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Antibiotic Prescribing in Ambulatory Pediatrics in the United States

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KEY WORDS

antibacterial agents, respiratory tract infections, pediatrics, physician's practice patterns, inappropriate prescribing

ABBREVIATIONS

ARTI—acute respiratory tract infection
NAMCS—National Ambulatory Medical Care Survey
NHAMCS—National Hospital Ambulatory Medical Care Survey
NCHS—National Center for Health Statistics
ICD-9-CM—*International Classification of Diseases, Ninth Revision, Clinical Modification*
CI—confidence interval
OR—odds ratio

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WHAT'S KNOWN ON THIS SUBJECT: Results of previous studies have indicated that most antibiotic prescriptions for children are for respiratory conditions, and many of them are inappropriate. Although antibiotic prescribing is declining overall, broad-spectrum antibiotic prescribing for respiratory conditions is increasing. Unnecessary antibiotic prescribing promotes resistance and adverse events.

WHAT THIS STUDY ADDS: Respiratory conditions account for >70% of antibiotic prescriptions in ambulatory pediatrics. Broad-spectrum antibiotics, especially macrolides, represent 50% of pediatric antibiotic use. Broad-spectrum antibiotics are frequently prescribed unnecessarily for conditions for which antibiotics are unlikely to provide benefit.

abstract

BACKGROUND: Antibiotics are commonly prescribed for children with conditions for which they provide no benefit, including viral respiratory infections. Broad-spectrum antibiotic use is increasing, which adds unnecessary cost and promotes the development of antibiotic resistance.

OBJECTIVE: To provide a nationally representative analysis of antibiotic prescribing in ambulatory pediatrics according to antibiotic classes and diagnostic categories and identify factors associated with broad-spectrum antibiotic prescribing.

PATIENTS AND METHODS: We used the National Ambulatory and National Hospital Ambulatory Medical Care surveys from 2006 to 2008, which are nationally representative samples of ambulatory care visits in the United States. We estimated the percentage of visits for patients younger than 18 years for whom antibiotics were prescribed according to antibiotic classes, those considered broad-spectrum, and diagnostic categories. We used multivariable logistic regression to identify demographic and clinical factors that were independently associated with broad-spectrum antibiotic prescribing.

RESULTS: Antibiotics were prescribed during 21% of pediatric ambulatory visits; 50% were broad-spectrum, most commonly macrolides. Respiratory conditions accounted for >70% of visits in which both antibiotics and broad-spectrum antibiotics were prescribed. Twenty-three percent of the visits in which antibiotics were prescribed were for respiratory conditions for which antibiotics are not clearly indicated, which accounts for >10 million visits annually. Factors independently associated with broad-spectrum antibiotic prescribing included respiratory conditions for which antibiotics are not indicated, younger patients, visits in the South, and private insurance.

CONCLUSIONS: Broad-spectrum antibiotic prescribing in ambulatory pediatrics is extremely common and frequently inappropriate. These findings can inform the development and implementation of antibiotic stewardship efforts in ambulatory care toward the most important geographic regions, diagnostic conditions, and patient populations. *Pediatrics* 2011;128:000

Antibiotics are among the most frequently prescribed classes of medications for children.[1] Previous studies have estimated that >150 million ambulatory visits result in an antibiotic prescription annually, including >30 million prescriptions for children.[2,3] However, in many of these instances, antibiotics are prescribed for conditions of viral origin, for which they provide no clinical benefit.[4–9]

The overall rate of antibiotic prescribing in ambulatory settings is declining[2,6,10]; some of this decline is attributable to reductions in prescribing for respiratory conditions of viral origin.[6] The Centers for Disease Control and Prevention led substantial efforts during the 1990s to raise awareness about inappropriate antibiotic prescribing that likely contributed to these trends.[11] On the other hand, prescribing of broad-spectrum agents, especially macrolides, has increased substantially during the past decade.[6,10,12–15] The consequences of inappropriate antibiotic prescribing, either in the form of treatment when no therapy is necessary or prescribing an unnecessarily broad-spectrum agent when a narrower-spectrum agent would be effective, are manifold. Antibiotic overuse contributes to unnecessary costs and avoidable adverse events[16] and influences the development of antibiotic-resistant infections.[17,18]

Although antibiotic-prescribing patterns for pediatric acute respiratory tract infections (ARTIs) have been studied,[2,6,8–10] little is known about overall patterns of antibiotic prescribing in ambulatory pediatrics across the spectrum of diagnostic conditions. Furthermore, the types of diagnostic conditions, as well as patient and physician characteristics associated with prescribing broad-spectrum antibiotics, are unknown. In this study we addressed 2 objectives. First, we sought to describe the overall use of antibiotics in ambulatory pediatrics according to antibiotic classes, with a particular focus on estimating the tendency for physicians to prescribe antibiotics for a range of diagnoses. Second, we sought to identify factors associated with broad-spectrum antibiotic prescribing during ambulatory care visits. This insight will help provide targets for future interventions designed to improve judicious antibiotic use.

METHODS

Data Source and Design

We analyzed data from the National Ambulatory Medical Care Survey (NAMCS) and the National Hospital Ambulatory Medical Care Survey (NHAMCS) between 2006 and 2008. Each year, the National Center for Health Statistics (NCHS) administers these cross-sectional surveys to collect data from a nationally representative sample of visits to offices, outpatient departments, and emergency departments. Data collected at visits include patient demographics, physician specialty, practice setting, diagnoses (up to 3, based on codes from the *International Classification of Diseases, Ninth Revision, Clinical Modification* [ICD-9-CM]), and medications prescribed.[19]

The NAMCS includes data from patient visits to physician offices. In a 3-stage procedure, the NCHS first samples 112 geographic primary sampling units and then samples from physician practices within units and patient visits within physician practices. The NHAMCS includes data from patient visits to hospital outpatient departments and emergency departments. The NHAMCS follows a 4-stage sampling design consisting of geographic primary sampling units, hospitals within units, emergency service areas and clinics within hospitals, and patient visits within emergency service areas or clinics. For each visit, the NCHS provides a patient visit weight, which represents the inverse probability that the patient was selected from a broader population. Using these weights, nationally representative estimates can be generated from the sampled data in the NAMCS and NHAMCS.[19]

Study Population and Diagnostic Categories

The eligible study population included all children younger than 18 years who visited ambulatory care settings during 2006–2008. During this period there were 64 753 sampled visits in the NAMCS and NHAMCS. Visits were grouped into 1 of 6 diagnostic categories on the basis of the primary diagnosis assigned at that visit to enable analysis of antibiotic prescribing on the basis of diagnosis (Appendix). Categories included respiratory conditions, skin/cutaneous/mucosal conditions, urinary tract infections, gastrointestinal infections, miscellaneous infections, and other conditions. For respiratory conditions, 3 smaller subcategories were created, including ARTIs for which antibiotics are typically indicated (eg, otitis media, sinusitis, pharyngitis, pneumonia), ARTIs for which antibiotics are not indicated (eg, nasopharyngitis, bronchitis, viral pneumonia, influenza), and other respiratory conditions for which antibiotics are not definitely indicated (eg, asthma, allergy, chronic sinusitis, chronic bronchitis), which were based in part on a previously published scheme.[6] For certain diagnoses such as pharyngitis and pneumonia, the ICD-9-CM codes do not adequately specify bacterial or viral etiology. Therefore, we classified these diagnoses as conditions for which antibiotics are indicated. One exception was viral pneumonia (ICD-9-CM 480.x), which was categorized as a condition for which antibiotics are not indicated.

In certain instances, the secondary diagnoses contributed to the diagnostic classification. When the primary diagnosis specified a routine child health visit (ICD-9-CM code V20), the secondary diagnosis was used to classify the diagnosis. For visits in which the second or third diagnosis listed was one for which antibiotics are typically indicated ($n = 2036$; ARTIs for which antibiotics are indicated, skin infections, and urinary tract infections), the visit was excluded from the diagnostic classification scheme, because the diagnosis for which the antibiotic was intended would be ambiguous.

Antibiotic Classification

On the basis of codes from the Multum Lexicon Drug Database and the National Drug Code Directory,[20] antibiotics were grouped into classes including penicillins, sulfonamides, cephalosporins, macrolides, quinolones, lincomycin derivatives, tetracyclines, and carbapenems. We defined broad-spectrum antibiotics as broad-spectrum penicillins (antipseudomonal penicillins and β-lactam/β-lactamase inhibitor combinations), second- to fourth-generation cephalosporins, macrolides, quinolones, lincomycin derivatives (clindamycin), and carbapenems. Visits in which both broad- and narrow-spectrum antibiotics were prescribed were classified as those during which broad-spectrum antibiotics were prescribed.

Several steps were taken to exclude topical antibiotics. First, drugs classified in the Multum system as topical (Multum level 1, category 133) were excluded. Aminoglycosides were excluded, because these antibiotics are predominantly prescribed in their topical formulations for patients in ambulatory practice. Quinolone antibiotics were assumed to be topical and excluded even if not classified as "topical" in the Multum database when the antibiotic name recorded on the patient record form suggested a topical formulation (eg, Floxin otic, Cipro-HC, Ciprodex, Vigamox, Cipro eye solution, Quixin otic, Zymar). In addition, we excluded quinolones from the systemic antibiotic category for visits when the diagnosis was either infective otitis externa or conjunctivitis, because topical formulations are usually prescribed for these diagnoses. After these exclusions, there were 10 273 sampled visits during which patients received antibiotics.

Analysis

We measured 4 major outcomes. First, using NCHS-provided weights, based on the sampled visits, we derived estimates of the frequency of antibiotic prescribing for all ambulatory pediatric visits according to class (eg, penicillins, macrolides) and spectrum of activity (eg, broad or narrow spectrum). Second, we performed an analysis across conditions, whereby we estimated the distribution of diagnostic categories (eg, percentage of all antibiotic prescriptions for respiratory conditions) that accounted for overall antibiotic prescribing. Third, we performed an analysis within conditions, whereby we estimated the distribution of antibiotic prescribing according to category within each diagnostic category (eg, percentage of respiratory conditions for which an antibiotic was prescribed). Fourth, we performed multivariable logistic regression to identify demographic and clinical factors associated with broad-spectrum antibiotic prescribing. Demographic factors considered were patient age (0–5, 6–12, and 13–17 years), US Census region (Northeast, Midwest, South, West), race (white, black, and other), gender, year (2006, 2007, and 2008), and urban versus nonurban based on whether the visit was made in a metropolitan statistical area. Clinical factors included diagnosis (ARTI, other respiratory conditions, skin/mucosal conditions, and other), insurance (private, public, and self-pay/other), and setting (office, outpatient clinic, and emergency department). To examine the association of physician specialty (pediatrics, general/family practice, and other) on broad-spectrum antibiotic prescribing, a separate model was used only for the visits in office/outpatient clinic settings. Variables were included in the model if they were nominally associated ($P < .2$) with broad-spectrum antibiotic prescribing in bivariate analysis. Race was included regardless of its bivariate association with broad-spectrum antibiotic prescribing.

All analyses were performed by using Stata 11 (Stata Corp, College Station, TX) and accounted for the components of the complex survey design, including patient visit weights, strata, and primary sampling unit design variables.

RESULTS

Distribution of Antibiotic Prescribing

Between 2006 and 2008, antibiotics were prescribed in an estimated average of 49 million (95% confidence interval [CI]: 43–55 million) ambulatory pediatric visits annually, which represents 21% of all ambulatory visits for children. Broad-spectrum antibiotics were prescribed in 50% of the visits in which antibiotics were prescribed, which is an estimated 24.6 million (95% CI: 21.2–28.1 million) visits annually. The most commonly prescribed antibiotic classes overall were narrow-spectrum penicillins (38% of visits in which antibiotics were prescribed) and macrolides (20%) (Fig 1). Quinolones, tetracyclines, lincomycin derivatives, and sulfonamides were prescribed relatively infrequently, together accounting for <11% of visits in which antibiotics were prescribed. Within the category of broad-spectrum antibiotics, macrolides were the most frequently prescribed (40% of broad-

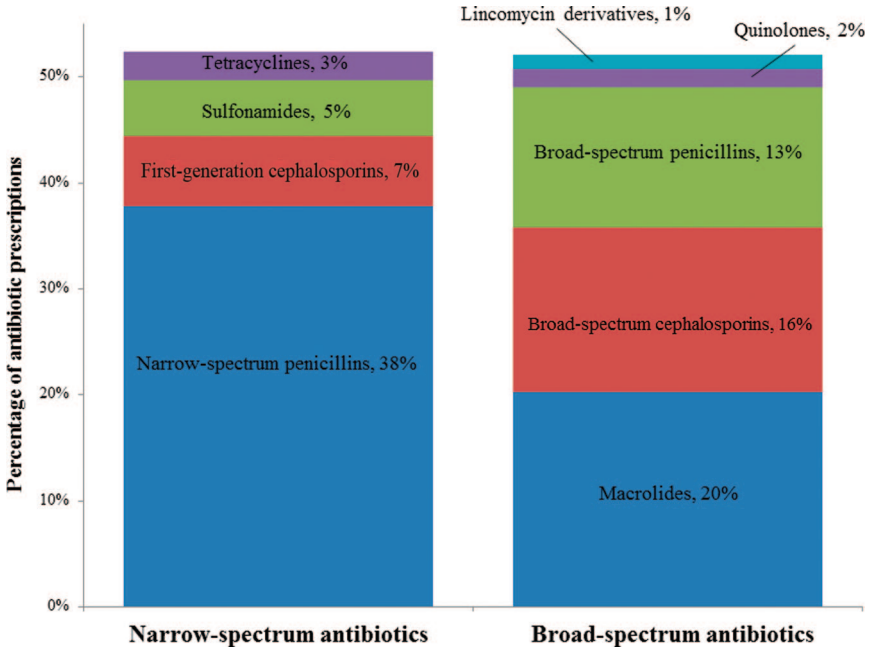

FIGURE 1

Frequency of narrow- and broad-spectrum antibiotic use according to class for all pediatric ambulatory visits, 2006–2008. Totals are slightly more than 100%, because multiple antibiotics were prescribed during a small number of visits.

TABLE 1 Antibiotic-Prescribing Patterns Across Diagnostic Conditions

Condition	Across-Condition Contribution to Antibiotic Prescribing, %
Respiratory	72.3
ARTIs for which antibiotics are indicated	48.9
ARTIs for which antibiotics are not indicated	13.1
Other respiratory conditions for which antibiotics are not definitely indicated	10.3
Other	27.7
Skin/cutaneous/mucosal	11.9
Urinary tract infections[a]	2.0
Gastrointestinal infections	0.3
Miscellaneous infections	1.9
Other	11.6
Total	100[a]

Data indicate the percentage that each condition contributed to overall antibiotic prescribing on the basis of an estimated total of 43.9 million visits in which antibiotics were prescribed. This total does not include 2036 sampled visits excluded in which a concomitant infection appeared as a secondary or tertiary diagnosis. See Appendix for ICD-9-CM codes specified by each condition.

[a] Excludes nitrofurantoin.

spectrum antibiotic prescriptions, 20% of overall antibiotic prescriptions), followed by broad-spectrum cephalosporins (31% of broad-spectrum antibiotics, 16% of overall antibiotics), and broad-spectrum penicillins (26% of broad-spectrum antibiotics, 13% of overall antibiotics) (Fig 1).

Antibiotic Prescribing Across Diagnostic Conditions

Respiratory conditions accounted for most (72.3%) visits in which antibiotics were prescribed (Table 1). However, although 48.9% of antibiotic prescribing was for ARTIs for which antibiotics are indicated, 23.4% was for respiratory conditions for which antibiotics are potentially unnecessary, including ARTIs for which antibiotics are not indicated and other respiratory conditions (Table 1). Collectively, these visits for respiratory infections for which antibiotics were potentially inappropriately prescribed accounted for >10 million visits annually, including >6 million with broad-spectrum antibiotics. Skin/cutaneous/mucosal conditions were the next most frequent (12%) diagnostic category for which antibiotics were prescribed. Urinary tract infections only accounted for 2% of antibiotic prescribing, whereas the "other" category, a group in which no clear infectious etiology was noted, accounted for 11%. The distribution of diagnostic categories was generally similar when focused exclusively on broad-spectrum antibiotics. The most notable difference when compared with overall antibiotic visits was that ARTIs for which antibiotics are not indicated and other respiratory conditions accounted for a higher percentage of broad-spectrum antibiotic visits (30% of broad-spectrum antibiotic visits versus 23% of all antibiotic visits).

Antibiotic Prescribing Within Diagnostic Conditions

When antibiotic-prescribing patterns were examined within individual diagnostic conditions, respiratory conditions remained the most important group. Overall, an antibiotic was prescribed during 48.4% of the visits in which a respiratory condition was the primary diagnosis, including 71.7% for ARTIs for which antibiotics are indicated and 29.6% for ARTIs for which antibiotics are not indicated (Table 2). Among visits during which antibiotics were prescribed, 11.3 million were for acute otitis media and 2.1 million were for bronchitis. The categories with the next highest frequency of antibiotic prescribing were other respiratory conditions (28%), urinary tract infections (59%), and skin/cutaneous/mucosal conditions (19%) (Table 3). Within conditions, given that an antibiotic was prescribed, the tendency to prescribe a broad-spectrum antibiotic was highest for ARTIs for which antibiotics are not indicated (62.5%) and other respiratory conditions (64.5%).

Factors Associated With Broad-Spectrum Antibiotic Prescribing

The bivariate associations between demographic and clinical variables and

TABLE 2 Antibiotic-Prescribing Patterns According to Condition

Condition	Estimated Annual No. of Visits for Condition, Millions	No. of Visits for Condition for Which Antibiotics Were Prescribed, Millions (%)	No. of Visits in Which Broad-Spectrum Antibiotics Were Prescribed, Millions (% of Antibiotics That Were Broad-Spectrum)
Respiratory	65.6	31.7 (48.4)	16.9 (53.1)
ARTIs for which antibiotics are indicated	29.9	21.5 (71.7)	10.3 (48.0)
ARTIs for which antibiotics are not indicated	19.5	5.8 (29.6)	3.6 (62.5)
Other respiratory conditions for which antibiotics are not definitely indicated	16.2	4.5 (27.8)	2.9 (64.5)
Other	158.6	12.2 (7.7)	5.1 (41.9)
Skin/cutaneous/mucosal	28.2	5.2 (18.6)	2.0 (37.8)
Urinary tract infections[a]	1.4	0.9 (59.3)	0.3 (39.3)
Gastrointestinal infections	2.3	0.1 (5.7)	0.1 (54.1)
Miscellaneous infections	8.7	0.8 (9.6)	0.2 (29.0)
Other	117.9	5.1 (4.3)	2.5 (48.3)
Total[b]	224.2	43.9 (19.6)	22.0 (50.1)

Data indicate the estimated number of visits annually in which antibiotics were prescribed for each diagnostic condition and the percentage of overall antibiotic prescribing accounted for by each condition. See Appendix for ICD-9-CM codes specified by each condition.

[a] Excludes nitrofurantoin.

[b] Totals do not include 2036 visits excluded because a concomitant infection appeared as a secondary or tertiary diagnosis. When all visits were included, the overall percentage of visits during which antibiotics were prescribed was 21%.

broad-spectrum antibiotic prescribing are shown in Table 2. Among the variables considered for inclusion in the multivariable logistic regression model on the basis of $P < .20$, diagnosis, age, race, region, insurance status, and setting were included (Table 2). Of these variables, diagnosis, age, US Census region, and insurance status were independently associated with broad-spectrum antibiotic prescribing (Table 2). Relative to other antibiotics, broad-spectrum antibiotics were more likely to be prescribed for ARTIs for which antibiotics are not indicated (odds ratio [OR]: 1.80 [95% CI: 1.34–2.42]) and other respiratory conditions (OR: 1.93 [95% CI: 1.40–2.66]) than for ARTIs for which antibiotics are indicated and other diagnoses. Likewise, patients younger than 6 years were more likely (OR: 1.27 [95% CI: 1.04–1.54]) than patients aged 6 to 12 years to receive broad-spectrum antibiotics. Visits in the South were more likely (OR: 1.82 [95% CI: 1.30–2.55]) to result in broad-spectrum antibiotic prescribing than visits in the West, and those with public or no insurance were less likely (OR: 0.79 [95% CI: 0.66–0.94]) than those with private insurance to receive a broad-spectrum antibiotic. There was no independent association between setting, race, or specialty and broad-spectrum antibiotic prescribing.

DISCUSSION

The results of this study provide a current and comprehensive examination of antibiotic-prescribing patterns for US children in ambulatory care settings. In this study, we found that antibiotic prescribing during ambulatory pediatric visits was frequent, occurring in >1 in 5 visits. The use of broad-spectrum antibiotics was common and accounted for 50% of overall antibiotic prescribing and occurred during nearly 25 million visits per year. We also found that respiratory conditions account for the vast majority of antibiotic prescriptions for children. More strikingly, our study reveals that the use of broad-spectrum antibiotics was highest among respiratory conditions for which antibiotics are typically not indicated (eg, viral conditions, asthma) compared with any other type of diagnostic category. Despite substantial and favorable changes in the extent to which antibiotics were prescribed overall during recent years,[6] this finding raises serious concerns about the overuse of broad-spectrum antibiotics, particularly for patients for whom antibiotic therapy is not indicated at all.

Our results highlight key differences in antibiotic-prescribing patterns for children compared with adults. For the US population as a whole, Grijalva et al[6] reported that antibiotics are prescribed during 13% of all visits and that ARTIs (including those for which antibiotics are not typically indicated) account for 44% of all antibiotic prescribing. In our study, which was focused exclusively on children, we found that antibiotics were prescribed more frequently (>20% of visits) and that ARTIs accounted for >60% of these visits. In regards to broad-spectrum antibiotic prescribing, we observed both differences and similarities relative to prescribing for adults. Steinman et al[21] reported that broad-spectrum antibiotics accounted for 48% of antibiotic prescribing overall and 54% of antibiotic use for ARTIs, which is similar to our findings. In addition, Steinman et al[21] also found that broad-spectrum antibiotic prescribing was higher in the South relative to

TABLE 3 Multivariable Model of Factors Associated With Broad-Spectrum Antibiotic Prescribing

Independent Variable	% Receiving Broad-Spectrum Agents	*P*	Broad-Spectrum Prescribing, Adjusted OR (95% CI)
Diagnostic conditions		.0001	
ARTIs for which antibiotics are indicated	48		1.00
ARTIs for which antibiotics are not indicated	63		1.80 (1.34–2.42)
Other respiratory conditions for which antibiotics are not definitely indicated	64		1.93 (1.40–2.66)
Skin/cutaneous/mucosal conditions	38		0.69 (0.52–0.91)
All other conditions	45		0.93 (0.74–1.16)
Age		.12	
0–5 y	52		1.27 (1.04–1.54)
6–12 y	47		1.00
13–17 y	49		1.16 (0.93–1.46)
US Census region		.001	
Northeast	46		1.23 (0.82–1.84)
Midwest	48		1.30 (0.90–1.86)
South	55		1.82 (1.30–2.55)
West	42		1.00
Insurance		.004	
Private	53		1.00
Public	48		0.79 (0.66–0.94)
Self-pay/other	40		0.59 (0.41–0.84)
Setting		.003	
Office	51		1.00
Outpatient department	45		0.90 (0.76–1.07)
Emergency department	46		0.99 (0.86–1.15)
Race		.50	
White	51		1.00
Black	48		0.78 (0.60–1.01)
Other	47		1.04 (0.72–1.51)
Specialty		.13	
Pediatrics	52		1.00
General/family practice	46		0.87 (0.67–1.13)
Other	53		1.32 (0.90–1.94)
Gender		.57	[a]
Male	51		
Female	49		
Metropolitan statistical area		.43	[a]
Nonmetropolitan	48		
Metropolitan	50		
Year		.72	[a]
2006	49		
2007	50		
2008	51		

[a] Not entered into model.

other geographic regions and that differences existed on the basis of insurance status, findings that are also similar to ours. One major difference between adults and children regarding broad-spectrum antibiotic prescribing relates to antibiotic selection. For adults, fluoroquinolones are the most commonly prescribed broad-spectrum antibiotic category overall,[14,21] in contrast to pediatric populations, for which fluoroquinolones accounted for <3% of antibiotic prescribing overall and among broad-spectrum antibiotics.

Although narrow-spectrum penicillins (eg, amoxicillin) were the most commonly prescribed antibiotic class, broad-spectrum antibiotics accounted for 50% of antibiotic prescribing, and among them, macrolides (primarily azithromycin) were the leading class. Several previous studies have found large increases in the use of macrolides during the past decade both as a class overall[10,15] and for selected conditions.[12,13] Our results confirm that physicians continue to frequently prescribe macrolides for pediatric patients. Our findings suggest that it is likely that in many visits in which macrolides are prescribed, either no antibiotic therapy is necessary, or a narrower-spectrum alternative would be appropriate. Macrolides are an attractive antibiotic class because of their long half-life, which enables a short duration of therapy and once-daily dosing. Physicians may prescribe macrolides in certain instances to target atypical pathogens such as *Mycoplasma pneumoniae* as a cause of pneumonia. However, the efficacy of macrolides for *Mycoplasma* has not been definitively established,[22] and macrolide resistance to *Streptococcus pneumoniae*, which is an important cause of both upper and lower respiratory tract infections, is a growing concern.[23]

A finding of interest from this study is that, after respiratory conditions, skin/mucosal conditions are the category for which antibiotics and broad-spectrum antibiotics are next most commonly prescribed. The authors of several recent studies[24–26] and a treatment guideline[27] questioned the value of routine antibiotic use for adequately drained purulent abscesses. More definitive data from ongoing randomized clinical trials might provide evidence to support efforts to reduce unnecessary antibiotic use for this common clinical condition.[27]

We found that certain clinical and demographic factors were independently associated with broad-spectrum antibiotic prescribing. As previously noted, ARTIs for which antibiotics are not indicated and other

noninfectious respiratory conditions are more likely than other clinical conditions to receive treatment with broad-spectrum antibiotics. Because of the high frequency with which children seek care for respiratory conditions, this clearly remains a critical area for continued education around judicious antibiotic use. Children younger than 6 years received broad-spectrum antibiotics more frequently than those of other ages. Some of this may be appropriate use of broad-spectrum antibiotics according to the types of respiratory conditions most common in this age group (eg, the treatment of acute otitis media with agents such as amoxicillin/clavulanate).[28] We found that broad-spectrum antibiotic prescribing was higher in the South than other geographic regions. Although the explanation for this geographic variation is uncertain, higher rates of broad-spectrum antibiotic prescribing in the South were found previously in a study among adults.[21] Regional differences in exposure to interventions focused on appropriate antibiotic prescribing,[29,30] as well as regional differences in insurance plans' formulary restrictions,[31] could all have a role.

We also found that children with public or no insurance were less likely to receive broad-spectrum antibiotics compared with those with private insurance. Although this finding raises concerns about differences in the quality of care provided for children on the basis of insurance type, the clinical implications might be negligible, because broad-spectrum antibiotics are frequently prescribed inappropriately. Recent evidence indicates that antibiotic-prescribing patterns, including the selection of broad- versus narrow-spectrum agents, are highly sensitive to out-of-pocket costs; when out-of-pocket costs are lowered, broad-spectrum antibiotic prescribing increases.[32] However, because cost also influences whether patients will ultimately fill a prescription, by factoring cost into their antibiotic-selection decisions, physicians caring for children with public or no insurance are likely providing high-quality care by prescribing less expensive antibiotics and are thereby decreasing potential economic barriers to compliance.[33]

This study has limitations that need to be acknowledged when considering the findings. The diagnoses used for our analysis relied on ICD-9-CM codes. Although the NAMCS and NHAMCS databases are regularly validated, we cannot ensure the accuracy of the diagnoses assigned during these visits, and misclassification can occur. We made efforts to ensure that visits in our sample for which antibiotics were prescribed were targeting the assigned diagnosis, including excluding visits for which secondary diagnoses could potentially have justified an antibiotic. In addition, we categorized pharyngitis as a condition for which antibiotics are indicated, although the number of viral causes typically exceed those of group A *Streptococcus*. In some instances we might have categorized a visit as one in which antibiotics were not indicated when a reasonable justification existed; however, on the basis of how we conducted the analysis, any bias collectively would have been in a conservative direction, and we might have underestimated the extent to which unnecessary antibiotic prescribing occurs. We also chose to not classify some antibiotics as systemic because of concerns that the antibiotic was topical (eg, quinolones and aminoglycosides). Although some of these could have been systemic formulations, this potential bias would not substantially influence our findings, because these antibiotic categories were prescribed infrequently overall. The age category of 0 to 5 years is heterogeneous, and finer stratification might have revealed additional insights about broad-spectrum prescribing. An additional limitation relates to the timing of our study. We used the most recently available years for the NAMCS and NHAMCS databases (2006–2008); however, changes might have occurred during the ensuing years.

CONCLUSIONS

We found that broad-spectrum antibiotic prescribing accounts for 50% of antibiotic use in ambulatory pediatrics and that respiratory conditions for which antibiotics are not indicated, lack of private insurance, and geographic region are important contributing factors. The overuse of broad-spectrum antibiotics is problematic, because many of these agents are prescribed unnecessarily, have high cost, and promote bacterial resistance.[34,35] Antibiotic stewardship programs have been shown to be effective interventions for improving antibiotic-prescribing patterns in hospital settings,[36] including reducing overuse of broad-spectrum antibiotics. Broader development and implementation of programs specifically tailored to ambulatory care settings is a public health priority. Our findings can assist program development by highlighting several important target areas and by providing a nationally representative framework for examining antibiotic-prescribing practices that can be modified to examine prescribing practices on a local level.

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APPENDIX Diagnostic Conditions Used to Classify Antibiotic Prescribing

Condition	ICD-9-CM Codes	Description
Respiratory		
ARTIs for which antibiotics are indicated	034, 381–383, 461–463, 475, 481–486	Sinusitis, pharyngitis, tonsillitis, otitis media, mastoiditis, streptococcal sore throat, peritonsillar abscess, nonspecific pneumonia
ARTIs for which antibiotics are not indicated	460, 464–466, 480, 487–488, 490	Nasopharyngitis, laryngitis/tracheitis, unspecified ARTI, bronchitis (acute and not otherwise specified), bronchiolitis, viral pneumonia, influenza
Other respiratory conditions for which antibiotics are not definitely indicated	460–519 excluding those codes above; 995.3	Includes chronic sinusitis, chronic bronchitis, asthma, allergy, other respiratory conditions
Other conditions		
Skin/cutaneous/mucosal	680–686, 690–698, 700–709, 870–897, 910–919, 940–949, 035, 110–111, 360–379, 380–389, 704.8, 728.0, 611.0, 771.5, 728.86	Includes infections of the skin and subcutaneous tissue, inflammatory and other skin conditions, open wounds, superficial injuries, burns, erysipelas, dermatophytosis/dermatomycosis, diseases of the eye/adnexa, ear diseases other than otitis media and mastoiditis, folliculitis, infective myositis, mastitis, necrotizing fasciitis
Urinary tract infections	590.1, 590.2, 590.8, 590.9, 595.0, 595.9, 599.0	Acute pyelonephritis, renal abscess, other pyelonephritis/pyelonephrosis, kidney infection (unspecified), acute cystitis, cystitis (unspecified), urinary tract infection (unspecified)
Gastrointestinal infections	001–009, 787.0, 787.91	Intestinal infectious diseases, nausea/vomiting, diarrhea
Miscellaneous infections	010–018, 020–027, 030–033 036–109, 112–139, 320–323	Includes tuberculosis, zoonotic diseases, diptheria, pertussis, meningitis, and miscellaneous infectious/parasitic diseases other than those of the skin and subcutaneous tissue or digestive tract
Other	Remaining codes	Miscellaneous conditions for which no infectious etiology is identified

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