical software.

RESULTS

There were 800 CAP encounters during the study period, including 413 (52%) in the preintervention and 387 (48%) in the postintervention period. Children were slightly older in the postintervention period (36 vs 44 months, $P < .01$) and were less likely to have a viral ICD-10 code (17% vs 11%, $P = .02$). Otherwise, there was no significant difference in other clinical or demographic variables (Table 1). The proportion of CAP encounters with an appropriate antibiotic choice and duration increased from 52% in the preintervention period to 80% in the postintervention period ($P < .01$). This improvement was driven by increases in appropriate antibiotic duration (54% vs 83%, $P < .01$), whereas appropriate antibiotic choice was high in both the baseline and intervention periods (95% vs 94%). The decrease

in antibiotic duration was driven by shortening discharge durations (5 vs 4 days, $P < .01$) (Table 2).

The interrupted time series analysis demonstrated that there was no significant change over time in the proportion of appropriate antibiotic use before the intervention. However, there was an immediate absolute increase of 18% in the proportion of encounters receiving the appropriate antibiotic choice and duration (95% confidence interval [CI]: 3%–33%) at the time of the intervention, with no further change in the time trend following the intervention (–0.3% per month, 95% CI: –2% to 2%). When adherence to the antibiotic choice and duration measures were analyzed separately, the intervention had no impact on antibiotic choice but was associated with an immediate absolute 20% increase in the proportion of encounters in which antibiotic duration was appropriate (95% CI: 5%–36%) (Figure 2).

In the modified Poisson model adjusted for site, age, sex, race, PICU admission, and season, the likelihood of a patient receiving the appropriate antibiotic choice and duration did not change significantly over time before the intervention. However, there was an immediate increase in the likelihood of appropriate antibiotic choice and duration after intervention start (RR 1.32, 95% CI: 1.12–1.56, $P < .01$), with no further change in trend. PICU admission (RR 1.16, 95% CI: 1.02–1.32, $P = .03$) and admission to the community-based hospital (RR 1.18, 95% CI: 1.07–1.30, $P \leq .01$) were also associated with an increased likelihood of appropriate antibiotic prescribing (Table 3). When antibiotic choice and duration were analyzed separately, the intervention had no impact on the likelihood of appropriate antibiotic choice (RR 0.96, 95% CI: 0.91–1.02, $P = .21$) but was associated with an increase in the probability of receiving the appropriate antibiotic duration (RR 1.35, 95% CI: 1.16–1.58, $P < .01$). There was no significant difference in the preintervention versus postintervention periods in the proportion of CAP encounters in which there was any revisit (3% vs 5%, $P = .15$) or readmission (2% vs 4%, $P = .15$).

A sensitivity analysis excluding 39 patients who received three or fewer days of antibiotics produced results similar to the primary analysis (RR 1.37, 95% CI: 1.15–1.63, $P < .01$). Similar findings were demonstrated in a sensitivity analysis limited to those with bacterial CAP ICD-10 codes, excluding 116 encounters with viral diagnosis codes only (RR 1.37, 95% CI: 1.13–1.64, $P < .01$). Finally, when the 163 patients with β -lactam allergy, a positive blood culture, a respiratory culture positive for *S. aureus*, or concurrent otitis media or pharyngitis were excluded, the association between the intervention and appropriate antibiotic use was stronger (RR of 1.55, 95% CI of 1.25–1.93, $P < .01$).

DISCUSSION

We demonstrated the effectiveness of group-level clinician feedback reports in improving adherence to antibiotic use guidelines among academic general pediatrics clinicians within our pediatric health system. These electronically delivered feedback reports, coupled with clinician education, an established local guideline, and regular review of the metrics at divisional QI meetings, resulted in a 32% increase in the rate of appropriate antibiotic use for CAP over the 1-year postintervention period, driven by improved adherence to antibiotic duration recommendations. These findings support the use of clinician feedback reports

as a stewardship tool for inpatient ASPs, an approach made more feasible through use of electronically derived measures of antibiotic appropriateness.

Consistent with other reports, antibiotic treatment duration was identified as the key opportunity for improved stewardship locally [5, 7, 26–31]. We observed an immediate improvement in adherence to appropriate antibiotic duration recommendations at the start of our intervention, with no significant change over time. This is likely due to a “ceiling effect,” as no additional new interventions to improve performance were implemented beyond the monthly feedback reports, by design. Similar improvements in adherence to guideline-recommended antibiotic duration have been demonstrated in other studies utilizing combinations of clinician education, local guidelines, and audit with feedback [10–13]. For example, Foolad and colleagues conducted a multicenter study in which infectious diseases pharmacists reviewed patients with an admitting diagnosis of CAP and provided verbal recommendations to stop antibiotics 72 hours after patients achieved clinical stability. The median treatment duration was 3 days shorter in the intervention group (6 vs 9 days, $P < .001$), and the proportion of patients receiving 5 days of therapy was higher in the intervention group (35% vs 5%, $P < .001$) [11]. Monday et al performed a single center QI study and demonstrated that prospective audit with feedback performed by a non-infectious diseases physician reduced treatment duration from a median of 8 days to 5 days, with no difference in mortality, readmission, or length of stay [13]. Although ultimately successful, these interventions require significant human resources, whereas our approach may offer a less resource intensive strategy.

Several reports support the use of prescribing feedback reports in the ambulatory setting. Outpatient feedback reports generally summarize individual prescribing performance for a given condition or conditions, often with comparisons to peer clinicians [14–18]. There are several important differences between the inpatient and outpatient setting that impact feedback report implementation. First, unlike the ambulatory setting where a single clinician is generally making antibiotic prescribing decisions, inpatients are often managed by multiple clinicians, such that attribution of an individual prescribing decision to one person is difficult. For this reason, we developed group-level feedback reports, which aggregate all CAP encounters cared for by the general pediatrics service and compare these to historical performance. Second, and in contrast to outpatients who generally have 1 diagnosis and 1 antibiotic prescription, hospitalized patients may carry multiple infectious diagnoses and receive different antibiotics over the course of the admission and at discharge. This contributes to challenges with developing reliable metrics of appropriate antibiotic use, with few pediatric studies published to date establishing validated measures that do not rely on manual chart review [19, 32]. The group level electronic feedback reports deployed in this study were both feasible and effective tools for driving improvement, despite these differences.

These strengths notwithstanding, our study has several limitations. First, despite the use of robust statistical methods, we cannot definitively conclude that the observed changes were the result of our intervention, as opposed to an unmeasured time varying confounder. This is unlikely, however, given that we worked closely with key stakeholders, such that we should be aware of any potential confounders. Second, our definitions for CAP as well as

the appropriate antibiotic choice and duration measures used in the feedback reports were developed and validated within a single health system and require external validation. Third, the impact of clinician feedback reports within our health system may not generalize to other settings, both because baseline adherence to the choice and duration metrics may differ across centers and because the acceptability of the feedback reports may vary. Furthermore, these reports were implemented in the setting of a longstanding guideline as well as a forum for reviewing performance metrics monthly, implementation supports which may differ across centers. Fourth, these metrics prioritize being practical for electronic implementation and may therefore be more permissive in classifying antibiotics as appropriate than would be feasible if real time chart review were conducted. For example, although many patients with a β -lactam allergy label do not truly have allergies and could therefore receive first line, narrow-spectrum antibiotics, it was not practical to assess the nature of the reported allergy, so any alternative antibiotic were classified as appropriate. Fifth, we implemented the emailed feedback reports with clinician education, monthly review of the metrics, and with an established CAP clinical care guideline. Our study was not designed to evaluate the impact of each of these separately, but rather, each of these was considered a fundamental element of high-quality audit and feedback report implementation [22]. Finally, although we were not able to detect a statistical difference in revisits following the intervention, we cannot rule out the possibility that rare adverse outcomes would have been detected with a larger cohort or that revisits or readmissions could have occurred outside of our system. That said, even if a low rate of deleterious outcomes are detected with shorter antibiotic durations, these must be balanced against potentially shorter hospital length of stay and reduced risk of antibiotic adverse events [33].

Overall, we demonstrated the effectiveness of audit and feedback reports, implemented with clinician education, monthly review of metrics, and a long-standing guideline in improving compliance with evidence-based recommendations for antibiotic duration in children hospitalized with CAP. Future work should focus on evaluating the impact, feasibility, and acceptability of inpatient feedback reports focused on CAP at other institutions, as well as developing similar reports for other infections.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Financial support.

This work was supported by the CDC Safety and Healthcare Epidemiology Prevention Research Development (SHEPHERD) 2017 Domain 1: A-002, "Assessing Appropriate Antibiotic Use in Hospitals and Outpatient Settings Through Electronic Health Records" and 2021 Domain 1: A-009, "Using Electronically Derived Automated Reports of Appropriate Antibiotic Use to Inform Stewardship Interventions."

References

1. Gill PJ, Anwar MR, Thavam T, et al. Identifying conditions with high prevalence, cost, and variation in cost in US children's hospitals. *JAMA Netw Open* 2021; 4:e2117816.
2. Gerber JS, Kronman MP, Ross RK, et al. Identifying targets for antimicrobial stewardship in children's hospitals. *Infect Control Hosp Epidemiol* 2013; 34:1252–8. [PubMed: 24225609]

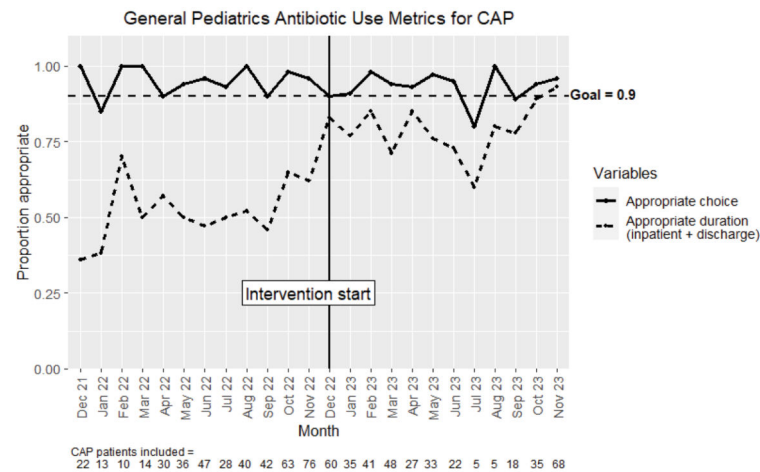
3. Agency for Healthcare Research and Quality. National estimates on use of hospitals by children from the HCUP Kids' Inpatient Database (KID). Available at: <https://hcupnet.ahrq.gov/#setup>. Accessed 21 August 2024.
4. Bradley JS, Byington CL, Shah SS, et al. The management of community-acquired pneumonia 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. *Clin Infect Dis* 2011; 53:e25–76. [PubMed: 21880587]
5. 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; 326:1713–24. [PubMed: 34726708]
6. 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; 175:475–82. [PubMed: 33683325]
7. Uranga A, España PP, Bilbao A, et al. Duration of antibiotic treatment in community-acquired pneumonia: a multicenter randomized clinical trial. *JAMA Intern Med* 2016; 176:1257–65. [PubMed: 27455166]
8. Same RG, Amoah J, Hsu AJ, et al. The association of antibiotic duration with successful treatment of community-acquired pneumonia in children. *J Pediatric Infect Dis Soc* 2021; 10:267–73. [PubMed: 32525203]
9. Metlay JP, Waterer GW, Long AC, et al. . Diagnosis and treatment of adults with community-acquired pneumonia. An official clinical practice guideline of the American Thoracic Society and Infectious Diseases Society of America. *Am J Respir Crit Care Med* 2019; 200:e45–67. [PubMed: 31573350]
10. Avdic E, Cushinotto LA, Hughes AH, et al. Impact of an antimicrobial stewardship intervention on shortening the duration of therapy for community-acquired pneumonia. *Clin Infect Dis* 2012; 54:1581–7. [PubMed: 22495073]
11. Foolad F, Huang AM, Nguyen CT, et al. A multicentre stewardship initiative to decrease excessive duration of antibiotic therapy for the treatment of community-acquired pneumonia. *J Antimicrob Chemother* 2018; 73:1402–7. [PubMed: 29462306]
12. van den Bergh D, Messina AP, Goff DA, et al. A pharmacist-led prospective antibiotic stewardship intervention improves compliance to community-acquired pneumonia guidelines in 39 public and private hospitals across South Africa. *Int J Antimicrob Agents* 2020; 56:106189. [PubMed: 33045348]
13. Monday LM, Yazdanpaneh O, Sokolowski C, et al. A physician-driven quality improvement stewardship intervention using lean six sigma improves patient care for community-acquired pneumonia. *Glob J Qual Saf Healthc* 2021; 4:109–16. [PubMed: 37261063]
14. Gerber JS, Prasad PA, Fiks AG, et al. Effect of an outpatient antimicrobial stewardship intervention on broad-spectrum antibiotic prescribing by primary care pediatricians: a randomized trial. *JAMA* 2013; 309:2345–52. [PubMed: 23757082]
15. Vernacchio L, Hatoun J, Patane LB, O'Donnell H, Herigon JC. Improving short course treatment of pediatric infections: a randomized quality improvement trial. *Pediatrics* 2024; 153:e2023063691.
16. Meeker D, Linder JA, Fox CR, et al. Effect of behavioral interventions on inappropriate antibiotic prescribing among primary care practices: a randomized clinical trial. *JAMA* 2016; 315:562–70. [PubMed: 26864410]
17. Metlay JP, Camargo CA Jr, MacKenzie T, et al. Cluster-randomized trial to improve antibiotic use for adults with acute respiratory infections treated in emergency departments. *Ann Emerg Med* 2007; 50:221–30. [PubMed: 17509729]
18. Finkelstein JA, Huang SS, Kleinman K, et al. Impact of a 16-community trial to promote judicious antibiotic use in Massachusetts. *Pediatrics* 2008; 121:e15–23. [PubMed: 18166533]
19. Chiotos K, Grundmeier R, Meyahnwi D, et al. Validation of an electronic algorithm to identify appropriate antibiotic use for community-acquired pneumonia in children. *Antimicrob Steward Healthc Epidemiol* 2023; 3:s106–s106.

20. Feudtner C, Feinstein JA, Zhong W, Hall M, Dai D. Pediatric complex chronic conditions classification system version 2: updated for ICD-10 and complex medical technology dependence and transplantation. *BMC Pediatr* 2014; 14:199. [PubMed: 25102958]
21. Landis-Lewis Z, Kononowech J, Scott WJ, et al. Designing clinical practice feedback reports: three steps illustrated in Veterans Health Affairs long-term care facilities and programs. *Implement Sci* 2020; 15:7. [PubMed: 31964414]
22. Brown B, Gude WT, Blakeman T, et al. Clinical performance feedback intervention theory (CP-FIT): a new theory for designing, implementing, and evaluating feedback in health care based on a systematic review and meta-synthesis of qualitative research. *Implement Sci* 2019; 14:40. [PubMed: 31027495]
23. Zou G. A modified poisson regression approach to prospective studies with binary data. *Am J Epidemiol* 2004; 159:702–6. [PubMed: 15033648]
24. Goyal MK, Johnson TJ, Chamberlain JM, et al. Racial and ethnic differences in antibiotic use for viral illness in emergency departments. *Pediatrics* 2017; 140:e20170203.
25. Fleming-Dutra KE, Shapiro DJ, Hicks LA, Gerber JS, Hersh AL. Race, otitis media, and antibiotic selection. *Pediatrics* 2014; 134:1059–66. [PubMed: 25404720]
26. 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; 397:1195–203. [PubMed: 33773631]
27. Ginsburg AS, Mvalo T, Nkwopara E, et al. Amoxicillin for 3 or 5 days for chest-indrawing pneumonia in Malawian children. *N Engl J Med* 2020; 383:13–23. [PubMed: 32609979]
28. McCallum GB, Fong SM, Grimwood K, et al. Extended versus standard antibiotic course duration in children <5 years of age hospitalized with community-acquired pneumonia in high-risk settings: four-week outcomes of a multicenter, double-blind, parallel, superiority randomized controlled trial. *Pediatr Infect Dis J* 2022; 41:549–55. [PubMed: 35476706]
29. McCarthy NL, Baggs J, Wolford H, et al. Length of antibiotic therapy among adults hospitalized with uncomplicated community-acquired pneumonia, 2013–2020. *Infect Control Hosp Epidemiol* 2024; 45:726–32. [PubMed: 38351597]
30. Vaughn VM, Gandhi TN, Hofer TP, et al. A statewide collaborative quality initiative to improve antibiotic duration and outcomes in patients hospitalized with uncomplicated community-acquired pneumonia. *Clin Infect Dis* 2022; 75:460–7. [PubMed: 34791085]
31. Madaras-Kelly KJ, Burk M, Caplinger C, et al. Total duration of antimicrobial therapy in veterans hospitalized with uncomplicated pneumonia: results of a national medication utilization evaluation. *J Hosp Med* 2016; 11:832–9. [PubMed: 27527659]
32. Yarahuan JKW, Kisvarday S, Kim E, et al. An algorithm to assess guideline concordance of antibiotic choice in community-acquired pneumonia. *Hosp Pediatr* 2024; 14:137–45. [PubMed: 38287897]
33. Same RG, Hsu AJ, Cosgrove SE, et al. Antibiotic-associated adverse events in hospitalized children. *J Pediatric Infect Dis Soc* 2021; 10:622–8. [PubMed: 33452808]

Dear Colleague,

CHOP is undertaking an initiative to improve **antibiotic prescribing** for children hospitalized with community acquired pneumonia (CAP) to align practice with the CAP clinical pathway. The appropriate total antibiotic duration for most patients with CAP (including inpatient + discharge antibiotics) is **5 days**.

- In November 2023, **93%** of CAP patients received the appropriate antibiotic duration and **96%** received the appropriate choice.



How can we improve?

Improving adherence to the recommended antibiotic duration of 5 days at discharge is the biggest opportunity for improvement. Here are some tips:

- If you are writing a discharge prescription the day prior to discharge, make sure the start date reflects the anticipated date of discharge so the TOTAL duration is 5 days.
- Consider all doses administered when counting the TOTAL days, including doses given in the emergency department.
- Ensure discharge prescriptions are written to reflect a TOTAL of 5 days, not 5 MORE days from the day of discharge.

Resources

- [CAP Clinical Pathway](#)
- Appendices on Metric Development and Data Definitions are attached
- Study team email: empower@chop.edu

Figure 1.

Example feedback report. Example of the feedback report circulated monthly to general pediatrics clinicians by email. Abbreviation: CHOP, Children's Hospital of Philadelphia.

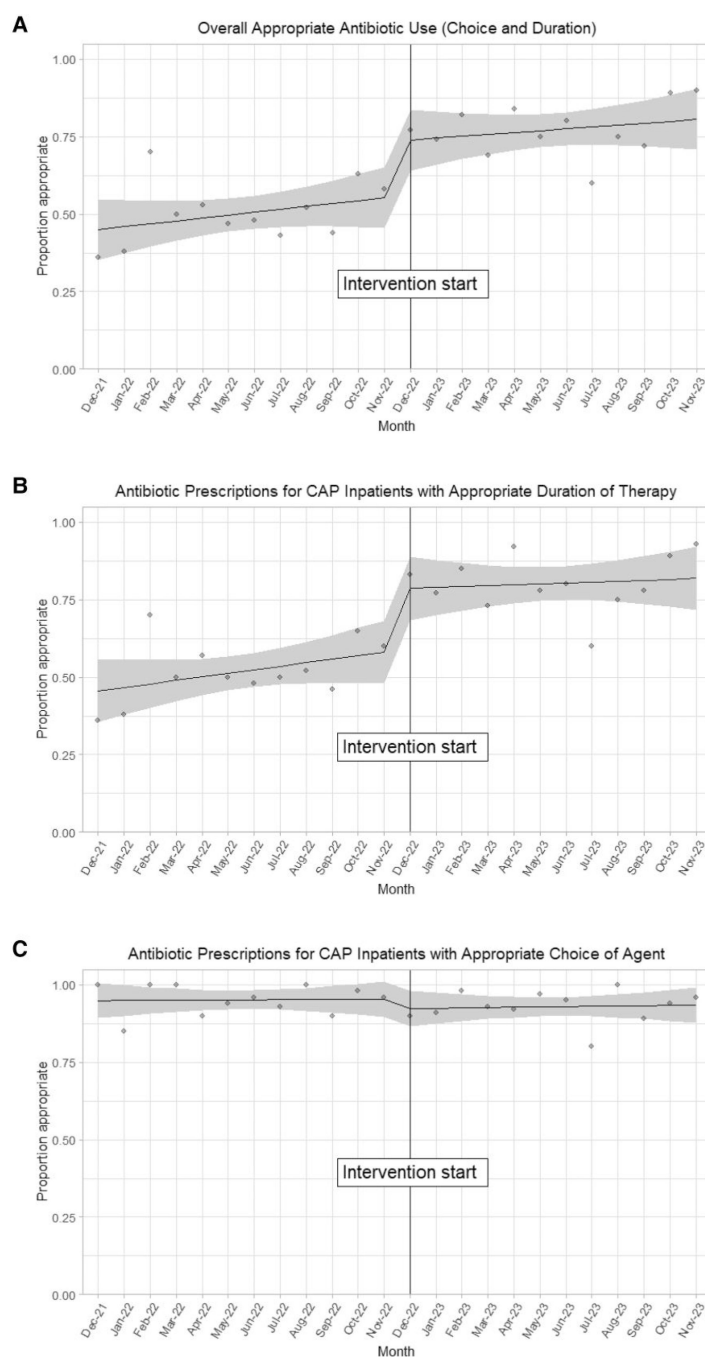


Figure 2.

Plots of proportions of appropriate antibiotic use over time and interrupted time series analyses evaluating the effect of feedback reports on antibiotic use for children hospitalized with CAP, December 2021 to November 2023. *A*, Impact of feedback reports on overall appropriate antibiotic use (choice and duration). *B*, Impact of feedback reports on antibiotic duration. *C*, Impact of feedback reports on antibiotic choice. Plots of the proportions of antibiotic choice and duration metrics over time (circles), interrupted time series analysis (solid line), and 95% CIs (shading). Panel *A*: overall antibiotic use (choice and duration);

Panel *B.* antibiotic duration; and Panel *C.* antibiotic choice. Abbreviation: CAP, community-acquired pneumonia.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 1.
Clinical and Demographic Characteristics of Children Hospitalized With CAP, December 2021–November 2023

Variable	Preintervention ^a N = 413 N (%)	Postintervention ^b N = 387 N (%)	P Value
CAP encounters	413 (52)	387 (48)	
Age in months, median (IQR)	36 (22–60)	44 (25–70)	<.01
Age groups			
6 m to <2 y	116 (28)	94 (24)	
2 to 4 y	193 (47)	176 (46)	.37
5 to 11 y	84 (20)	97 (25)	
≥12 y	20 (5)	20 (5)	
Race and ethnicity			
Non-Hispanic White	154 (37)	146 (38)	
Non-Hispanic Black	123 (30)	112 (29)	.93
Hispanic	69 (17)	59 (15)	
Asian	21 (5)	22 (6)	
Other	46 (11)	48 (12)	
Male sex	209 (51)	192 (50)	.78
Viral pneumonia ICD-10 code	72 (17)	44 (11)	.02
PICU admission	56 (14)	44 (11)	.35
Complicated pneumonia ^c	2 (<1)	7 (2)	.08
Concurrent acute otitis media or Group A <i>Streptococcus</i> pharyngitis ^d	73 (18)	56 (15)	.22
Beta-lactam allergy	15 (4)	20 (5)	.29
Positive blood culture or respiratory culture positive for <i>Staphylococcus aureus</i> ^e	3 (<1)	1 (<1)	.42

Abbreviations: CAP, community-acquired pneumonia; ICD-10, International Classification of Diseases version 10; IQR, interquartile range; PICU, pediatric intensive care unit.

^aPreintervention period, December 2021 to November 2022.

^bPostintervention period, December 2022 to November 2023.

^cComplicated pneumonia was defined based on ICD-10 diagnosis codes.

^dOtitis media and Group A *Streptococcus* pharyngitis were defined based on ICD-10 codes.

^eAll positive culture criteria were combined given the low number of events. There were no patients with *Pseudomonas aeruginosa*.

Table 2.
Outcome Measures for Children Hospitalized With CAP, December 2021–November 2023

Variable	Preintervention ^a N = 413 N (%)	Postintervention ^b N = 387 N (%)	P Value
Appropriate antibiotic choice and duration	213 (52)	308 (80)	<.01
Appropriate antibiotic choice	394 (95)	362 (94)	.25
Appropriate antibiotic duration	221 (54)	322 (83)	<.01
Total duration of antibiotics, median (IQR)	7 (6–8)	6(5–7)	<.01
Duration of inpatient antibiotics, median (IQR)	2 (2–3)	2 (2–3)	.014
Duration of discharge antibiotics, median (IQR)	5 (3–6)	4 (3–5)	<.01
Length of stay, median (IQR)	2 (1–2)	1 (1–2)	.04
Any pneumonia-related revisit within 28 d of discharge	13 (3)	20 (5)	.15
Pneumonia-related readmission within 28 d of discharge	8 (2)	14 (4)	.15

Abbreviations: CAP, community-acquired pneumonia; IQR, interquartile range.

^aPreintervention period, December 2021 to November 2022.

^bPostintervention period, December 2022 to November 2023.

Table 3.

Modified Poisson Regression of the Effect of Feedback Reports on Appropriate Antibiotic Choice and Duration for Children Hospitalized With CAP, December 2021–November 2023

Variable	RR	95% CI	P Value
Intervention	1.32	1.12, 1.56	<.01
Time in months	1.02	0.99, 1.05	.19
Postintervention time	0.99	0.96, 1.02	.60
Site			
Quaternary care	...	...	
Community-based	1.18	1.07, 1.30	<.01
Race/Ethnicity			
Non-Hispanic White	...	...	
Non-Hispanic Black	0.98	0.87, 1.12	.81
Hispanic	1.03	0.90, 1.19	.65
Asian	0.89	0.71, 1.11	.31
Other	0.93	0.78, 1.10	.39
Male sex	1.04	0.94, 1.14	.46
Age groups			
6 m to <2 y	—	—	
2 to 5 y	1.00	0.89, 1.12	.98
6 to 11 y	0.91	0.79, 1.05	.20
≥12 y	0.90	0.69, 1.17	.43
PICU admission ^a	1.16	1.02, 1.32	.03
Season ^b			
Warm	...	...	
Cold	1.09	0.97, 1.22	.14

Abbreviations: CAP, community-acquired pneumonia; CI, confidence interval; PICU, pediatric intensive care unit; RR, risk ratio.

^aBecause PICU admission >48 h is an exclusion criteria for this study, this variable reflects the risk ratio of PICU admission <48 h relative to no PICU admission.

^bThe warm season includes encounters April–September, and the cold season includes encounters October–March.