

Antibiotic Use by Pediatric Residents: Identifying Opportunities and Strategies for Antimicrobial Stewardship

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ABSTRACT

OBJECTIVES: To determine the antibiotic prescribing practices of pediatric residents and assess how they acquire knowledge leading to prescribing behaviors.

METHODS: We performed a cross-sectional electronic survey of all pediatric residents at the Children's National Medical Center and Nicklaus Children's Hospital, assessing antibiotic prescribing patterns for common pediatric infections, use of antibiograms, and factors influencing antibiotic choice.

RESULTS: Eighty-five surveys (45%) were returned complete and included in the analysis. Increased deviations from clinical guideline recommendations were observed for antibiotic treatments of sinusitis and community-acquired pneumonia as compared with otitis media and group A streptococcal pharyngitis. Only 57% of residents reported having used antibiograms. General pediatric inpatient attending physicians were identified as the most influential source for house staff antibiotic knowledge.

CONCLUSIONS: Results illustrate the need for better promotion and integration of clinical guidelines with antibiograms when developing antibiotic education programs for residents in training. In addition, pediatric hospitalists should play an active role in the implementation of these programs and can provide valuable insight into the development of educational programs in conjunction with graduate medical education divisions.

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Significant increases in the prevalence of multi-drug-resistant bacterial pathogens such as methicillin-resistant *Staphylococcus aureus* and carbapenemase-producing or extended-spectrum β -lactamase-producing Gram-negative bacteria have highlighted the importance of judicious use of antibiotics both in the hospital- and office-based practice settings. Inappropriate uses of antibiotics have been reported in children with asthma exacerbations or viral syndromes, as well as among children hospitalized for community-acquired pneumonia, for whom broad-spectrum antibiotic regimens are overused.^{1,2} Antimicrobial stewardship (AS) programs during recent years have been effective in reducing inappropriate antibiotic use and have become more common at children's hospitals in the United States.³ Guidance on appropriate antimicrobial use is an integral component of AS.

Pediatric residents play a critical role in shaping antimicrobial utilization patterns at children's hospitals because they are part of the front-line clinical team that initiates and selects antibiotic therapies. As part of an effort to develop effective and practical AS education programs directed toward house staff at our institutions, we developed and conducted a survey among the pediatric residents with the objective of determining their prescribing practices regarding antibiotics, comparing them to official guidelines, and assessing how they acquire their knowledge and prescribing behaviors.

METHODS

A cross-sectional study was conducted through the use of an anonymous survey that was distributed to all pediatric residents in 2 large freestanding tertiary children's hospitals. The Children's National Medical Center (CNMC) serves patients in the greater Metropolitan Washington, DC, area with an extensive network of primary care clinics in addition to its main campus. Nicklaus Children's Hospital (NCH) is the largest freestanding pediatric hospital in South Florida. The survey was sent electronically to all residents through respective internal e-mail systems. Weekly reminders were sent over a 4-week period.

Institutional Review Boards at CNMC and NCH have approved this project.

The first part of the survey assessed the knowledge of residents regarding antibiotic use in common pediatric infections. The survey assessed common antibiotic practices for otherwise well patients without comorbidities, such as suspected immunodeficiencies, and excluded neonates because the approach to their treatment is different from that in older children. Residents were instructed to write in their first and second choices of antibiotics for treating uncomplicated acute otitis media and group A streptococcal pharyngitis, as well as their antibiotics of choice for outpatient and inpatient management of uncomplicated sinusitis, uncomplicated pneumonia, and uncomplicated urinary tract infections. First antibiotic choice was included for analysis because there was a wide variation in antibiotic choice and a significant number of questions were left unanswered. Because of high variability, antibiotics were combined into classes for the purpose of this study. Although there are significant differences in coverage between different generations of antibiotics, the majority of answers did not specify generation.

The second aim of the survey was to understand how antibiotic knowledge and prescribing behaviors are acquired. The responders were asked questions regarding the use of antibiograms and their experience and exposure to antibiotic use for patients with viral syndromes and/or infections. Finally, they were asked to rank 9 factors that influence their choice of antibiotics. The 9 factors are: general pediatric inpatient attending physician (hospitalist), general pediatric outpatient attending physician, infectious disease attending physician, noninfectious disease specialist attending physician, pediatric resident colleagues, didactic conferences, professional society guidelines, journal articles, and textbooks. The top 3 choices from each individual survey were used for statistical analysis to identify the major influential factors of antibiotic choice.

The results were tabulated respective of the responder's postgraduate year (PGY) status

as provided in the questionnaire. Data were analyzed by using SAS software, version 9.3 or later (SAS Institute Inc, Cary, NC) and χ^2 tests were used to compare results ($\times 2$) across PGY status and antibiotic choice. A probability of <0.05 was considered statistically significant.

RESULTS

The survey was distributed to 189 pediatric residents, 105 from CNMC and 84 from NCH, and returned by 89 (47%). Eighty-five (45%) surveys were included for analysis; the remaining 4 were excluded in the analysis because they were deemed incomplete, having only provided demographic data. Fifty-four (64%) respondents were from CNMC, with close to half in their second year of training (43%), and the remaining respondents were roughly divided among the first and third PGYs. At NCH, there was a similar distribution, with 17 (55%) of the respondents identifying as PGY-2 and the remaining respondents being divided among PGY-1 and PGY-3. Among the total respondents, 33% were identified as PGY-1, 43% were PGY-2, and 24% were PGY-3.

Antibiotic Choice for Common Pediatric Infections

Tables 1 and 2 summarize the antibiotic preferences by PGY year for each of the pre-specified conditions. Responses were comparable across different years of experience and between both hospitals.

There was no significant difference between residents in antibiotic choice for acute otitis media and pharyngitis; however, there was considerable variation among treatments for pneumonia, sinusitis, and urinary tract infections (Tables 1 and 2).

Antibiotic Prescribing Behaviors

When pediatric residents were asked how frequently they refer to an antibiogram when prescribing antibiotics, 54% indicated that they "sometimes" use an antibiogram. However, 25% noted that they had never referred to an antibiogram, with an additional 17% disclosing that they did not know what an antibiogram was or not responding. Just 3% of the respondents used antibiograms "very frequently." When asked if they knew where to locate or

TABLE 1 Primary Antibiotic Selection for Outpatient Management of Common Infections

Antibiotic Selection	All % (N = 85)	PGY-1 % (n = 24)	PGY-2 % (n = 40)	PGY-3 % (n = 21)	P ^a
Acute otitis media					
Amoxicillin ^b	100 (85)	100 (24)	100 (40)	100 (21)	.5
Streptococcal pharyngitis					
Penicillin ^b	44 (37)	42 (10)	43 (17)	48 (10)	.6
Amoxicillin ^b	55 (47)	58 (23)	52 (12)	52 (11)	—
Do not know or no response	1 (1)	4 (1)	0	0	—
Sinusitis, outpatient					
Amoxicillin	48 (41)	33 (8)	56 (22)	50 (11)	.04
Amoxicillin-clavulanate ^b	34 (29)	25 (6)	36 (14)	41 (9)	—
Cephalosporin	2 (2)	4 (1)	2 (1)	0	—
Azithromycin	4 (3)	13 (3)	0	0	—
Do not know or no response	12 (10)	25 (6)	5 (2)	9 (2)	—
Pneumonia, outpatient					
Amoxicillin ^b	87 (74)	79 (19)	88 (35)	95 (20)	.20
Amoxicillin-clavulanate	4 (3)	0	8 (3)	0	—
Azithromycin	1 (1)	0	3 (1)	0	—
Cephalosporin	2 (2)	4 (1)	3 (1)	0	—
Clarithromycin	1 (1)	0	0	5 (1)	—
Do not know or no response	5 (4)	17 (4)	0	0	—
Urinary tract infection, outpatient					
Trimethoprim-sulfamethoxazole ^b	35 (30)	46 (11)	28 (11)	38 (8)	.43
Cephalosporin	42 (36)	38 (9)	43 (17)	48 (10)	—
Nitrofurantoin	1 (1)	0	3 (1)	0	—
Quinolone	5 (4)	8 (2)	5 (2)	0	—
Amoxicillin	5 (4)	0	5 (2)	10 (2)	—
Amoxicillin-clavulanate	1 (1)	0	3 (1)	0	—
Do not know or no response	11 (9)	8 (2)	15 (6)	5 (1)	—

Percentages may not sum to 100 because of rounding. —, not applicable.

^a χ^2 test.

^b The IDSA recommended first-line therapy.

access antibiograms specific to their hospitals, 50% of respondents answered “no.” Awareness and utilization rates of antibiograms increased with progression through PGY levels (Table 3).

Seventy-five percent of respondents indicated that they have prescribed antibiotics for patients they considered to have a viral syndrome (Table 3). When asked to identify reasons for prescribing antibiotics, 63% indicated that they were following instructions from an attending physician or senior resident, 21% cited concerns of the patient developing a bacterial infection in the future, and 16% listed parental pressure.

Finally, when asked about the most influential sources for their antibiotic choices, 89% ranked their general pediatric inpatient attending physician in the top 3. Fifty-four percent ranked this group as the most influential source. In contrast, only 12% listed infectious disease specialists in their top 3. Seventy-two percent of respondents included their general pediatric outpatient attending physician as one of their top 3 sources, 35% included their resident colleagues, and 30% included guidelines from professional societies. Textbooks, didactics lectures, and journal articles were included in the top 3 sources by 14%, 12%, and 11% of respondents, respectively.

DISCUSSION

In teaching institutions, pediatric residents are often members of the front-line clinical team that determines initial antibiotic choice in children with infectious diseases. Yet, the factors that determine antibiotic selection by pediatric residents are remarkably understudied. To our knowledge, this is the first study that evaluates pediatric resident knowledge and practice habits toward antibiotic use at freestanding children's hospitals and compares their antibiotic choices with recently published clinical guidelines from professional societies.⁴ Our survey identified several areas of antibiotic use among resident physicians that could be optimized through AS and education. Overall, antibiotic

TABLE 2 Primary Antibiotic Selection for Inpatient Management of Noncomplicated Infections

Antibiotic Selection	All % (N = 85)	PGY-1 % (n = 24)	PGY-2 % (n = 40)	PGY-3 % (n = 21)	P ^a
Sinusitis, inpatient					
Ampicillin or ampicillin-sulbactam	13 (11)	4 (1)	15 (6)	19 (4)	.06
Cephalosporin ^b	40 (34)	21 (5)	50 (20)	43 (9)	—
Clindamycin ^b	10 (8)	13 (3)	10 (4)	5 (1)	—
Piperacillin or tazobactam	2 (2)	4 (1)	0	5 (1)	—
Amoxicillin or amoxicillin-clavulanate	10 (8)	8 (2)	13 (5)	5 (1)	—
Quinolone	1 (1)	0	3 (1)	0	—
Do not know or no response	24 (20)	50 (12)	10 (4)	19 (4)	—
Pneumonia, inpatient					
Ampicillin ^b	49 (42)	33 (8)	55 (22)	57 (12)	<.01
Amoxicillin	13 (11)	4 (1)	3 (1)	43 (9)	—
Cephalosporin	32 (27)	42 (10)	43 (17)	0	—
Quinolone	1 (1)	4 (1)	0	0	—
Do not know or no response	5 (4)	17 (4)	0	0	—
Urinary tract infection, inpatient					
Trimethoprim-sulfamethoxazole	1 (1)	0	0	5 (1)	.05
Ampicillin	1 (1)	4 (1)	0	0	—
Cephalosporin ^b	82 (70)	63 (15)	90 (36)	90 (19)	—
Quinolone	2 (2)	8 (2)	0	0	—
Meropenem	1 (1)	0	3 (1)	0	—
Nitrofurantoin	1 (1)	0	3 (1)	0	—
Do not know or no response	11 (9)	25 (6)	5 (2)	5 (1)	—

Percentages may not sum to 100 because of rounding. —, not applicable.

^a χ^2 test.

^b The IDSA recommended first-line therapy.

selections for otitis media and streptococcal pharyngitis were appropriate. However, we observed increased deviation in antibiotic selection from current clinical guidelines for sinusitis and community-acquired

pneumonia. For treatment of sinusitis, the most frequently selected antibiotics were amoxicillin and ceftriaxone for outpatient and inpatient therapies, respectively. The most recent guidelines for rhinosinusitis

from the Infectious Diseases Society of America (IDSA) recommend amoxicillin-clavulanate for first-line therapy and recommends against monotherapy with amoxicillin or second- or third-generation

TABLE 3 Antibigram Knowledge

Survey Questions and Answer Choices	All % (N = 85)	PGY-1 % (n = 24)	PGY-2 % (n = 40)	PGY-3 % (n = 21)	P ^a
How often have you referenced antibiograms when prescribing antibiotics?					
Very often	3 (3)	0 (0)	3 (1)	9 (2)	.01
Sometimes	54 (47)	21 (5)	68 (27)	65 (15)	—
Never	25 (22)	42 (10)	23 (9)	13 (3)	—
Don't know what an antibiogram is	10 (9)	29 (7)	3 (1)	4 (1)	—
No response	7 (6)	8 (2)	5 (2)	9 (2)	—
Do you know where to find your hospital's antibiogram?					
Yes	50 (43)	8 (2)	65 (26)	71 (15)	.01
No	50 (43)	92 (22)	35 (14)	29 (6)	—
Have you prescribed antibiotics for suspected viral infections?					
Yes	73 (62)	75 (18)	70 (28)	76 (16)	.25
No	27 (23)	25 (6)	30 (12)	24 (5)	—

Percentages may not sum to 100 because of rounding. —, not applicable.

^a χ^2 test.

cephalosporins.⁵ The IDSA guideline for pediatric community-acquired pneumonia recommends amoxicillin as the first antibiotic of choice.⁶ However, 10% of the respondents selected a non-amoxicillin antibiotic for outpatient therapy and a significant majority selected ceftriaxone for inpatient therapy. Antibiotic selections for urinary tract infections were overall appropriate, although selections for outpatient antibiotic treatment were more variable. The most recent guidelines from the American Academy of Pediatrics for urinary tract infections recommend incorporating local antibiotic resistance patterns when selecting oral agents.^{7,8} Antibiotic selection variability and deviations from national clinical guidelines illustrate the need for effectively promoting and integrating guideline recommendations into resident educational curricula.

Nearly a third of the respondents either did not know what an antibiogram was or have never referred to one when prescribing antibiotics. An antibiogram is a periodic summary of antimicrobial susceptibilities of local bacteria, providing sensitivities of a given organism to certain antibiotics.

Antibiograms are an essential tool for clinicians to assess local susceptibility rates and aid in selecting empirical antibiotic therapy. Antibiogram use is recommended by many professional societies and national agencies for addressing the growing problem of antibiotic resistance.^{9,10} This is a key target for AS intervention identified from our survey that can have a substantial impact on altering physicians' antibiotic prescribing behavior. By educating clinicians on how to access, interpret, and apply these data to their patients and in practice settings when selecting empirical antibiotic regimens, therapies can be optimized.

Inappropriate antibiotic use in patients with viral infections and asthma exacerbations in the outpatient setting has been well documented¹ and poses an ongoing challenge for AS. The significant number of residents reporting such incidences is consistent with findings from previous studies in adult training programs. Interestingly, residents most commonly

attributed their prescribing behavior to directions from their senior physicians. This is also consistent with previous reports describing resident physicians appropriately prescribing fewer antibiotics when not clinically indicated compared with attending physicians.¹¹

We found that the most influential source for resident antibiotic choices in the survey were general pediatric inpatient hospitalist attending physicians. This likely reflects the structure of the residency curriculum, in which rotations through the general pediatric inpatient services make up a significant proportion of training. In addition, the clinical scenarios queried in the survey for antibiotic selections are primarily managed by general pediatricians and rarely involve a consultation with an infectious diseases specialist, which likely accounts for the significantly lower level of perceived influence by infectious diseases physicians or other subspecialty physicians. These findings illustrate the important role general pediatricians must play when designing and implementing antibiotic education programs and activities targeting residents.

By including 2 tertiary children's hospitals in 2 separate regions of the United States, we can begin to extrapolate our findings to describe general trends in antibiotic use. A larger multicentered study is needed to identify common knowledge gaps and deficits, as well as antibiotic prescribing patterns among residents across the United States.

Education has an important role in multidisciplinary AS programs. The impact of educational interventions has been associated with physician motivation, which may be affected by age, training, and practice circumstances. Clearly, a better understanding of these practices and how to change them is required. Focused education with clear and continuously accessible guidelines for physicians has shown to be an effective strategy in improving antibiotic prescribing practices.¹² Perhaps AS programs targeted at physicians during their early training, such as pediatric residency, could have a greater impact in antimicrobial prescription

practices. This pilot study provides new data describing the prescribing antibiotic behaviors among pediatric residents and identifies opportunities for improving AS programs. The results should stimulate efforts to target education and empower all levels of providers in the use of evidence-based medicine practice guidelines in the care of children. System-based strategies should integrate all members of the pediatric team, especially general pediatricians and pediatric hospitalists, who play a major role in resident training and education.

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