ORIGINAL ARTICLE

Antimicrobial Stewardship Programs in Pediatrics

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OBJECTIVE. To describe the prevalence, characteristics, and barriers to implementation of antimicrobial stewardship programs (ASPs) in pediatrics.

DESIGN AND PARTICIPANTS. In December 2008, we surveyed the pediatric members of the Emerging Infections Network, a network of infectious diseases consultants located throughout North America. Participants responded regarding whether their hospital had or planned to develop an ASP, its characteristics, barriers to improvement or implementation, and perceptions about antimicrobial resistance.

RESULTS. Of 246 pediatric infectious disease consultants surveyed, 147 (60%) responded. Forty-five respondents (33%) reported having an ASP, and 25 (18%) were planning a program. The percentage of respondents from freestanding children's hospitals who were planning ASPs was higher than the percentage of respondents from other settings who were planning ASPs ($P = .04$). Most existing programs were developed before 2000 and had a limited number of full-time equivalent staff, and few programs used a prospective audit-and-feedback structure. Many programs were not monitoring important end points associated with ASPs, including cost and number of antibiotic-days. The major barriers to implementation of an ASP were lack of resources, including funding, time, and personnel, noted by more than 50% of respondents. Regardless of the presence of an ASP, respondents perceived antibiotic resistance as a more significant problem nationally than at their local hospital ($P < .001$).

CONCLUSIONS. The prevalence of ASPs in pediatrics is limited, and opportunities exist to improve current programs.

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Inappropriate antimicrobial prescribing is common[1-7] and is a key factor in the increase of rates of drug resistance,[8,9] which causes a significant public health burden in terms of morbidity, mortality, and cost.[10-13] Antimicrobial stewardship programs (ASPs) are designed to optimize antimicrobial prescribing, to lower costs, to prevent medication errors, to improve therapeutic outcomes, and to prevent the development of antimicrobial resistance. Multiple single-center evaluations of ASPs have demonstrated benefits through improvement in antimicrobial prescribing.[14-20] In 2007, a guideline[9] for developing ASPs was published by the Infectious Diseases Society of America (IDSA) and was endorsed by the American Academy of Pediatrics and the Pediatric Infectious Diseases Society.

Recent single-center evaluations of pediatric ASPs have documented improvement in antimicrobial prescribing and cost saving,[21-23] although the extent to which ASPs are implemented in pediatric settings is unknown. The IDSA guideline specifically highlights the pediatric population as a research priority for further investigation about the effectiveness of ASPs.[9] Therefore, our objective was to describe the prevalence and characteristics of ASPs in pediatrics and to identify perceived barriers to the implementation and improvement of ASPs.

METHODS

In December 2008, we distributed a survey to the 246 pediatric infectious diseases consultants (IDCs) in the Emerging Infections Network (EIN). The EIN membership includes pediatric IDCs throughout North America who are currently engaged in clinical practice and who are members of the IDSA or the Pediatric Infectious Diseases Society. The survey was distributed by email or facsimile, and nonresponding members received 1 or 2 follow-up queries at 2-week intervals. EIN membership has broad coverage of pediatric hospitals throughout North America, with members affiliated with 51% of the institutions in the National Association of Children's Hospitals and Related Institutions (NACHRI). Of the NACHRI institutions listing a board-certified pediatric IDC, the EIN membership represents 59%.

Participants in the survey were initially asked whether their hospital currently has an ASP and, if so, what year it was initiated. If it did not have an ASP, participants were asked whether a program was in the planning stage. These questions

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created 2 overall categories: current ASP and no ASP. Within the category of no ASP, there were 2 subcategories: planning an ASP and no plans for an ASP. All respondents were asked to describe their workplace as freestanding children's hospital, children's hospital within a hospital, pediatric ward in a hospital, or other.

For those respondents with ASPs, additional questions focused on characteristics of the ASP. These included whether the program uses prior authorization or prospective audit and feedback, which personnel and how many full-time equivalents (FTEs) are involved with the program, which antibiotics and end points are monitored, and which types of recommendations the ASP provides to prescribing physicians. This question used a Likert-type scale with responses of "never," "rarely," "sometimes," and "frequently." Results were analyzed by combining the responses of "sometimes" and "frequently."

All participants were asked to describe whether several potential factors were barriers to the improvement of their currently existing ASP or to the implementation an ASP (if they were in the planning stage or did not have plans for an ASP). Finally, participants were asked about their perception of the importance of antimicrobial resistance on a national level and at their local institution. We compared proportions between categorical variables by the Pearson χ^2 test or Fisher exact test, as appropriate, with SAS software, version 9.1 (SAS).

RESULTS

Survey Respondents

The survey was distributed to 246 pediatric IDCs, and responses were received from 147 (60%). Among respondents, 9 reported that they did not work in a hospital setting and were therefore excluded from further analysis, leaving a total of 138 respondents for analysis. Respondents and nonrespondents were similar in terms of age ($P = .29$), geographic region ($P = .42$), and whether they were employed in a university and/or academic setting ($P = .07$).

ASP Characteristics

Overall, only 45 respondents (33%) reported currently having an ASP at their hospital (Table 1). Of respondents with currently existing ASPs, only a few programs were developed recently. More than 70% were developed before 2005, and 60% reported that their program started before 2000. Five respondents indicated that their program was initiated after the 2007 IDSA guideline was published. We observed no differences in the hospital setting (Table 1; $P = .20$) or in the geographic region ($P = .12$) reported by respondents with ASPs, compared with the hospital setting and geographic region reported by respondents without ASPs. Of the 93 respondents who do not have ASPs, 25 (27%) reported that an ASP was in the planning stages at their institution, which represents 18% of survey respondents (Table 1). A higher percentage of respondents from freestanding children's hospitals without ASPs were planning ASPs (27%), compared with the percentage of respondents from other hospital settings without ASPs that were planning ASPs (0%–13%) ($P = .04$). Freestanding children's hospitals accounted for 17 (68%) of the 25 programs in the planning stage.

Most of the currently existing ASPs (88%) or those in the planning stage (93%) were directed or codirected by an IDC. However, most programs had a limited number of FTEs dedicated to their ASP. Among existing programs, more than half had 0.25 or fewer FTEs dedicated for an IDC, with approximately 40% having 0 physician FTEs. For programs in the planning stage, nearly 60% had 0 physician FTEs. Although a pharmacist was reported to be involved in a higher percentage of programs being planned (25 [100%]) than of currently existing ASPs (71%) ($P = .06$), nearly 40% in both groups had 0 FTEs dedicated for pharmacists. In terms of other specialties, a higher percentage of programs in the planning stage anticipated including infection control practitioners (71%), compared with the percentage of currently existing programs that included infection control practitioners (34%) ($P = .04$); however, inclusion of a microbiologist was low for both groups (30%).

With regard to program structure, of the 45 respondents with ASPs, 78% reported that their program incorporates prior authorization. On the other hand, only 33% of respondents with ASPs reported that their program used the strategy of prospective audit and feedback, the core strategy most favored by the IDSA. Sixty-four percent of respondents

TABLE 1. Antimicrobial Stewardship Programs (ASPs) among 138 Respondents, by Hospital Setting

		No ASP		
Type of workplace	Have ASP	Planning ASP	No plans for ASP	Total, % of respondents
Freestanding children's hospital	15/62 (24)	17/62 (27)	30/62 (48)	62 (45)
Children's hospital within hospital	19/53 (36)	7/53 (13)	27/53 (51)	53 (38)
Pediatric ward	10/21 (48)	1/21 (5)	10/21 (48)	21 (15)
Other	1/2 (50)	0/2 (0)	1/2 (50)	2 (1)
Any	45 (33)	25 (18)	68 (49)	138 (100)

NOTE. Data are expressed as proportion of respondents (percent of category) or no. of respondents (percent of all respondents).

with ASPs reported that education was a specific component of the program. There was limited use of antimicrobial order forms (by 27%) and antimicrobial cycling (by 9%).

Antimicrobial Monitoring

The specific antimicrobials monitored by currently existing ASPs are shown in Figure 1. The most frequently monitored antimicrobials were linezolid (by 89% of ASPs), carbapenems (by 76%), vancomycin (by 70%), and fluoroquinolones (by 62%). Notably, third-generation cephalosporins and aminoglycosides were monitored by only 22% of respondents.

ASP Interventions

The most commonly reported ASP interventions were narrowing therapy on the basis of culture results (76%), optimizing antimicrobial dosage (62%), and eliminating redundant therapy (62%) (Figure 2). Approximately 50% of respondents with ASPs reported that stopping antimicrobial therapy, narrowing therapy empirically, broadening therapy based on culture, or shortening duration were common ASP interventions.

End Points Monitored

Most respondents with ASPs reported that their program monitors some end points (Figure 3), the most common being mismatches between the organism cultured and antibiotic prescribed ("bug-drug mismatch"). However, only 55% of respondents with ASPs reported monitoring antimicrobial cost and only 44% reported monitoring antimicrobial days as end points associated with the program. Similarly, a low percentage of respondents with programs in the planning stage anticipated monitoring antimicrobial cost (54%) or number of antimicrobial-days (37%). It was also notable that only 47% of respondents with ASPs reported monitoring compliance with ASP recommendations.

Barriers to Improvement and Implementation

Respondents noted multiple barriers to the improvement of currently existing ASPs and to the development and implementation of new programs. Barriers were reported most often by respondents for whom programs were in planning stages (Table 2). Twenty-five respondents who were planning programs (100%) noted that significant barriers existed to implementing a program. A lack of resources (time and funding) were the most important barriers, noted by approximately 70% of respondents who were planning ASPs. Fifty-six percent of respondents who were planning ASPs indicated that concern about a loss of autonomy by prescribers was also a barrier to implementation of the program. In addition, 40% noted that a lack of awareness by hospital administrators about the value of ASPs was a significant barrier.

Perception of Antimicrobial Resistance

More than 80% of respondents reported that they believe antimicrobial resistance is a highly important problem nationwide. On the other hand, only 50% perceived that antimicrobial resistance was a highly important problem at their own institutions, which was significantly lower than the per-

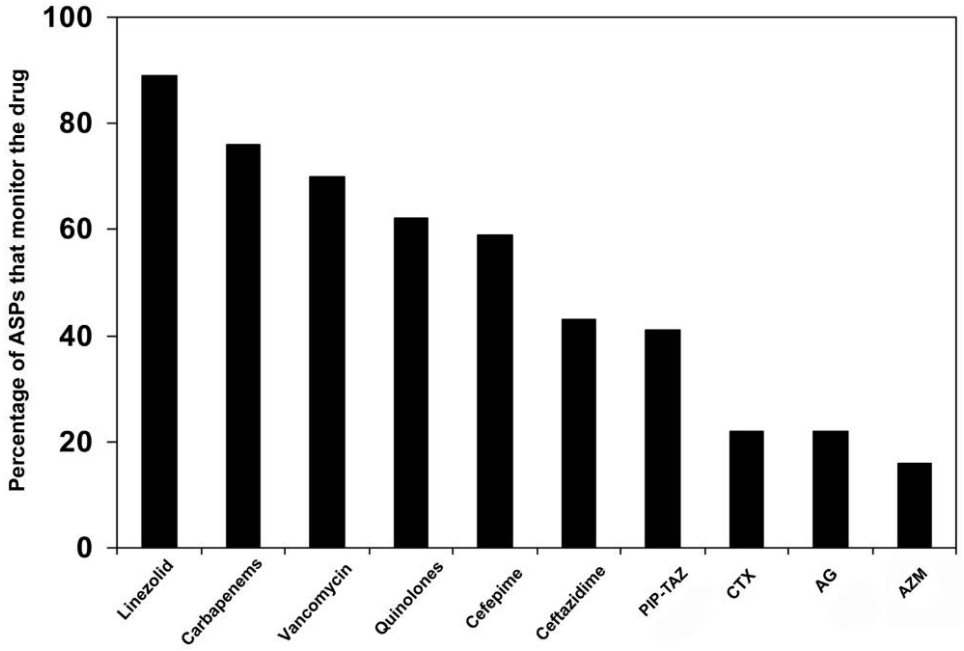

FIGURE 1. Bar graph showing percentage of antimicrobial stewardship programs (ASPs) that monitor specified antibiotics. AG, aminoglycosides; AZM, azithromycin; CTX, ceftriaxone-cefotaxime; PIP-TAZ, piperacillin-tazobactam; quinolones, fluoroquinolones.

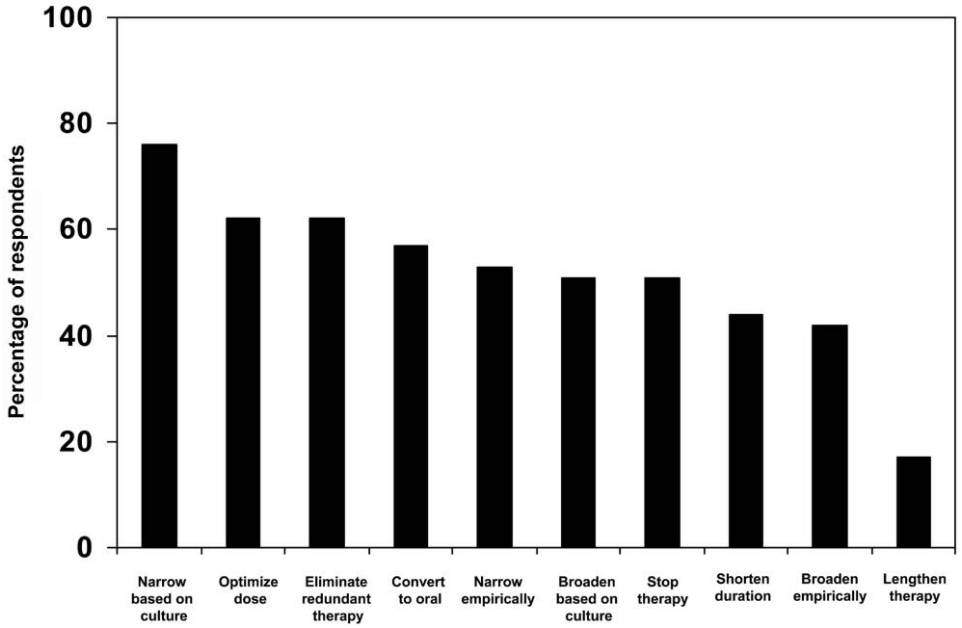

FIGURE 2. Bar graph showing percentage of respondents whose antimicrobial stewardship program frequently or sometimes provides these specified recommendations.

centage who perceived that antimicrobial resistance was a highly important problem nationally ($P < .01$). There were no differences in the perception of the problem at individual institutions ($P = .76$) or nationally ($P = .55$) by respondent's status of ASP (current, planning, or no plans for ASP).

DISCUSSION

We found that the prevalence of ASPs in pediatric settings is limited and that few of the existing programs follow all of the IDSA guideline recommendations. Many programs are still in the planning stage, and respondents reported multiple barriers to starting new programs. Furthermore, respondents with ASPs also reported barriers to improving their existing programs.

It was notable that several of the most commonly prescribed antibiotics in pediatrics are not monitored by most programs, including piperacillin-tazobactam, third-generation cephalosporins, aminoglycosides, and azithromycin. Some programs may choose to focus on the most costly agents or those necessary for the treatment of epidemiologically important organisms (eg, linezolid and carbapenems). It may also be that some pediatric ASPs are extensions of adult stewardship programs, where different prescribing practices exist. However, a recent evaluation of a pediatric ASP showed these commonly prescribed antibiotics were important sources of ASP interventions.[22] Because antibiotics are the drug class most frequently associated with errors in pediatrics,[24] ASPs need to be tailored to reflect pediatric prescribing patterns.

The most commonly reported ASP interventions were narrowing therapy on the basis of culture results, optimizing dose, and eliminating redundant antimicrobial therapy. Only 50% of respondents reported that stopping antimicrobials, narrowing therapy empirically, and shortening duration were recommendations provided frequently or sometimes by their ASP. This is in contrast to a recently implemented ASP in a large freestanding children's hospital that uses a prospective audit-and-feedback approach, for which stopping or narrowing therapy accounted for nearly 60% of all recommendations.[25] Our finding that few existing pediatric programs use prospective audit and feedback likely explains this difference. In programs with prospective audit and feedback, antimicrobials are reviewed 48–72 hours after starting therapy (rather than at the time of initiation), when more clinical data are available to identify patients for whom further therapy is unnecessary or can be streamlined. Thus, the structure of the program is likely to have an impact on how frequently various interventions are provided.

In addition to influencing the types of interventions provided, the structure of an ASP may have implications for its effectiveness and acceptance. A recent study showed that postprescription review was superior to prior approval; more recommendations were made because of the greater availability of clinical information.[14] Furthermore, an audit-and-feedback approach is less cumbersome to prescribers because it does not create a barrier to initiating therapy. A perception that ASPs may delay the initiation of appropriate therapy is associated with poor satisfaction.[23] Indeed, fear of loss of physician autonomy was a barrier for some respondents in our survey. A prospective audit-and-feedback approach may be more acceptable to prescribers, which is important because

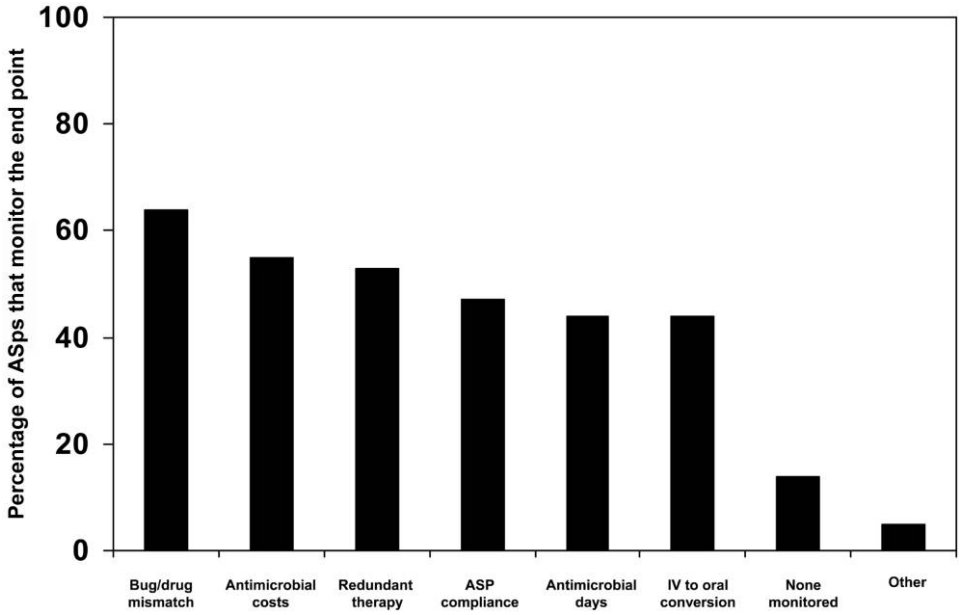

FIGURE 3. Bar graph of percentage of antimicrobial stewardship programs (ASPs) that monitor specified end points. IV, intravenous.

obtaining the support of the prescribing physicians within an institution is crucial to ensuring the success of ASPs.

The major barrier to implementing and improving ASPs identified by respondents was the cost associated with the program. Thus, we were surprised to find that only 55% of programs were monitoring antimicrobial cost and only 44% were monitoring the number of antimicrobial-days. Recent program evaluations of pediatric ASPs have estimated annual cost savings ranging from $150,000 to $300,000.[21,23] In addition, some of our respondents noted that a major barrier to implementing an ASP was that institutional leaders were not aware of the potential value of a program. Given that institutional cost savings is a major benefit of ASPs, making a credible "business case" to hospital leadership has the potential to secure more resources to support ASPs. Our finding that a relatively high percentage of freestanding children's hospitals were planning programs may be explained by the fact that many are members of the Child Health Corporation of America, which has focused on quality improvement interventions including control of multidrug-resistant organisms.

We found that respondents viewed antimicrobial resistance as a more important problem nationally than at their own institution, which is similar to findings from previous studies of internists and other specialties.[26,27] To our knowledge, this is the first study to specifically explore perceptions about antibiotic resistance among pediatric infectious disease specialists. The fact that the presence or absence of an ASP did not influence respondents' perceptions about the importance of antimicrobial resistance suggests that other factors may be the drivers for an institution to implement an ASP.

There are several limitations to this study. Although we had a high response rate to the survey, the results may not be generalizable to all hospitals that provide care for children. Nonetheless, the EIN membership covers nearly 60% of children's hospitals that employ pediatric IDCs within

TABLE 2. Perceived Barriers to Implementation, Development, and Improvement of an Antimicrobial Stewardship Program (ASP)

	No. (%) of respondents		
Barrier	With current ASP (n = 45)	Planning ASP (n = 25)	No plans for ASP (n = 68)
Any[a]	36 (80)	25 (100)	59 (87)
Loss of prescriber autonomy	14 (31)	14 (56)	23 (34)
Lack of funding[a]	14 (31)	18 (72)	35 (51)
Lack of time[a]	16 (36)	17 (68)	36 (53)
Administration not aware of ASP value	10 (22)	10 (40)	17 (25)

[a] $P < .05$.

the NACHRI. Given the high response (64%) among EIN members in academic or university settings, if any bias exists, we would expect that our results have overestimated the prevalence of pediatric ASPs, because they are less common in community hospitals.[28] On the basis of characteristics of the EIN membership, ASPs administered by non-IDCs may not have been captured in our survey, and IDCs not directly involved in their institution's program may have been less likely to respond. Because we used the individual respondent as the unit of analysis and not the institution, it is possible that institutional clustering could have biased our results. We feel that this is unlikely, however, because the 138 respondents included in the study reflected a total of 108 unique institutions. When examined by institution, 35% reported an ASP and 18% reported a program in the planning stage, which is nearly identical to the results based on individual responses.

In conclusion, to our knowledge, this is the first overview of pediatric ASPs, and therefore it provides a benchmark to measure the implementation of new programs in the future. Although we found limited use of ASPs in pediatric settings and several barriers to implementing new programs, there are multiple opportunities for currently existing programs to improve. A greater emphasis on the monitoring of end points (eg, cost and number of antibiotic-days) would enable more effective promotion of the economic and patient safety benefits attributable to ASPs. Additionally, incorporating a prospective audit-and-feedback approach may enhance the effectiveness of and satisfaction with existing and future ASPs. To achieve greater acceptance and more widespread implementation, pediatric ASPs must be tailored to reflect the unique needs and practices of pediatricians who interact with these programs and their pediatric patients.

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