Antimicrobial stewardship programs (ASPs) provide assistance in the optimal selection, dosage, and duration of antimicrobial treatment to enhance clinical outcomes, minimize resistance, and improve patient quality and safety. The increased recognition that antimicrobial use is often inappropriate, contributes to avoidable adverse events and promotes antimicrobial resistance, has led to the development of ASPs. Studies in both adults and children have demonstrated proven benefits resulting from ASPs. The most consistent outcome has been a reduction in costs attributable to reduced antimicrobial days or use of less costly alternatives. Although some studies have shown clinical benefits such as reductions in the incidence of *Clostridium difficile* colitis, antibiotic related adverse events, hospital-length of stay, and antibiotic resistance, the evidence supporting these benefits is weaker.

A recent survey conducted among members of the Emerging Infections Network estimated that while only approximately one-third of pediatric institutions have ASPs, many institutions are currently developing programs. Several potential barriers to successful program implementation were identified, namely limited financial resources and dedicated full-time equivalents for physicians and to a lesser extent concerns about institutional administrative support and impact on physician autonomy. The current interest in ASPs for pediatric settings is reflected in recent publications that have evaluated their impact.

Findings from these studies are favorable with estimated annual cost savings ranging from $150 to 300,000/yr. The purpose of this review is to describe the recommended structural components for developing a pediatric ASP and to identify important areas for future investigation.

**CORE STRATEGIES**

In 2007, the Infectious Diseases Society of America (IDSA) published a guideline for development of an institutional ASP. In addition to identifying the key elements to a comprehensive ASP, this guideline specifically noted that evaluation of ASPs in pediatric settings is a current research priority.

Although the key structural components of an ASP in pediatrics should be the same as for adult patients, important differences may exist in the types of agents and endpoints that are monitored.

The first step in developing an ASP program is selecting the strategy/strategies that meet institutional expectations. Two core strategies have been described by the IDSA guideline: (1) prospective-audit with feedback and (2) formulary restriction and preauthorization also termed prior approval. Prospective-audit with feedback programs review selected antibiotics and provides feedback to clinicians after a predetermined time (eg, 48–72 hours), focusing the intervention on assessing the appropriateness of continuing antibiotic therapy. Prior approval programs require the clinicians to obtain ASP approval prior to initiating an antibiotic. Although both types of programs are effective, recent studies suggest that the prospective audit-with feedback structure is the most favorable and efficient. The timing of the intervention occurring after initiation of therapy rather than at initiation provides several advantages. It enables the ASP time to gather more clinical information for feedback, it targets inappropriate continuation of therapy, which occurs more frequently than inappropriate initiation of therapy, and it has less impact on prescribing autonomy which may enhance acceptability of the intervention. Despite these advantages, few published studies of prospective-audit ASPs exist.

A recently implemented prospective-audit with feedback program developed at Children’s Mercy Hospital, a 317 bed free-standing children’s hospital in Kansas City intervened in 25% of cases reviewed, the most common being to stop antibiotics. A recent survey of clinicians indicated high overall satisfaction with the program (unpublished data).

**SUPPLEMENTARY STRATEGIES**

The IDSA guidelines provide additional strategies that can be implemented to supplement core strategies or used to improve antibiotic prescribing in settings with limited resources. These include education, guidelines, streamlining/de-escalation therapy, intravenous/oral conversion, dose optimization and antimicrobial order forms (Table 1). The most effective mixture of strategies depends on unique needs of individual institutions. The use of multiple strategies likely has the greatest impact on reducing antibiotic use.

**CLINICAL PHARMACIST**

A dedicated clinical pharmacist, preferably with infectious disease training, is essential to a successful comprehensive ASP. A study from an adult ASP noted that ID pharmacists were more effective in their antibiotic recommendations and cure rates than ID fellows. The ASP pharmacist provides a consistent individual with whom the clinicians can interact.

**IDENTIFYING TARGETED ANTIMICROBIALS**

The next step in program development is identifying the antimicrobials for monitoring. The CDC’s 12-step program to reduce antimicrobial resistance in children recommends that use of broad-spectrum antibiotics including vancomycin, extended-spectrum cephalosporins, carbapenems, linezolid, and oral fluoroquinolones should be monitored. Many programs also monitor use of antiviral and antifungal agents. Ultimately, the number of targeted antimicrobials and the individual agents of highest priority need to be tailored to reflect each individual institution’s unique prescribing patterns and available resources.

**ADDITIONAL COLLABORATIONS**

ASPs require collaboration with information systems specialists.
The importance of ASPs is evident by current state and national-level initiatives. California legislation has mandated hospitals to provide oversight to antibiotic utilization and the CA Department of Public Health is leading a program to assist hospitals in developing and strengthening ASPs. The CDC recently launched “Get Smart for Healthcare,” a program designed to assist providers in ASP implementation.

Several challenges remain in the area of pediatric ASPs. The most important is to develop strategies to facilitate greater implementation of ASPs in pediatric settings in both children’s hospitals and general community hospitals. In general hospitals, a challenge is to ensure that ASPs reflect the unique clinical needs of practitioners caring for children. Novel methods are needed, perhaps via computerized decision support and health information technology, to enable the functionality of key aspects of ASPs at low cost in community hospitals where a dedicated pediatric infectious disease physician or pharmacist may not exist. Finally, current ASPs need to continuously seek and respond to feedback from physicians.

**REFERENCES**


**TABLE 1. Antimicrobial Stewardship Strategies**

<table>
<thead>
<tr>
<th>Core Strategies</th>
<th>Description</th>
<th>References</th>
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<tr>
<td>Prospective-audit with feedback</td>
<td>Review and provide feedback on antibiotics after they have been ordered</td>
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<td>Prior approval</td>
<td>Review and approve antibiotic prior to initiation</td>
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<tr>
<th>Supplemental Strategies</th>
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<td>Education</td>
<td>Lectures, educational conferences, handbooks</td>
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<td>Clinical guidelines</td>
<td>Guidelines can incorporate appropriate antibiotic selections and dosing</td>
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<tr>
<td>Streamlining/de-escalation therapy</td>
<td>Focus on identifying drug-drug mismatches and stopping antibiotics when cultures are negative</td>
<td>4, 8</td>
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<tr>
<td>IV to PO conversion</td>
<td>Changing antibiotics with good bioavailability to oral (eg, linezolid, clindamycin, fluoroquinolones)</td>
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<tr>
<td>Dose optimization</td>
<td>Assuring the appropriate doses are being administered for the given clinical condition</td>
<td>4, 8</td>
</tr>
<tr>
<td>Antimicrobial order forms</td>
<td>Require clinicians to justify antibiotic use and can provide automatic stop orders within the form</td>
<td>15</td>
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*Bug-drug mismatch—When the spectrum of the antibiotic being used to treat the organism is either too broad (eg, vancomycin to treat methicillin susceptible *Staphylococcus aureus*) or too narrow (eg, the organism is resistant).