Ambulatory Visit Rates and Antibiotic Prescribing for Children With Pneumonia, 1994–2007

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KEY WORDS

pneumonia, physician practice patterns, antibiotic use, epidemiology, pneumococcal conjugate vaccine

ABBREVIATIONS

CAP—community acquired pneumonia
PCV7—heptavalent pneumococcal conjugate vaccine
ED—emergency department
ICD-9-CM—*International Classification of Diseases, Ninth Revision, Clinical Modification*
CBC—complete blood count
CI—confidence interval
OR—odds ratio

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WHAT'S KNOWN ON THIS SUBJECT: Pneumococcus is the most commonly identified bacterial cause of community-acquired pneumonia. Pediatric pneumonia hospitalizations have decreased since the introduction of the pneumococcal conjugate vaccine in 2000. However, few data exist on national trends in the incidence of pediatric outpatient pneumonia.

WHAT THIS STUDY ADDS: This study provides the first comprehensive national estimates of pediatric outpatient pneumonia incidence. Rates of outpatient pediatric pneumonia have not changed despite introduction of the pneumococcal conjugate vaccine, and broad-spectrum antibiotic prescribing for outpatient pneumonia is commonplace.

abstract

BACKGROUND: The incidence of pediatric hospitalizations for community-acquired pneumonia (CAP) has declined after the widespread use of the heptavalent pneumococcal conjugate vaccine. The national incidence of outpatient visits for CAP, however, is not well established. Although no pediatric CAP treatment guidelines are available, current data support narrow-spectrum antibiotics as the first-line treatment for most patients with CAP.

OBJECTIVE: To estimate the incidence rates of outpatient CAP, examine time trends in antibiotics prescribed for CAP, and determine factors associated with broad-spectrum antibiotic prescribing for CAP.

PATIENTS AND METHODS: The National Ambulatory and National Hospital Ambulatory Medical Care Surveys (1994–2007) were used to identify children aged 1 to 18 years with CAP using a validated algorithm. We determined age group–specific rates of outpatient CAP and examined trends in antibiotic prescribing for CAP. Data from 2006–2007 were used to study factors associated with broad-spectrum antibiotic prescribing.

RESULTS: Overall, annual CAP visit rates ranged from 16.9 to 22.4 per 1000 population, with the highest rates occurring in children aged 1 to 5 years (range: 32.3–49.6 per 1000). Ambulatory CAP visit rates did not change between 1994 and 2007. Antibiotics commonly prescribed for CAP included macrolides (34% of patients overall), cephalosporins (22% overall), and penicillins (14% overall). Cephalosporin use increased significantly between 2000 and 2007 ($P = .002$). Increasing age, a visit to a nonemergency department office, and obtaining a radiograph or complete blood count were associated with broad-spectrum antibiotic prescribing.

CONCLUSIONS: The incidence of pediatric ambulatory CAP visits has not changed significantly between 1994 and 2007, despite the introduction of heptavalent pneumococcal conjugate vaccine in 2000. Broad-spectrum antibiotics, particularly macrolides, were frequently prescribed despite evidence that they provide little benefit over penicillins. *Pediatrics* 2011;127: 411–418

Streptococcus pneumoniae is the most commonly identified bacterial cause of community-acquired pneumonia (CAP).¹ In February 2000, a heptavalent pneumococcal conjugate vaccine (PCV7) was licensed in the United States and subsequently added to the routine childhood vaccination schedule.² The incidence of pediatric hospitalizations for CAP has since declined.³ There is, however, a paucity of data on national trends in the incidence of CAP diagnosed in the outpatient setting. Previous studies^{3–7} of pediatric outpatient CAP have focused more broadly on all respiratory tract infections or more narrowly on specific age, geographic, racial, or ethnic groups.

Current evidence supports the use of narrow-spectrum antibiotics, such as penicillin or the aminopenicillins (amoxicillin and ampicillin), as first-line treatment for most patients with CAP for several reasons. First, invasive *S pneumoniae* isolates have demonstrated decreased penicillin resistance rates since the introduction of PCV7.⁸ Second, patients with CAP caused by penicillin-resistant pneumococci do not seem to experience treatment failures even when treated with penicillins.^{9–11} Third, pneumococcal resistance to some broad-spectrum antibiotics, such as second-generation cephalosporins and macrolides, is increasing and such resistance is associated with treatment failures and breakthrough pneumococcal infections, especially in children.^{12–14} These findings underscore the fact that broad-spectrum antibiotics seem to be unnecessary and, in some circumstances, less effective than narrow-spectrum therapy in the treatment of childhood CAP. Most children with CAP are managed as outpatients; thus, the outpatient setting provides an opportunity to facilitate the reduction in unnecessary broad-spectrum antibiotic prescribing for CAP.¹

Given the current lack of pediatric CAP-management guidelines, we hypothesized that antimicrobial treatment for outpatient pediatric CAP might include frequent overuse of broad-spectrum antibiotics and that prescribing might differ between provider specialties. Therefore, our objectives were to examine time trends in visit rates and antibiotic-prescribing patterns for pediatric CAP and to identify factors associated with broad-spectrum antibiotic prescribing.

METHODS

Data Sources

We used the National Ambulatory Medical Care Survey and National Hospital Ambulatory Medical Care Survey. These surveys are administered by the National Center for Health Statistics and collect data on patient visits to community, non-federally funded office-based physician practices (National Ambulatory Medical Care Survey) and hospital-based emergency departments (EDs) and outpatient clinics (National Hospital Ambulatory Medical Care Survey) throughout the United States.¹⁵

The surveys employ a multistage probability design in selecting physicians and patients for participation, as described previously.¹⁶ Both surveys collect data on patient demographics, diagnoses, laboratory testing, vital signs, and prescribed medications. Patient data are weighted to create national estimates using selection probabilities, adjustment for nonresponse, ratio adjustment to fixed totals, and weight smoothing. The 2007 National Ambulatory Medical Care Survey included 32 778 patient records representing an estimated 994 million outpatient visits; the 2007 National Hospital Ambulatory Medical Care Survey included 35 490 patient record forms from EDs and 34 473 patient record forms from outpatient hospi-

tal clinics representing an estimated 117 million and 89 million visits, respectively.¹⁷

We combined data from the 1994–2007 surveys to capture the full spectrum of outpatient CAP visits and include the introduction of PCV7 in 2000.² Between 19.4% and 21.5% of survey participants were children aged 1 to 18 years annually, ranging from 14 268 to 21 601 unweighted patient records. Both surveys record up to 3 diagnoses per patient visit using the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) codes and between 5 and 8 medications. Medications were identified using the National Drug Code directory.

Participants

Patients aged 1 to 18 years with CAP were identified using a previously validated ICD-9-CM code algorithm.¹⁸ Patients were defined as having pneumonia if they had a primary ICD-9-CM diagnosis of pneumonia (480–483 and 485–486) or a primary ICD-9-CM diagnosis of a pneumonia symptom such as fever or cough (780.6, 786.0, 786.2–786.5, 786.7) with a secondary ICD-9-CM diagnosis of pneumonia, empyema (510), or pleurisy (511.0–1 and 511.9). Children younger than 1 year were excluded because of their high incidence of viral bronchiolitis, making the CAP diagnosis in these patients less certain. Patients with chronic or immunocompromising conditions (eg, malignancies), with other concurrent serious bacterial illnesses (eg, meningitis, urinary tract infection), and patients requiring hospital admission also were excluded using previously identified ICD-9-CM codes because appropriate antibiotic selection might differ in these populations (Appendix).¹⁹ We defined patients with outpatient CAP as those with pneumonia who were not admitted; these patients were evaluated in either the ED or the

office setting, defined as all ambulatory clinics.

Antibiotics

Antibiotic exposure, defined as all antimicrobial agents prescribed during the CAP encounter, was categorized by spectrum of activity as follows: penicillins (penicillin, amoxicillin, and ampicillin), macrolides (erythromycin, clarithromycin, and azithromycin), cephalosporins (including any first-, second-, or third-generation cephalosporins), and others (including broad-spectrum penicillins such as amoxicillin-clavulanate, fluoroquinolones, sulfonamides, tetracyclines, and any other antibiotics). Children prescribed more than 1 antibiotic class contributed to determining the rates of each class. We defined broad-spectrum antibiotics as any nonpenicillins prescribed for CAP.

Statistical Analysis

The National Ambulatory Medical Care Survey and the National Hospital Ambulatory Medical Care Survey data from 1994 to 2007 were combined in 2-year intervals to ensure robust estimates. Nationally representative CAP visit estimates were obtained using adjusted patient weights, and population-based estimates of CAP incidence rates were determined using age group- and year-specific census estimates. All estimates were based on more than 30 unweighted observations and a relative standard error of less than 30%, unless otherwise specified.¹⁷ Because our previous work noted a difference in pediatric CAP complications by age group, we examined the incidence of outpatient CAP in those aged 1 to 5 years, 6 to 10 years, and 11 to 18 years.²⁰ Because of the low numbers of subjects with nonwhite race, we categorized race as white, black, or other. A linear test of trend was used to assess trends in CAP visit rates, and logistic regression was

used to estimate trends in antibiotic class prescribing.²¹

We used multivariable logistic regression to identify factors associated with broad-spectrum antibiotic prescribing during 2004–2007. After 2004, medicines were defined as new or chronic, helping eliminate confounding caused by antibiotics prescribed for previous diagnoses. A stepwise selection approach was used to select covariates for inclusion in the final model; variables considered for inclusion were age, race, insurance status, geographic region, asthma, visit setting, visit to a pediatrician versus other specialty, presence of fever, and obtaining a radiograph or complete blood count (CBC). We conducted additional analyses using logistic regression to determine whether the observed association between broad-spectrum prescribing and visit setting was attributable to residual confounding or to specific antibiotic classes.

Stata version 11.0 (Stata Corp, College Station, TX) was used for all analyses. All reported *P* values are 2 tailed and account for the complex survey design. We considered a *P* value less than .05 to be statistically significant. This study was

considered exempt from review by the institutional review board of the Children's Hospital of Philadelphia.

RESULTS

Visit Rates for Outpatient Pneumonia Overall

Over the study period, an estimated 1.3 to 1.8 million CAP visits occurred annually, and an estimated 7.9% of patients were admitted overall. The proportion of CAP patients admitted decreased from 10.4% to 7.7% over the study, although this change was not significant (*P* = .7). Of the remaining outpatient visits, an estimated 1.0 to 1.4 million occurred in the office setting, and 203 000 to 295 000 occurred in the ED setting. Overall numbers of CAP visits and population-based CAP incidence rate data by age group, gender, race, and visit setting are presented in Table 1 and Table 2.

The overall annual outpatient CAP rates ranged from 16.9 to 22.4 per 1000 population. CAP rates differed by age group over the study period (Fig 1). In children aged 1 to 5 years, annual visit rates ranged from 32.3 to 49.6 per 1000 population, but no temporal

TABLE 1 Estimated Numbers of Visits for Pediatric Outpatient CAP by Age Group, Gender, Race, and Visit Location Over the Study Period

	<i>n</i> (million, %) ^a						
	1994–1995	1996–1997	1998–1999	2000–2001	2002–2003	2004–2005	2006–2007
Age, y							
1–5	1.59 (60.1)	1.27 (53.4)	1.66 (62.4)	1.69 (54.5)	1.93 (60.1)	1.45 (57.3)	1.99 (60.3)
6–10	0.70 (26.6)	0.96 (40.3)	0.49 (18.4)	1.01 (32.6)	0.92 (28.7)	0.54 (21.3)	0.73 (22.1)
11–18	0.35 (13.3)	0.15 (6.3) ^b	0.50 (18.8)	0.40 (12.9)	0.36 (11.2)	0.54 (21.4)	0.58 (17.6)
Total	2.65 (100)	2.38 (100)	2.66 (100)	3.10 (100)	3.21 (100)	2.53 (100)	3.30 (100)
Gender							
Male	1.60 (60.7)	1.06 (44.5)	1.40 (52.6)	1.71 (55.2)	1.59 (49.5)	1.00 (39.4)	1.53 (46.4)
Female	1.04 (39.3)	1.32 (55.5)	1.26 (47.4)	1.39 (44.8)	1.62 (50.5)	1.54 (60.6)	1.77 (53.6)
Race ^c							
White	2.24 (84.5)	1.91 (80.3)	2.02 (75.9)	2.44 (78.7)	2.78 (86.6)	2.27 (89.7)	2.81 (85.2)
Black	0.32 (12.1)	0.37 (15.5)	0.49 (18.4)	0.54 (17.4)	0.37 (11.5)	0.20 (7.9)	0.38 (11.5)
Visit location							
ED	0.41 (15.5)	0.43 (18.1)	0.49 (18.4)	0.57 (18.4)	0.59 (18.4)	0.53 (20.9)	0.53 (16.1)
Office	2.24 (84.5)	1.95 (81.9)	2.17 (81.6)	2.53 (81.6)	2.62 (81.6)	2.00 (79.1)	2.77 (83.9)

^a Some totals and proportions may not add exactly to 100% as a result of rounding.

^b Estimate is based on fewer than 30 unweighted records.

^c Race proportions do not total to 100%. The race category "other" is not included as a result of fewer than 30 unweighted observations during each study time period.

TABLE 2 Estimated Population-Based Rate of Visits for Pediatric Outpatient CAP by Age Group, Gender, Race, and Visit Location Over the Study Period

	Annual CAP Rate/1000 People (95% CI) ^a						
	1994–1995	1996–1997	1998–1999	2000–2001	2002–2003	2004–2005	2006–2007
Age, y							
1–5	40.0 (27.3–52.7)	32.3 (19.6–44.9)	42.9 (25.4–60.4)	43.7 (26.5–61.0)	49.6 (32.0–67.2)	36.3 (23.1–49.5)	48.8 (32.0–65.6)
6–10	18.4 (8.5–28.4)	24.1 (12.5–35.7)	12.0 (5.8–18.2)	24.4 (12.0–36.8)	22.9 (12.3–33.4)	13.7 (6.1–21.4)	18.4 (6.8–30.1)
11–18	5.9 (2.2–9.6)	2.4 (0.4–4.3) ^a	7.8 (2.3–13.4)	6.2 (2.6–9.8)	5.3 (1.8–8.9)	8.1 (2.4–13.7)	8.7 (2.7–14.6)
Total	19.2 (13.3–25.2)	16.9 (11.8–21.9)	18.5 (12.3–24.7)	21.3 (13.6–29.0)	22.0 (16.3–27.7)	17.3 (11.9–22.6)	22.4 (15.2–29.6)
Gender							
Male	24.3 (15.4–33.2)	14.6 (8.5–20.7)	18.9 (10.2–27.6)	23.0 (13.8–32.2)	22.2 (15.1–29.3)	14.5 (9.2–19.8)	21.7 (12.7–30.7)
Female	15.7 (9.8–21.5)	20.1 (13.1–27.1)	18.0 (10.8–25.2)	20.0 (10.5–29.4)	24.2 (15.1–33.4)	21.3 (12.3–30.3)	24.4 (14.7–34.1)
Race							
White	20.6 (14.3–27.0)	17.2 (11.4–23.1)	18.0 (11.1–24.9)	21.5 (13.7–29.2)	24.4 (17.4–31.5)	19.9 (13.1–26.6)	24.5 (15.6–33.4)
Black	14.5 (2.7–26.2)	16.4 (4.8–27.9)	21.1 (9.1–33.1)	22.9 (4.2–41.4)	15.7 (5.7–25.7)	8.3 (5.1–11.4)	15.9 (8.1–23.7)
Visit location							
ED	3.0 (2.1–3.8)	3.0 (2.2–3.8)	3.4 (2.3–4.5)	3.9 (2.8–5.0)	4.0 (3.1–5.0)	3.6 (2.6–4.6)	3.6 (2.7–4.5)
Office	16.3 (10.5–22.1)	13.8 (8.9–18.7)	15.1 (9.2–21.0)	17.4 (10.0–24.8)	18.0 (12.3–23.6)	13.7 (8.5–18.8)	18.8 (11.9–25.7)

^a Estimate is based on fewer than 30 unweighted records.

FIGURE 1

Two-yearly community-acquired pneumonia rates by age group. *Estimate for the 11- to 18-year-old age group contains fewer than 30 unadjusted records.

trend was evident for the study period overall ($P = .29$) or after the introduction of PCV7 in 2000 ($P = .96$). Annual visit rates were lower for children aged 6 to 10 years, ranging from 12.0 to 24.4 per 1000 population, and children aged 11 to 18 years, ranging from 2.4 to 8.7 per 1000 population. For the children aged 6 to 10 years, there was no temporal trend in visit rate overall ($P = .73$) or after 2000 ($P = .48$); however, there was a trend toward an increase among those aged 11 to 18 years during the study period overall ($P = .18$) and after 2000 ($P = .09$).

The annual outpatient CAP rate did not differ significantly by race, ranging be-

tween 17.2 and 24.5 per 1000 population among white children and between 8.3 and 22.9 per 1000 population among black children ($P = .72$). Neither group had a significant change in CAP visits over the study period.

Visit Rates for CAP in ED and Office Settings

Most CAP visits occurred in office settings (82.1% in offices, 17.9% in EDs). There was a nonsignificant increase in visit rates to offices and EDs over the entire study period ($P = .53$ and $P = .12$, respectively). The annual rate of CAP visits to the ED ranged between 3.0 and 4.0 per 1000 population over the

study period, whereas the rate of CAP office visits ranged between 13.7 and 18.8 per 1000 population. However, between 2000 and 2007 there was a 7.8% increase in office visits ($P = .03$) and an 8.5% decrease in ED visits ($P = .003$).

Antibiotics Prescribed for Outpatient Pneumonia

The 3 most commonly prescribed antibiotic classes for CAP were macrolides, cephalosporins, and penicillins (Fig 2). Macrolides were most commonly prescribed, ranging from 27.8% (95% confidence interval [CI]: 17.8–37.7%) to 41.7% (95% CI: 29.4–53.9%) of all antibiotics prescribed for CAP. Use of macrolides increased ~10.0% every 2 years over the entire study, although this increase was not statistically significant ($P = .075$); that increase was also present from 2000 to 2007 but was not significant ($P = .57$). Cephalosporins were the second most commonly prescribed antibiotic, ranging from 10.5% (95% CI: 4.4–16.7%) to 33.5% (95% CI: 19.8–47.4%) of all antibiotics prescribed for CAP. The increase in prescriptions for cephalosporins over the entire study period was not significant ($P = .48$); however, cephalosporin prescribing increased significantly from 2000 to 2007 ($P =$

FIGURE 2

Antibiotic prescribing for community-acquired pneumonia, 1994–2007. *Estimate for penicillin in 1996–1997 and 1998–1999 contains fewer than 30 unadjusted records.

TABLE 3 Risk Factors Associated With Broad-Spectrum Antibiotic Receipt

Variable	Unadjusted OR (95% CI)	Adjusted OR ^a (95% CI)	<i>P</i> ^b
Visit setting			
ED	1 (reference)	1 (reference)	—
Office	1.7 (0.7–3.9)	4.7 (2.3–9.7)	<.001
Age ^c	1.2 (1.1–1.4)	1.2 (1.1–1.4)	.004
Obtaining a radiograph	2.2 (0.8–5.9)	4.5 (1.6–12.6)	.004
Obtaining a CBC	2.3 (0.8–6.8)	2.8 (1.2–6.3)	.015

^a Adjusted for visit setting (ED versus office visit), age, obtaining a radiograph, and obtaining a CBC.

^b *P* for adjusted ORs.

^c Reflects increase in odds of broad-spectrum antibiotic receipt for each 1-year increase in age.

.002). Penicillin prescriptions were less common, ranging from 4.7% (95% CI: 0.7–8.7%) to 24.9% (95% CI: 13.4–36.4%) of all cases of CAP and had a nonsignificant decrease over the entire study period ($P = .42$) and from 2000 to 2007 ($P = .32$). Combination antibiotic therapy for CAP occurred in 11.5% (95% CI: 8.4–14.6%) of patients.

Factors Associated With Broad-Spectrum Prescribing for Pneumonia

In 2004–2007, an estimated 1.2 million children were seen in the office annually for CAP; 68.2% (95% CI: 58.9–77.5%) received antibiotics, 84.4% (95% CI: 73.7–95.0%) of which were broad spectrum. An estimated 266 000 children were seen in the ED annually for CAP, of whom 86.1% (95% CI: 81.4–

90.8%) received antibiotics, 76.3% (95% CI: 70.7–81.9%) of which were broad spectrum.

Factors associated with broad-spectrum prescribing that remained significant in the final multivariable model are presented in Table 3. Covariates examined for their association with broad-spectrum antibiotic prescribing but not included in the final model included presence of fever (odds ratio [OR]: 0.3 [95% CI: 0.06–1.7]; $P = .19$), geographic region ($P = .22$ by *F* test), black race (OR: 1.5 [95% CI: 0.6–3.7]; $P = .42$), government insurance (OR: 1.4 [95% CI: 0.4–4.5]; $P = .57$), asthma (OR: 0.7 [95% CI: 0.1–4.6]; $P = .71$), or evaluation by a pediatrician versus any other specialty (OR: 0.8 [95% CI: 0.3–2.4]; $P = .73$). In the final model, increas-

ing age, evaluation in the office setting, obtaining a radiograph, and obtaining a CBC were significantly associated with broad-spectrum antibiotic receipt.

We performed additional analyses to examine whether residual confounding explained the observed association between broad-spectrum prescribing and visit setting. There was no evidence of effect modification of imaging receipt on the association between visit setting and prescription for broad-spectrum antibiotics ($P = .08$). None of the antibiotic classes was individually associated with office setting ($P = .23, 0.91$, and 0.76 for penicillins, cephalosporins, and macrolides, respectively). Because providers with access to imaging might have been more able to diagnose atypical pneumonias and therefore prescribe macrolides, we also examined whether prescribing of each antibiotic class was associated with visit setting, while adjusting for imaging use. Penicillin prescribing was significantly less likely in the office setting compared with the ED (adjusted OR: 0.2 [95% CI: 0.1–0.5]; $P < .001$), but neither cephalosporin (adjusted OR: 1.7 [95% CI: 0.7–4.1]; $P = .21$) nor macrolide (adjusted OR: 1.4 [95% CI: 0.5–3.7]; $P = .53$) prescribing individually was more likely in the office setting compared with the ED setting. In addition, examining each antibiotic class as the outcome of our final multivariable model (adjusting for age, visit setting, obtaining a radiograph, or CBC), the association with decreased penicillin prescribing in the office setting remained significant (adjusted OR: 0.2 [95% CI: 0.1–0.4]; $P < .001$), whereas the associations with increased macrolides (adjusted OR: 1.1 [95% CI: 0.4–3.1]; $P = .89$) and cephalosporins (adjusted OR: 2.4 [95% CI: 0.9–6.7]; $P = .09$) were not significant.

DISCUSSION

Our study provides 4 main findings. We provide the first comprehensive national estimates of outpatient pediatric pneumonia. Second, the rate of outpatient pediatric CAP visits did not change significantly over a 14-year period, spanning the introduction of PCV7. Third, nonpenicillins were frequently prescribed for CAP, and macrolides remained the most commonly prescribed class of antibiotics for CAP over the 14-year study period. Fourth, increasing age, evaluation in the office setting when compared with the ED, and obtaining a radiograph or a CBC during the visit were associated with broad-spectrum antibiotic prescribing.

Outpatient CAP visit rates did not appreciably change over time despite licensure of PCV7 in 2000; Grijalva et al¹⁶ reported similar results in children under 6 years of age using data through 2003. There are several possible explanations. Radiographs confirming the CAP diagnosis were not routinely performed in the outpatient setting, which could lead to an overestimation of pneumonia rates. Clinical examination findings may have poor specificity for pneumonia diagnosis. In a randomized, double-blind study of PCV7 effectiveness, there was no difference in clinically diagnosed pneumonia incidence, but there was a 20% reduction in radiograph-confirmed pneumonia in PCV7 recipients compared with placebo recipients.²² Moreover, pneumococcal vaccination in adults is associated with reduced hospital mortality and length of stay for pneumonia.²³ PCV7, therefore, may prevent severe pneumococcal CAP cases requiring hospitalization but may have minimal impact on the less severe CAP cases, which may or may not be caused by pneumococcus, diagnosed and managed in the outpatient setting. Our data did not demonstrate

a decreasing proportion of CAP outpatients admitted; however, the surveys' intent is to capture a nationally representative sample of outpatient visits rather than inpatient admissions.

Nonpenicillins were frequently used for outpatient pediatric CAP, with macrolides being the most commonly prescribed class of antibiotics; additionally, cephalosporin use has increased since 2000. Dosing convenience and effective marketing of newer antibiotics may have made their use for outpatient infections increasingly appealing, yet current data suggest that penicillins remain appropriate first-line agents for pediatric CAP on the basis of their narrow spectrum of activity and known efficacy against the common bacterial causes of pneumonia.

We identified 4 factors strongly associated with the use of broad-spectrum antibiotics in the outpatient setting. Increasing age may be associated with increased broad-spectrum antibiotic use if providers are concerned about the higher prevalence of atypical pathogens such as *Mycoplasma pneumoniae* among older children, although the efficacy of antibiotic therapy for pediatric *Mycoplasma pneumoniae* has not been conclusively shown.^{24–26} A preference for dosing convenience in older patients expected to manage their own medicines also may contribute to this finding.

Broad-spectrum antibiotic prescribing for CAP was more common in office settings than in the ED setting. This finding merits future study but is consistent with previous studies^{27,28} demonstrating decreased broad-spectrum antibiotic prescribing in the ED for acute otitis media and sore throat. Our data suggest that the increased use of broad-spectrum antibiotics in the office setting is not attributable to any individual class of broad-spectrum antibiotics. There may be increased exposure to pharmaceutical company rep-

resentatives and samples in the office setting, creating a stimulus for the use of newer, better advertised, and typically broader-spectrum antibiotics. Treatment patterns in EDs also may be more standardized than they are in the office setting, with an increased use of institutional guidelines.

It is frequently impractical to perform radiographs as part of routine outpatient CAP diagnosis, and data suggest that performing radiographs may be associated with increased antibiotic use.^{29,30} Distinguishing atypical from viral pneumonia on chest radiograph can be difficult, which may have led providers to employ broad-spectrum antibiotics to include coverage for atypical pathogens. Obtaining a CBC may be a surrogate for disease severity in our outpatient population.

This study had several possible limitations. There is no unique ICD-9-CM code for CAP, so some misclassification of CAP patients may have occurred, although we minimized this possibility by using a previously validated ICD-9-CM diagnosis code algorithm for identifying patients with CAP.¹⁸ Likewise, we were unable to identify causative pathogens, and some patients diagnosed with CAP may have had viral etiologies. However, even with the understanding that some pneumonias in our cohort were likely viral, the misdiagnosis of viral pneumonias as bacterial should not have affected antibiotic selection once the physician's intent was to treat bacterial pneumonia.

Factors other than changing pneumococcal drug resistance may affect antibiotic choice. We attempted to account for these potential confounders in several ways. First, patients with chronic medical conditions were excluded, but our exclusion may have been incomplete, allowing some patients requiring broad-spectrum CAP therapy to remain in the study cohort. However, these patients would be

more likely to receive care in the ED, and had any of these patients remained in the study it would cause us to underestimate the magnitude of broad-spectrum prescribing differences between offices and the ED. Second, specific covariates were examined for inclusion in our multivariable model to account for severity of illness. Our ability to adjust for illness severity was likely imperfect, but patients evaluated in the ED for CAP were likely more ill than those in office settings, again causing us to underestimate setting differences in broad-spectrum prescribing.

Finally, survey data have certain inherent limitations. Patient allergies are not available in either survey; antibiotic class allergies, although uncommon in general, might alter antimicrobial prescribing for CAP. The surveys

also lack detailed clinical information such as symptoms or physical examination findings, which could help confirm the CAP diagnosis in patients identified using our algorithm.

Our study has several implications. The unchanged rate of outpatient pediatric CAP diagnosis despite introduction of PCV7 suggests that better diagnostics are needed to distinguish bacterial from viral pneumonia. Likewise, efforts to improve bacterial pneumonia diagnosis have the potential to decrease broad-spectrum antibiotic overuse significantly.

CONCLUSIONS

Future studies are warranted to establish the comparative effectiveness of different antibiotics for the empiric treatment of pediatric outpatient CAP. The establishment and adoption of

guidelines for the diagnosis and management of pediatric outpatient pneumonia are likely to reduce broad-spectrum antibiotic overuse for this common pediatric condition.

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APPENDIX International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) Codes Used To Identify Patients With Complex Chronic or Immunocompromising Conditions and Specific Infections for Exclusion

Category	Subcategory	ICD-9-CM codes
Cardiovascular	Cardiomyopathies	425.0–425.4, 429.1
	Conduction disorders	426.0–427.4
	Dysrhythmias	427.6–427.9
	Heart and great vessel malformations	745.0–747.4
Gastrointestinal	Inflammatory bowel disease	555.0–556.9
	Chronic liver disease and cirrhosis	571.4–571.9
	Congenital anomalies	750.3, 751.1–751.3, 751.6–751.9
	Human immunodeficiency virus infection	042
Hematologic/Immunologic	Hereditary immunodeficiency	279.00–279.9, 288.1–288.2, 446.1
	Hereditary anemias	282.0–282.4
	Sickle cell disease	282.5–282.6
	Malignant neoplasms	140.0–208.9, 235.0–239.9
Malignancy	Amino acid metabolism	270.0–270.9
	Carbohydrate metabolism	271.0–271.9
	Lipid metabolism	272.0–272.9
	Storage disorders	277.3, 277.5
Metabolic	Other metabolic disorders	275.0–275.3, 277.2, 277.4, 277.6, 277.8–277.9
	Mental retardation	318.0–318.2
	Central nervous system degeneration and disease	330.0–330.9, 334.0–334.2, 335.0–335.9
	Infantile cerebral palsy	343.0–343.9
Neuromuscular	Muscular dystrophies and myopathies	359.0–359.3
	Brain and spinal cord malformations	740.0–742.9
	Bone and joint anomalies	259.4, 737.3, 756.0–756.5
	Diaphragm and abdominal wall	553.3, 756.6–756.7
Other Congenital/Genetic defects	Chromosomal anomalies	758.0–758.9
	Other congenital anomalies	759.7–759.9
Renal	Chronic renal failure	585
	Congenital anomalies	753.0–753.9
Respiratory	Cystic fibrosis	277.0
	Respiratory malformations	748.0–748.9
	Chronic respiratory disease	770.7
	Bacterial meningitis	320.0–320.9
Specific Infections	Urinary tract infection	599.0
	Septic arthritis	711.0, 711.4, 711.6–711.9
	Osteomyelitis	730.0–730.9

Adapted from Feudtner et al¹⁹