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Antibiotic Prescribing During Pediatric Ambulatory Care Visits for Asthma

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Antibiotic Prescribing During Pediatric Ambulatory Care Visits for Asthma

WHAT'S KNOWN ON THIS SUBJECT: There have been several recent trials evaluating the efficacy of antibiotics as an asthma therapy, but to date, national guidelines do not recommend them as an asthma therapy. Inappropriate antibiotic prescribing may lead to avoidable adverse events and bacterial resistance.

WHAT THIS STUDY ADDS: Antibiotics are prescribed during nearly 1 million US asthma visits annually when antibiotic need is undocumented. The frequent coprescription of systemic corticosteroids suggests that greater symptom severity increases this practice. Conversely, asthma education delivery is associated with decreased antibiotic prescribing.

abstract

FREE

OBJECTIVE: National guidelines do not recommend antibiotics as an asthma therapy. We sought to examine the frequency of inappropriate antibiotic prescribing during US ambulatory care pediatric asthma visits as well as the patient, provider, and systemic variables associated with such practice.

PATIENTS AND METHODS: Data from the National Ambulatory Medical Care Surveys and National Hospital Ambulatory Medical Care Survey were examined to assess office and emergency-department asthma visits made by children (aged <18 years) for frequencies of antibiotic prescription. *International Classification of Diseases, Ninth Revision* (ICD-9) codes were used to assess the presence of coexisting conditions warranting antibiotics. Multivariable logistic regression models assessed associations with the prescription of antibiotics.

RESULTS: From 1998 to 2007, an estimated 60.4 million visits occurred for asthma without another ICD-9 code justifying antibiotic prescription. Antibiotics were prescribed during 16% of these visits, most commonly macrolides (48.8%). In multivariate analysis, controlling for patient age, gender, race, insurance type, region, and controller medication use, systemic corticosteroid prescription (odds ratio [OR]: 2.69 [95% confidence interval (CI): 1.68–4.30]) and treatment during the winter (OR: 1.92 [95% CI: 1.05–3.52]) were associated with an increased likelihood of antibiotic prescription, whereas treatment in an emergency department was associated with decreased likelihood (OR: 0.48 [95% CI: 0.26–0.89]). A second multivariate analysis of only office-based visits demonstrated that asthma education during the visits was associated with reduced antibiotic prescriptions (OR: 0.46 [95% CI: 0.24–0.86]).

CONCLUSIONS: Antibiotics are prescribed during nearly 1 in 6 US pediatric ambulatory care visits for asthma, ~1 million prescriptions annually, when antibiotic need is undocumented. Additional education and interventions are needed to prevent unnecessary antibiotic prescribing for asthma. *Pediatrics* 2011;127:1014–1021

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KEY WORDS

asthma, ambulatory care, antibiotics, emergency department

ABBREVIATIONS

NAMCS —National Ambulatory Medical Care Surveys
NHAMCS—National Hospital Ambulatory Medical Care Survey
ICD-9-CM—*International Classification of Diseases, Ninth Revision, Clinical Modification*
CI—confidence interval
OR—odds ratio

Dr Paul was responsible for the drafting of the manuscript and participated in the study concept, design, and analysis. Ms Maselli led the data analysis and participated in the study design as well as the manuscript revision. Dr Hersh participated in the study concept, design, and analysis as well as the manuscript revision. Dr Boushey assisted with data analysis as well as the manuscript revision. Dr Nielson assisted with data analysis as well as the manuscript revision. Dr Cabana supervised all aspects of the project, including the study concept, design, analysis, and manuscript generation.

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The National Asthma Education and Prevention Program guidelines specify that antibiotics should not be used as part of chronic asthma therapy or for acute exacerbations, with the exception of patients with comorbid bacterial infections such as pneumonia or sinusitis.[1,2] Nonetheless, over the past several decades there has been great interest in and numerous studies evaluating the role of antibiotics as part of asthma therapy.[3–5] Macrolide and ketolide antibiotics have been specifically evaluated because they are believed to have anti-inflammatory actions[6–9] in addition to their antimicrobial activity, which includes effectiveness against *Mycoplasma pneumoniae* and *Chlamydophila pneumoniae*, "atypical bacteria" that commonly infect the respiratory tract.[10–13] The studies evaluating antibiotics as an asthma therapy have mixed results, showing inconsistent evidence of benefit, although common bacterial pathogens (eg, *Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Moraxella catarrhalis*) are frequently present in the airways of wheezing children.[14] In accordance, neither US[2] nor international[15] guidelines for asthma management currently recommend antibiotic treatment for asthma exacerbations.

We sought to determine how frequently clinicians in US ambulatory care settings are prescribing antibiotics during pediatric asthma visits in the absence of a documented comorbidity that would justify their use. Using a nationally representative database of ambulatory health care visits, we further sought to evaluate patient demographic, clinical, provider, and visit features that were associated with antibiotic prescribing. We hypothesized that children with greater illness severity would be more likely to receive inappropriate antibiotic prescriptions on the basis of chart documentation from their visits. We further hypothesized that younger children would be more likely to receive antibiotics because of greater diagnostic uncertainty and that nonpediatricians, who less frequently treat children, would be more likely to prescribe antibiotics. Identifying factors associated with unjustified antibiotic prescribing during pediatric asthma care could help guide future interventions designed to prevent unnecessary antibiotic use in these children.

METHODS

Data Source

Data from the National Ambulatory Medical Care Surveys (NAMCS) and the National Hospital Ambulatory Medical Care Survey (NHAMCS) were examined to assess office and emergency department–based visits made by children (aged <18 years) for frequencies of antibiotic prescription during asthma visits from 1998 to 2007. The NAMCS is a nationally representative data set of visits to physician offices in the United States conducted by the National Center for Health Statistics.[16] The NAMCS uses a 3-stage probability-sampling design. The first stage involves sampling within geographic regions, the second stage involves sampling physician practices within the regions, and the third stage involves sampling patient visits within each selected physician practice. Physicians who participate in the NAMCS during a specific year are not eligible to be selected again for participation for at least another 3 years. Visits are assigned a weight to enable extrapolation to determine national estimates for all aspects of the survey. For each patient visit, the data set includes demographic and clinical information, including medications prescribed and the reason(s) for the visit on the basis of *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) codes. Additional information includes physician specialty and participation of allied health professionals (eg, nurse practitioner, physician assistant, or registered nurse). Since 2001, the NAMCS has included a data element asking physicians to indicate whether asthma education was provided during the visit.

The NHAMCS is another public-use database designed to collect data on the use and provision of ambulatory care services in hospital emergency and outpatient departments. The NHAMCS is a population-based stratified sample survey of emergency-department visits in US hospitals. The NHAMCS uses a 4-stage probability sampling to include geographic primary sampling units, hospitals within the primary sampling units, emergency departments within the hospitals, and patients within the emergency departments. National estimates are based on patient weighting assigned by the National Center for Health Statistics statisticians. The weight for each visit takes into account all sampling stages and is used to produce unbiased national annual estimates. Both the NAMCS and the NHAMCS are public-use data sets that are exempted from review by the University of California at San Francisco institutional review board.

Study Population

Ambulatory care visits by children (aged <18 years) with ICD-9 codes for asthma (493.x) as the first diagnosis were evaluated. ICD-9 codes also were used to determine whether a comorbid secondary condition existed that would justify prescription of an antibiotic (Table 1). In brief, although the use of words such as "justified," "unjustified," or "inappropriate" to describe antibiotic prescription for individual cases may be debatable, the use of

TABLE 1 Comorbid Conditions and ICD-9 Codes Selected to Justify Antibiotic Prescription at Ambulatory Care Asthma Visits

Infection Type	ICD-9-CM Codes	Specific Conditions
Acute respiratory tract	461–463, 381–382, 383, 033, 034, 035, 475, 481–486, and 010–018	Sinusitis, pharyngitis, tonsillitis, acute otitis media, mastoiditis, diphtheria, pertussis, streptococcal sore throat, peritonsillar abscess, nonviral pneumonia, and tuberculosis
Skin	680–686 and 035	Skin infection and erysipelas
Urinary tract	595.0, 595.9, and 599.0	Urinary tract infection

such terms for analysis of this data set is consistent with other similar studies[17–20] and with US and international guidelines for asthma care.[2,15]

Data Analysis

We determined the percentage of all pediatric, ambulatory, asthma-related visits during which an antibiotic was prescribed without being justified by a comorbid diagnosis for which antibiotics are typically indicated. Antibiotic class was categorized into macrolides, aminopenicillins, cephalosporins, and all other antibiotics. Bivariate analyses were conducted comparing visits with and without unjustified antibiotic prescription on the basis of patient, clinical, physician, and system factors. Patient demographic variables included gender, age, race, ethnicity, and insurance.

Age was collapsed into a 3-level categorical variable consistent with National Asthma Education and Prevention Program guidelines (age <5, 5–11, and ≥12 years) to capture differences in outcome by specific age groups. Race and ethnicity were combined to create 4 categories (white [non-Hispanic], black [non-Hispanic], Hispanic, and other). Insurance was examined in 2 groups (private and all other, eg, Medicaid, self-pay, no charge, or charity). Other patient-level predictors included measures of illness acuity, including prescription of oral corticosteroids or inhaled corticosteroids, performance of a chest radiograph, and presence of a fever (≥38.0°C). To assess seasonality, months of the year were grouped into 4 periods (June through August, September through November, December through February, and March through May). Whether asthma education was delivered also was included as a variable for visits in the NAMCS data set. The single physician-level characteristic included as a variable was specialty (pediatrics, emergency-department physician, or other). The single system-level variable was US Census region (Northeast, Midwest, South, or West).

We then performed multivariable logistic regression to identify independent predictors of unjustified antibiotic prescription. Independent variables that nominally were associated with antibiotic prescription (χ^2 test, $P < .20$) were entered into the multivariable model. Estimates and 95% confidence intervals (CIs) were generated by accounting for the complex survey design. All variables included in the model had an adequate sample size of more than 30 visits to ensure stable estimates as per the National Center for Health Statistics recommendations, unless otherwise specified. An additional bivariate analysis compared visits with prescription of macrolide antibiotics (azithromycin, clarithromycin, and erythromycin) with visits where any other antibiotic was prescribed. The analyses were conducted using SAS 9.2 (SAS Institute, Cary, NC) and SUDAAN 10.0 (RTI International, Research Triangle Park, NC).

RESULTS

For the 10-year period between 1998 and 2007, there were 5198 ambulatory care visits for asthma among children younger than 18 years of age in the data set, representing an estimated 60.5 million visits across the United States. During 15.6% of these visits, an antibiotic was prescribed without a coexisting diagnosis to justify such a treatment course. This equates to an estimate of ~1 million pediatric ambulatory visits per year in the United States for asthma during which antibiotics may be inappropriately prescribed. When antibiotics were prescribed during these visits, macrolides were the class of antibiotics most commonly chosen (48.8%), followed by aminopenicillins (26.3%) and cephalosporins (20.6%). All other antibiotic classes combined to account for the remaining 6.3%.

Bivariate Analyses

Bivariate comparisons demonstrated that patient demographic variables (age category, race/ethnicity, gender, and insurance type) were not associated with unjustified antibiotic prescription at asthma visits (Table 2), but a seasonal trend existed for antibiotic prescribing ($P = .08$). Although antibiotics were prescribed during ~12% of visits in the spring and summer months, they often were more prescribed in the fall (September through November: 18.5% of visits) and winter (December through February: 20.3% of visits).

Several variables associated with asthma or illness severity were assessed for their relationship with antibiotic prescribing. Although the prescription of an asthma controller medication, presence of a fever, and obtaining a chest radiograph were not associated with unjustified antibiotic prescribing, the prescription of a systemic corticosteroid (in an oral, intramuscular, and intravenous form) was

TABLE 2 Patient, Clinical, Physician, and System Factors Associated With Unjustified Antibiotic Prescribing at Ambulatory Care Visits

	Antibiotic Prescribed at Visit N (in Millions), Row %[a]	No Antibiotic Prescribed at Visit N (in Millions), Row %[a]	*P*
Age, y			.24
<5	3.73 (18.0)	16.96 (82.0)	
5–11	3.33 (13.1)	22.11 (86.9)	
12–17	2.40 (16.8)	11.92 (83.2)	
Race/ethnicity			.44
Non-Hispanic white	6.05 (17.6)	28.39 (82.4)	
Non-Hispanic black	1.41 (12.8)	9.59 (87.2)	
Hispanic	1.67 (13.3)	10.89 (86.7)	
Other	0.33 (13.5)[b]	2.12 (86.5)	
Gender			.40
Female	3.33 (14.3)	19.97 (85.7)	
Male	6.13 (16.5)	31.03 (83.5)	
Insurance type			.92
Private	5.54 (15.8)	29.60 (84.2)	
Nonprivate	3.92 (15.5)	21.40 (84.5)	
Season, month			.08
June to August	1.58 (12.2)	11.38 (87.8)	
September to November	2.83 (18.5)	12.47 (81.5)	
December to February	2.68 (20.3)	10.56 (79.7)	
March to May	2.36 (12.5)	16.59 (87.5)	
Other medications prescribed			
Corticosteroid (orally/intramuscular/intravenous)	3.03 (26.3)	8.48 (73.7)	.0007
No corticosteroid (orally/intramuscular/intravenous)	6.43 (13.1)	42.51 (86.9)	
Controller medication	4.07 (15.4)	22.37 (84.6)	.86
No controller medication	5.39 (15.9)	28.62 (84.1)	
Radiograph obtained	0.71 (19.0)	3.01 (81.0)	.35
No radiograph	8.75 (15.4)	47.98 (84.6)	
Fever ≥ 38.0°C[c]	0.13 (18.7)[b]	0.58 (81.3)	.90
No fever[c]	3.32 (17.7)	15.45 (82.3)	
Asthma education[d]	1.98 (11.2)	15.65 (88.8)	.04
No asthma education[d]	3.01 (19.3)	12.57 (80.7)	
Physician specialty			.11
Pediatrics	5.62 (17.0)	27.54 (83.0)	
Nonpediatrics and non–emergency department	2.99 (14.4)	17.81 (85.6)	
Emergency-department physician	0.84 (13.0)	5.65 (87.0)	
Region of United States			.33
Northeast	1.50 (11.4)	11.67 (88.6)	
Midwest	1.85 (16.1)	9.64 (83.9)	
South	4.37 (18.4)	19.35 (81.6)	
West	1.74 (14.4)	10.33 (85.6)	

[a] Numbers are US estimates derived by the National Center for Health Statistics from an actual sample of 5198 visits.
[b] Less than 30 visits in actual sample.
[c] Years 2003–2007 only.
[d] NAMCS only.

($P = .0007$). Antibiotics were prescribed during 26.3% of visits during which systemic corticosteroids were given compared with 13.1% of visits during which they were not prescribed.

Comparisons also were made for physician specialty and US region, with no significant differences in antibiotic prescribing between groups. Whether asthma education was provided at the visit was 1 final variable assessed only in the NAMCS data set for the years 2001–2007. It is noteworthy that although unjustified antibiotics were prescribed during 19.3% of visits when no asthma education was documented, they were prescribed during only 11.2% of visits during which asthma education was documented ($P = .04$).

Multivariate Analyses

In multivariate analysis, controlling for patient age, gender, race, insurance type, US region, and controller medication use, systemic corticosteroid prescription (odds ratio [OR]: 2.69 [95% CI 1.68–4.30]), and treatment during the winter season (OR: 1.92 [95% CI: 1.05–3.52]) increased the likelihood of antibiotic use (Table 3), whereas treatment in an emergency department decreased the likelihood of antibiotic prescription (OR: 0.48 [95% CI: 0.26–0.89]). A second multivariate analysis of the NAMCS data set using only the years when asthma education was included as a variable (2001–2007) demonstrated that asthma education reduced the likelihood of unjustified antibiotic prescription (OR: 0.46 [95% CI: 0.24–0.86]). Systemic corticosteroid prescribing also was associated with an increased likelihood of antibiotic prescription in this model (OR: 2.13 [95% CI: 1.10–4.11]).

A subgroup multivariate analysis of visits for children younger than 5 years of age, controlling for the same variables as above, found similar results. Systemic corticosteroid prescription was associated with an increased likelihood of antibiotic use (OR: 2.46 [95% CI: 1.21–4.99]), whereas treatment by an emergency physician was associated with a reduced likelihood of antibiotic prescription (OR: 0.38 [95% CI: 0.15–0.96]).

Associations With Antibiotic Choice

Within only those visits where antibiotics were prescribed, we sought to determine which variables were associated with the prescription of macrolide antibiotics compared with other classes. When systemic

TABLE 3 Multivariate Models of Factors Associated With Antibiotic Prescription at Ambulatory Care Asthma Visits

	NAMCS and NHAMCS, 1998–2007, Adjusted OR (95% CI)	NAMCS, 2001–2007, Adjusted OR (95% CI)[a]
Gender		
Female	0.89 (0.60–1.34)	0.99 (0.56–1.77)
Male	Reference	Reference
Age, y		
<5	0.87 (0.53–1.43)	0.87 (0.43–1.76)
5–11	0.65 (0.39–1.08)	0.76 (0.38–1.51)
12–17	Reference	Reference
Race/ethnicity		
Non-Hispanic white	Reference	Reference
Non-Hispanic black	0.59 (0.35–1.02)	0.82 (0.30–2.28)
Hispanic	0.72 (0.41–1.26)	0.51 (0.23–1.14)
Other	0.71 (0.28–1.78)	1.06 (0.34–3.27)
Insurance type		
Private	0.94 (0.65–1.36)	1.14 (0.64–2.04)
Nonprivate	Reference	Reference
Region of United States		
Northeast	0.74 (0.38–1.46)	0.66 (0.23–1.88)
Midwest	1.10 (0.62–1.97)	1.18 (0.45–3.08)
South	1.49 (0.92–2.41)	1.81 (0.92–3.58)
West	Reference	Reference
Corticosteroid (orally/intramuscular/intravenous)	2.69 (1.68–4.30)	2.13 (1.10–4.11)
Controller medication	0.99 (0.65–1.50)	0.97 (0.52–1.81)
Season, month		
June to August	Reference	Reference
September to November	1.56 (0.86–2.85)	1.66 (0.64–4.30)
December to February	1.92 (1.05–3.52)	1.73 (0.70–4.32)
March to May	1.04 (0.54–2.00)	1.47 (0.56–3.88)
Radiograph obtained	1.38 (0.77–2.45)	2.46 (0.53–11.35)
Physician specialty		
Pediatrics	1.13 (0.66–1.93)	1.50 (0.71–3.14)
Nonpediatrics and non–emergency department	Reference	Reference
Emergency-department physician	0.48 (0.26–0.89)	—
Time, year of visits	0.94 (0.87–1.01)	0.96 (0.83–1.11)
Asthma education	—	0.46 (0.24–0.86)

[a] Asthma education data were only available in NAMCS and only during these years.

corticosteroids and antibiotics were jointly prescribed, macrolides were the antibiotic class chosen in 68.9% of visits, whereas macrolides were only prescribed in 38.1% of encounters when systemic corticosteroids were not also administered ($P = .004$). A trend also was discovered between insurance type and antibiotic choice, with macrolides being prescribed in 54.9% of cases where an antibiotic was prescribed to a child with private insurance but only 37.6% of such cases for those without private insurance ($P = .06$). No other variable listed in Table 2 was associated with antibiotic choice.

DISCUSSION

The results of this study demonstrate that unjustified antibiotic prescriptions are common during ambulatory care pediatric visits for asthma, occurring at nearly 1 in 6 such visits, with macrolide antibiotics accounting for roughly one-half of all antibiotics prescribed. The finding that overall antibiotic use, and specifically macrolide antibiotic use, occurs more commonly when systemic corticosteroids are jointly prescribed is in agreement with studies that have reported that disease severity has some influence on this choice.[21,22] It is further possible that with increased disease severity, clinicians faced with diagnostic uncertainty (eg, acute asthma exacerbation versus bronchiolitis versus atypical pneumonia) may choose to treat multiple possible etiologies for the acute symptoms, although these data suggest that patient age does not increase the likelihood of such uncertainty as we had hypothesized.

Our findings raise similar concerns regarding antibiotic overuse and the associated impact on resistance as those using the NAMCS database to describe frequent antibiotic prescribing for colds, upper respiratory tract infections, and bronchitis in children.[17–20] Also consistent with the data in this report, the use of broad-spectrum antibiotics and, specifically, macrolides for these conditions within NAMCS visits was common.[20,23]

Others have used large data sets to evaluate antibiotic prescribing associated with asthma exacerbations. The study by Knapp et al,[24] for example, used the NHAMCS to assess antibiotic prescribing at over 400 000 moderate to severe asthma exacerbations seen in the emergency department and found that 29% of such visits resulted in an antibiotic prescription. Although this figure is more than double the rate we found in emergency-department settings, that study did not evaluate whether comorbid diagnoses may have accounted for some antibiotic prescribing as other studies also have failed to do.[25–29] Accounting for comorbidities was shown to be important by Vanderweil et al's[30] study of a sample of adults and children, which demonstrated that accounting for secondary diagnoses does reduce the proportion of visits with unjustified antibiotic prescriptions during emergency-department visits for asthma.

The lower frequency of antibiotic prescribing in the emergency-department setting was somewhat unexpected because nearly all emergency-department

visits for asthma are likely because of an exacerbation or increase in symptoms, whereas outpatient office visits may occur for reasons other than exacerbations, including follow-up of an exacerbation, medication management, lung function assessment, or symptom monitoring. Although the ability in emergency-department settings to rapidly obtain and review a chest radiograph theoretically could have explained the reduced frequency of antibiotic prescribing, the multivariate analyses did not support such an association nor did a previous inpatient study,[29] which demonstrated that obtaining a radiograph was associated with more frequent antibiotic use. The differences between pediatrician and emergency-department physician prescribing may be related to clinical features not included in the NAMCS and NHAMCS databases, as described by Jenkins et al[31] Pediatricians from Northern Ireland in their study were more likely to use the presence of crepitations as a reason for antibiotic prescription but less likely to use the criteria of respiratory rate, air entry, and the child's use of inhaled corticosteroids as reasons to prescribe antibiotics when treating a child with an asthma exacerbation compared with nonpediatricians. In addition, recent studies have shown that compared with visits to pediatricians, visits by children to emergency departments for respiratory tract infections are less likely to result in a prescription for a broad-spectrum antibiotic,[32,33] suggesting possible differences in antibiotic prescribing practices between these specialties.

The National Asthma Education and Prevention Program guidelines recommend asthma patient education as a routine part of clinical care at every visit.[2] Patient education should improve asthma self-management and knowledge of appropriate medications and their indications. We found that the delivery of asthma education was associated with reduced antibiotic prescribing for asthma visits in the NAMCS data set. This finding is consistent with others that have demonstrated a relationship between education and more judicious use of antibiotics for pediatric upper respiratory illnesses.[34–36] Patient asthma education is increasingly being viewed as an important marker of quality of care in the ambulatory care setting.[37] The results from this finding suggest other potential benefits for asthma education, as it seems to be associated with more judicious use of antibiotics by providers.

As with all studies describing large data sets, this study was limited to some extent by the data contained within it. It is probable that undocumented conditions that would have justified antibiotic prescribing existed to some extent within this sample. Other detailed information that may have guided the decision to prescribe antibiotics, such as presence of hypoxia, tachypnea, or inspiratory crackles was not available as variables for analysis. In addition, the lack of precision in the assignment of ICD-9 codes made it impossible to determine whether ambulatory visits for asthma were for exacerbations or other nonacute reasons related to asthma, although other studies similar to ours have used similar ICD-9 inclusion criteria to the present analysis.[24,30,38]

Despite these limitations, the current study demonstrates that clinicians are prescribing antibiotics as part of asthma treatment in a fashion that conflicts with US and international guidelines. Potential explanations for this practice include diagnostic uncertainty, undocumented comorbid conditions, prophylaxis of secondary infections, an attempt to capitalize on the anti-inflammatory properties of macrolide antibiotics, and possibly the belief that colonization by, or infection with, nonculitivable and/or unknown bacteria may be important in some patients with asthma.[39,40] Until evidence supports the use of antibiotics for this purpose, however, clinicians may need guidance to improve and further research to inform their abilities to distinguish asthma exacerbations from those conditions that may benefit from antibiotics.[41–47]

For those involved in practice management and physician education, this study documents a national rate of inappropriate antibiotic use for pediatric asthma that can be used to benchmark quality-improvement initiatives. Although this issue is challenging, several strategies to address provider antibiotic prescribing behavior have been shown to be effective in rigorous, randomized controlled trial designs. Physician education combined with a broader community-wide program was successful in improving antibiotic prescribing rates.[35] Provider feedback and patient education also was successful in decreasing the rate of increase of inappropriate antibiotic prescribing.[48] Although the interventions described did not focus specifically on antibiotic prescription during asthma visits, they suggest successful approaches that might be applied. In general, multifaceted interventions are more likely to be successful than single interventions focused on individual provider change.[49]

CONCLUSIONS

Antibiotics are prescribed at nearly 1 in 6 pediatric ambulatory care visits for asthma when the need for antibiotics is undocumented, equating to ~1 million prescriptions annually in the United States. Because evidence does not currently support this practice, clinicians should consider national guidelines and eliminate unnecessary antibiotic prescribing for asthma exacerbations.

REFERENCES

1. National Asthma Education and Prevention Program. Use of antibiotics to treat asthma exacerbations. *J Allergy Clin Immunol*. 2002; 110(5 suppl):S180–S183
2. National Asthma Education and Prevention Program: *Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma*. Bethesda, MD: US Department of Health and Human Services, National Institutes of Health, National Heart, Lung, and Blood Institute; 2007
3. Graham VA, Milton AF, Knowles GK, Davies RJ. Routine antibiotics in hospital management of acute asthma. *Lancet*. 1982; 1(8269):418–420
4. Graham V, Lasserson T, Rowe BH. Antibiotics for acute asthma. *Cochrane Database Syst Rev*. 2001:(3);CD002741
5. Blasi F, Johnston SL. The role of antibiotics in asthma. *Int J Antimicrob Agents*. 2007; 29(5):485–493
6. Shinkai M, Rubin BK. Macrolides and airway inflammation in children. *Paediatr Respir Rev*. 2005;6(3):227–235
7. Fonseca-Aten M, Okada PJ, Bowlware KL, et al. Effect of clarithromycin on cytokines and chemokines in children with an acute exacerbation of recurrent wheezing: a double-blind, randomized, placebo-controlled trial. *Ann Allergy Asthma Immunol*. 2006;97(4): 457–463
8. Piacentini GL, Peroni DG, Bodini A, et al. Azithromycin reduces bronchial hyperresponsiveness and neutrophilic airway inflammation in asthmatic children: a preliminary report. *Allergy Asthma Proc*. 2007;28(2): 194–198
9. Korematsu S, Yamamoto K, Nagakura T, et al. The indication and effectiveness of low-dose erythromycin therapy in pediatric patients with bronchial asthma. *Pediatr Allergy Immunol*. 21(3):489–492
10. Kamada AK, Hill MR, Ikle DN, Brenner AM, Szefler SJ. Efficacy and safety of low-dose troleandomycin therapy in children with severe, steroid-requiring asthma. *J Allergy Clin Immunol*. 1993;91(4):873–882
11. Spahn JD, Fost DA, Covar R, et al. Clarithromycin potentiates glucocorticoid responsiveness in patients with asthma: results of a pilot study. *Ann Allergy Asthma Immunol*. 2001;87(6):501–505
12. Johnston SL, Blasi F, Black PN, Martin RJ, Farrell DJ, Nieman RB. The effect of telithromycin in acute exacerbations of asthma. *N Engl J Med*. 2006;354(15):1589–1600
13. Strunk RC, Bacharier LB, Phillips BR, et al. Azithromycin or montelukast as inhaled corticosteroid-sparing agents in moderate-to-severe childhood asthma study. *J Allergy Clin Immunol*. 2008;122(6):1138–1144 e4
14. Bisgaard H, Hermansen MN, Bonnelykke K, et al. Association of bacteria and viruses with wheezy episodes in young children: prospective birth cohort study. *BMJ*. 341: c4978
15. Global Initiative for Asthma. Global strategy for asthma management and prevention [article online], 2010. Medical Communications Resources, Inc. Available at: www.ginasthma.org. Accessed January 5, 2011
16. Centers for Disease Control and Prevention. Ambulatory health care [article online], 2011. Available at: www.cdc.gov/nchs/about/major/ahcd/ahcd1.htm. Accessed December 16, 2010
17. Nyquist AC, Gonzales R, Steiner JF, Sande MA. Antibiotic prescribing for children with colds, upper respiratory tract infections, and bronchitis. *JAMA*. 1998;279(11): 875–877
18. McCaig LF, Besser RE, Hughes JM. Trends in antimicrobial prescribing rates for children and adolescents. *JAMA*. 2002;287(23): 3096–3102
19. Nash DR, Harman J, Wald ER, Kelleher KJ. Antibiotic prescribing by primary care physicians for children with upper respiratory tract infections. *Arch Pediatr Adolesc Med*. 2002;156(11):1114–1119
20. Grijalva CG, Nuorti JP, Griffin MR. Antibiotic prescription rates for acute respiratory tract infections in US ambulatory settings. *JAMA*. 2009;302(7):758–766
21. Glauber JH, Fuhlbrigge AL, Finkelstein JA, Homer CJ, Weiss ST. Relationship between asthma medication and antibiotic use. *Chest*. 2001;120(5):1485–1492
22. Stallworth LE, Fick DM, Ownby DR, Waller JL. Antibiotic use in children who have asthma: results of retrospective database analysis. *J Manag Care Pharm*. 2005;11(8):657–662
23. Mainous AG 3rd, Hueston WJ, Davis MP, Pearson WS. Trends in antimicrobial prescribing for bronchitis and upper respiratory infections among adults and children. *Am J Public Health*. 2003;93(11):1910–1914
24. Knapp JF, Hall M, Sharma V. Benchmarks for the emergency department care of children with asthma, bronchiolitis, and croup. *Pediatr Emerg Care*. 2010;26(5):364–369
25. Neville RG, Clark RC, Hoskins G, Smith B. National asthma attack audit 1991–2. General Practitioners in Asthma Group. *BMJ*. 1993; 306(6877):559–562
26. Duran-Tauleria E, Rona RJ, Chinn S, Burney P. Influence of ethnic group on asthma treatment in children in 1990–1: national cross sectional study. *BMJ*. 1996;313(7050): 148–152
27. Kljakovic M, McLeod D. Management of acute asthma: gaps between opinion and recorded action by general practitioners. *Int J Qual Health Care*. 1997;9(6):405–412
28. Kozyrskyj AL, Dahl ME, Ungar WJ, Becker AB, Law BJ. Antibiotic treatment of wheezing in children with asthma: what is the practice? *Pediatrics*. 2006;117(6). Available at: www.pediatrics.org/cgi/content/full/117/6/e1104
29. Davies G, Paton JY, Beaton SJ, Young D, Lenney W. Children admitted with acute wheeze/asthma during November 1998–2005: a national UK audit. *Arch Dis Child*. 2008;93(11):952–958
30. Vanderweil SG, Tsai CL, Pelletier AJ, et al. Inappropriate use of antibiotics for acute asthma in United States emergency departments. *Acad Emerg Med*. 2008;15(8): 736–743
31. Jenkins J, Shields M, Patterson C, Kee F. Decision making in asthma exacerbation: a clinical judgement analysis. *Arch Dis Child*. 2007;92(8):672–677
32. Linder JA, Bates DW, Lee GM, Finkelstein JA. Antibiotic treatment of children with sore throat. *JAMA*. 2005;294(18):2315–2322
33. Coco AS, Horst MA, Gambler AS. Trends in broad-spectrum antibiotic prescribing for children with acute otitis media in the United States, 1998–2004. *BMC Pediatr*. 2009;9:41
34. Finkelstein JA, Davis RL, Dowell SF, et al. Reducing antibiotic use in children: a randomized trial in 12 practices. *Pediatrics*. 2001; 108(1):1–7
35. Finkelstein JA, Huang SS, Kleinman K, et al. Impact of a 16-community trial to promote judicious antibiotic use in Massachusetts. *Pediatrics*. 2008;121(1). Available at: www.pediatrics.org/cgi/content/full/121/1/e15
36. Francis NA, Butler CC, Hood K, Simpson S, Wood F, Nuttall J. Effect of using an interactive booklet about childhood respiratory tract infections in primary care consultations on reconsulting and antibiotic prescribing: a cluster randomised controlled trial. *BMJ*. 2009;339:b2885
37. To T, Guttmann A, Lougheed MD, et al. Evidence-based performance indicators of primary care for asthma: a modified RAND Appropriateness Method. *Int J Qual Health Care*. 22(6):476–485
38. Knapp JF, Simon SD, Sharma V. Quality of care for common pediatric respiratory

illnesses in United States emergency departments: analysis of 2005 National Hospital Ambulatory Medical Care Survey Data. *Pediatrics*. 2008;122(6):1165–1170

39. Hilty M, Burke C, Pedro H, et al. Disordered microbial communities in asthmatic airways. *PLoS One*. 2010;5(1):e8578
40. Huang YJ, Nelson CE, Brodie EL, et al. Airway microbiota and bronchial hyperresponsiveness in patients with suboptimally controlled asthma. *J Allergy Clin Immunol*. 2011;127(2):372–381.e1–3
41. O'Brien KL, Dowell SF, Schwartz B, Marcy SM, Phillips WR, Gerber MA. Cough illness/bronchitis: principles of judicious use of antimicrobial agents. *Pediatrics*. 1998;101(1 suppl):178–181
42. American Academy of Pediatrics. Subcommittee on Management of Sinusitis and Committee on Quality Improvement. Clinical practice guideline: management of sinusitis. *Pediatrics*. 2001;108(3):798–808
43. Mathews B, Shah S, Cleveland RH, Lee EY, Bachur RG, Neuman MI. Clinical predictors of pneumonia among children with wheezing. *Pediatrics*. 2009;124(1). Available at: www.pediatrics.org/cgi/content/full/124/1/e29
44. Margolis P, Gadomski A. The rational clinical examination: does this infant have pneumonia? *JAMA*. 1998;279(4):308–313
45. Virkki R, Juven T, Rikalainen H, Svedstrom E, Mertsola J, Ruuskanen O. Differentiation of bacterial and viral pneumonia in children. *Thorax*. 2002;57(5):438–441
46. Mahabee-Gittens EM, Dowd MD, Beck JA, Smith SZ. Clinical factors associated with focal infiltrates in wheezing infants and toddlers. *Clin Pediatr (Phila)*. 2000;39(7):387–393
47. Lehtinen P, Jartti T, Virkki R, et al. Bacterial coinfections in children with viral wheezing. *Eur J Clin Microbiol Infect Dis*. 2006;25(7):463–469
48. Mainous AG 3rd, Hueston WJ, Love MM, Evans ME, Finger R. An evaluation of statewide strategies to reduce antibiotic overuse. *Fam Med*. 2000;32(1):22–29
49. Grimshaw JM, Shirran L, Thomas R, et al. Changing provider behavior: an overview of systematic reviews of interventions. *Med Care*. 2001;39(8 suppl 2):II2–II45

COMPLICATED NUMBERS: *"Can you get me this in a petite?" asked my daughter. "Petite" is not the word that automatically springs to mind when I think of my athletic daughter. However, despite my bewilderment, I dutifully rummaged around and returned with the requested article of clothing. My wife, daughter, and I were in Boston for the weekend visiting family and friends but also on a clothes shopping trip. My wife and daughter were looking for dresses for upcoming family weddings and my daughter was also looking for a pair of jeans promised to her as a reward for exemplary service. For me, buying a pair of pants is straightforward. Depending on the manufacturer, either a 32- or 33-inch waist works. My height hasn't changed in the past 30 years so the pant length is easy. For the women of my family, however, things clearly are more complicated. Despite both my daughter and wife having the same height and BMI, the dressing room was littered with dresses in sizes 2 to 8, small, medium, and large, and now, even petites. Evidently, I am not alone in my confusion. According to an article in* The New York Times *(Business: April 24, 2011), women's sizing in one brand or one store does not mean anything in another brand or a different store. Moreover, because of "vanity sizing" a woman may have dropped from a size 12 to a size 8 without losing a single pound of weight. Amazingly, a size 8 at one major retailer is a size 2 at another (despite being owned by the same company). Given the enormous variability in women's clothing sizes, it is no wonder that women enter the changing room with armloads of clothes to try. To make things a bit easier, a startup company now offers free 20-second full body scans in many malls across the country. The scan compares about 200 000 body measurements to clothes in its database of popular retail stores. At the end of the scan, the customer is given a printout of clothes from different manufacturers that should fit. So far, customers have been impressed with the results. As for us, there are no such scanners in Vermont, and we did not see one during our trip. The day wrapped up with a collection of clothes that included a size small, medium, and petite and two exhausted women while I had a new appreciation for my wife's antipathy to clothes shopping.*

Noted by WVR, MD

Antibiotic Prescribing During Pediatric Ambulatory Care Visits for Asthma

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