JPPT | A Pediatric Pharmacy Association Position Paper

Pediatric Antibiotic Stewardship Programs: The Path Forward

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Antibiotic overuse has been well-documented in all populations, including pediatrics. Pediatric pharmacists are valuable and well-integrated within inpatient antibiotic stewardship programs (ASP) in children's hospitals. The Pediatric Pharmacy Association (PPA) believes all pharmacists, regardless of practice setting, should receive education to support entry-level stewardship activities in pediatric patients. Additionally, pediatric antibiotic stewardship pharmacist leaders should ideally be trained in both infectious diseases (ID) and pediatrics. Currently, specialized training in pediatric ID lacks standardization due to the paucity of subspecialized training opportunities. This paper provides recommendations to support pediatric ASP training, education, and pharmacist staffing for inpatient programs. Further, it is recommended to ensure protected time is available for daily and longitudinal pediatric ASP activities to support optimal care and prevent burnout. Finally, the PPA supports the evolving role of the pediatric pharmacist in the ambulatory ASP arena and recommends investigations into unique payment modalities.

ABBREVIATIONS ASHP, American Society of Health-System Pharmacists; ASP, antibiotic stewardship program; CDC, Centers for Disease Control and Prevention; CE, Continuing education; FTE, full-time equivalent; ID, infectious diseases; PPA, Pediatric Pharmacy Association; PGY2, Post-graduate year 2; TJC, The Joint Commission

KEYWORDS Antibiotic stewardship; pharmacy education; pediatric pharmacist; antimicrobial resistance; pharmacy resident; pediatric infectious diseases

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Introduction

Approximately 20% of ambulatory and 60% of inpatient pediatric visits result in an antibiotic prescription.[1,2] Antibiotic use is not without risks, as antibiotic adverse drug events are the most common medication-related cause (46%) of emergency department visits for children.[3] Additionally, increased use of unnecessary and/or broader-than-needed antibiotics has led to increases in resistant bacterial infections among children.[4] These resistant bacteria cause about 2.8 million illnesses and 35,000 deaths annually in the United States across all ages.[5] Unfortunately, a limited number of new antibiotics are in development. Newer antibiotics often have limited safety and efficacy data in pediatric patients. Thus, very limited agents are available to combat multidrug-resistant bacteria, and drug shortages of available antibiotics continue to plague clinical practice.[6]

Antibiotic stewardship programs (ASP) combat antibiotic-related problems by optimizing antibiotic use and minimizing unintended consequences. Efforts and priorities of ASPs vary among different institutions; however, the overall aim is to improve infectious disease (ID) outcomes by limiting antibiotics to only when clinically indicated and employing the narrowest effective and safest agent for the shortest duration appropriate. Most hospitals, including children's hospitals, have implemented ASPs that meet all 7 of the Centers for Disease and Control and Prevention's (CDC) Core Elements.[7] Advancement in ambulatory ASPs has unfortunately not kept pace with inpatient ASPs, despite the availability of CDC Core Elements for Outpatient Stewardship. Much of this is due to a lack of financial support. A recent survey of children's hospitals reported that only 11% have financial support for pediatric ambulatory ASP activities.[8]

Pediatric-focused ASPs in both inpatient and ambulatory settings are best to serve this population. Pediatric ontogeny of drug disposition, ID, and pathogen-resistance patterns often differ from adults; thus, it is essential that postdoctoral trainees, such as those in pharmacy and/or medicine, receive training to successfully direct and manage pediatric-specific ASPs. Organizations suggest that pharmacist leaders of ASPs should have sufficient education, training, or expertise in ID and antibiotic stewardship.[9] While The Joint Commission (TJC) does not require age-specific pharmacist

education for those who manage pediatric patients as part of their ASP duties, the American Academy of Pediatrics recommends at least 1 ASP team member with pediatric expertise.[9,10] To successfully manage pediatric ASPs, pharmacists must be knowledgeable of unique pediatric considerations (eg, ontogeny, drug dosing, adverse effects), pediatric ID knowledge (eg, exposures, pathogens, disease states), and general ID principles (eg, antibiotic coverage, common diseases, antibiotic resistance). The most direct route to acquiring this knowledge is through ID-specific pharmacist postgraduate residency training conducted within a pediatric hospital. Unfortunately, very few of these pharmacy residencies exist. In a 2020 survey, only 14% of pediatric antibiotic stewardship/ID pharmacists with specialized postgraduate year 2 (PGY2) training had completed their ID PGY2 in a children's hospital. Most (54%) completed a pediatric residency, while 32% completed an ID program.[11] The Pediatric Pharmacy Association (PPA) believes that pharmacists trained and specialized in pediatric antibiotic stewardship/ID are necessary to implement pediatric antibiotic stewardship efforts in both inpatient and ambulatory ASPs and to ensure a high level of care for pediatric patients.

In 2017, the PPA formulated a position statement with implementation and sustainability recommendations regarding pediatric ASPs.[12] As practice has evolved, the PPA has re-evaluated heightened challenges, resulting in new recommendations (Box 1). In addition to education and training needs for pharmacists (eg, student pharmacists, generalist pharmacists, and pediatric antibiotic stewardship/ID specialty pharmacists), pediatric ambulatory ASP practices should be supported and expanded. To attain these goals and ensure continued success in inpatient pediatric ASP practices, pharmacists should have time reserved to conduct pediatric ASP practice, share clinical research or quality improvement initiatives, and limit the ever-present burnout that plagues the stewardship community.

Box 1. PPA Recommendations for Pediatric Antibiotic Stewardship

Summary of Recommendations

1. Incorporate education to support entry-level pediatric ASP efforts into pharmacy school curriculums.
2. Create high quality pediatric ID/ASP continuing education programs. Enhance collaboration efforts between pediatric and infectious diseases professional organizations.
3. Expand postdoctoral training programs for pharmacists in pediatric IDs.
4. Include antibiotic stewardship as an element of training in pediatric pharmacy residencies and include pediatrics as an element of training in ID pharmacy residencies.
5. Ensure pediatric stewardship services are provided for every pediatric patient, including those who are admitted to an adult acute care hospital, via in-house or remote consultation with pediatric antibiotic stewardship/ID pharmacist.
6. Recommend inclusion of pediatric ASP consult services for institutions with limited pediatric patients and no in-house pediatric ASP.
7. Support appropriate funding and allocation of resources for inpatient pediatric antibiotic stewardship pharmacists.
8. Investigate pediatric pay for performance or other payment methods to allow for sufficient pharmacist time and resources for expansion of ambulatory antibiotic stewardship services for pediatric patients.
9. Invest adequate time and resources for pediatric pharmacists to participate in antibiotic stewardship scholarly projects including presentation of research and quality improvement initiatives at local, state, or national conferences and publication of results.
10. Protect antibiotic stewardship pharmacists from burnout through management of workload and expectations.

ASP, *antibiotic stewardship program;* ID, *infectious disease*

Pharmacist Training

Student Pharmacists and Generalist Pharmacists. ***Incorporate Education to Support Entry-Level Pediatric ASP Efforts Into Pharmacy School Curriculums.*** The Pediatrics Practice and Research Network of the American College of Clinical Pharmacy and the American Association of Colleges of Pharmacy published a PPA-endorsed opinion paper in 2020 recommending all pharmacy schools offer a minimum of 25 contact hours of pediatric education.[13] Unfortunately, incorporating this level of pediatric pharmacy education is not the reality at many schools, and training specific to subpopulations such as pediatrics and specific ID considerations (eg, unique pathogens, optimal choice, dose, and duration of antimicrobials in this population) are often limited. In 2013, a survey estimated that 94% of pharmacy schools had only a median of 16 hours of pediatric didactic education with 61% of schools providing additional education through a pediatric elective.[14,15] In addition to sparce pediatric curricula, ID education is limited. Jeffres et al[16] reported that, across 106 pharmacy schools in the US, pharmacy students receive approximately 20 hours of ID fundamentals and 40 hours for infectious conditions/diseases. In the absence of additional postgraduation training, many pharmacists graduate with little to no formal training in pediatric antibiotic stewardship/ID-related pharmacotherapy.[17]

Whether practicing in inpatient or ambulatory settings, even nonpediatric focused, pharmacists are likely to encounter pediatric patients.[15,16] As such, the PPA believes all graduating pharmacists should be educated to support entry-level antibiotic stewardship activities and management, including pediatrics, regardless of practice site. This recommendation is in

addition to the topics already recommended by the 2020 Joint Statement on Pediatric Pharmacy Curricula (Table 1).[15,18,19]

Create High-Quality Pediatric ID/ASP Continuing Education Programs. Enhance Collaboration Efforts Between Pediatric and Infectious Diseases Professional Organizations. Education programs, some with continuing education (CE) credits, are available for those seeking additional education in either pediatrics or antibiotic stewardship/ID. High-quality education offerings are limited for those seeking combined pediatric antibiotic stewardship content. The PPA's growing library of educational programs targeting achievement of the PPA-endorsed minimum core competencies for all pharmacists involved in the care of hospitalized pediatric patients is a starting point for expanding CE related to pediatric antibiotic stewardship/ID.[20] In addition to general pediatric topics, these core competencies comprise pediatric ID education, including pediatric sepsis, urinary tract infections, septic arthritis, osteomyelitis, vaccines, pneumonia and tracheitis, croup, and bronchiolitis.[20] For higher-level CE, the PPA would like to explore future formal collaborations with ID organizations to provide more focused educational programs, including both entry-level and advanced pediatric antibiotic stewardship content. Furthermore, the PPA seeks to provide educational resources to pharmacists in various practice settings, including community and other ambulatory arenas. The PPA would also like to foster collaborations with other pharmacy organizations to explore the development of additional pediatric antibiotic stewardship pharmacist educational opportunities and resources.

Table 1. Published Educational Coverage Recommendations for Student Pharmacists and Pharmacy Post-Graduate Year-2 (PGY2) Residents, With a Focus on Pediatric Infectious Diseases Topics

Doctor of Pharmacy Curricula[15]	PGY2 Pediatric Pharmacy Residency[19]	PGY2 Infectious Diseases Pharmacy Residency[18]
Pediatric Topics, Applicable to Infectious Diseases	**Infectious Diseases Topics**	**Infectious Diseases Topics**
Anatomic and physiologic differences in pediatric patients	AIDS/HIV*	Cardiovascular Infections (eg, endocarditis)
Pediatric-related calculations, including pediatric pharmacokinetics, drug dosing, renal dosing, maintenance fluids	Antibiotic prophylaxis (eg, endocarditis, surgery)	Central nervous system infections (eg, meningitis, encephalitis)
Pediatric dosage forms	Antibiotic stewardship	Fever of unknown origin*
Fever	Catheter-related blood stream infection/sepsis*	Fungal infections
Pharmacodynamic principles	*Clostridioides difficile*	Gastrointestinal infections
Infectious Diseases Topics	Conjunctivitis*	Hepatitis B*
Ear infections (eg, otitis media, otitis externa)	CNS infections (ie, viral encephalitis*, meningitis)	Hepatitis C*
Endocarditis	Croup*	HIV-infection and AIDS*
Influenza	Endocarditis*	Intra-abdominal infections
Immunization	Epiglottitis*	Neutropenic fever
Meningitis (eg, aseptic, bacterial)	Fever	Non-tubercular mycobacterial infections
Neonatal sepsis	Fungal infections	Ophthalmologic infections*
Pinworm, lice, scabies	Osteomyelitis/septic arthritis*	Opportunistic infections in immunocompromised hosts
Pneumonia	Otitis media* & otitis externa	Otitis media & otitis externa
SSTIs and osteoarticular infections (eg, cellulitis, osteomyelitis, septic arthritis)	Parasitic infections	Parasitic infections*
STIs	Pneumonia	Reproductive organ infections*
Surgical prophylaxis	Sepsis	Respiratory infections: upper and lower (eg, pneumonia, RSV bronchiolitis)
UTIs	SSTIs* and osteoarticular infections (ie, cellulitis*, impetigo*, osteomyelitis*, septic arthritis*)	Rickettsial infections*
URTI (eg, bronchiolitis, croup, pharyngitis)	STIs*	Sepsis
	Shunt infections*	STIs*
	Strep throat*	SSTIs* and osteoarticular infections* (eg, cellulitis, osteomyelitis, septic arthritis)
	Tuberculosis*	Tuberculosis*
	UTIs	Travel medicine*
		Urologic infections
		Viral infections

Data in table are adapted and modified in part from references 15, 18, and 19.
AIDS, Acquired immunodeficiency syndrome; CNS, central nervous system; HIV, Human immunodeficiency virus; PK, pharmacokinetic; PD, pharmacodynamic; STI, sexually transmitted infection; SSTIs, skin and soft tissue infections; URTI, upper respiratory tract infection; UTI, urinary tract infection

* May be met through didactic discussion, reading assignments, case presentations, and/or written assignments; other entries must be met through patient experience.

Pediatric Infectious Diseases and Antibiotic Stewardship Pharmacists. ***Expand Postdoctoral Training Programs for Pharmacists in Pediatric Infectious Diseases.*** To provide comprehensive training, the PPA supports expanding postdoctoral training programs for pharmacists in pediatric ID. Per the CDC and TJC, ASPs should be led by a specialty-trained pharmacist or co-led by an ID-trained physician and pharmacist.[9,21] The PPA believes that pediatric ASPs should have a pharmacist leader as director/co-director who is competent in both ID and pediatrics. Currently, most pharmacists leading pediatric ASPs have trained in pediatrics or ID.[11,22] Training for pharmacists seeking to specialize in pediatric antibiotic stewardship/ID lacks standardization primarily because of the paucity of subspecialized training opportunities.[23,24] The number of American Society of Health-System Pharmacists (ASHP) PGY2 residency training programs in pediatrics (N = 83) or ID (N = 144 including 4 of these pediatric ID focused within children's hospitals) are much more readily available compared with the sparce PGY2 ID un-accredited residency programs or fellowships available at children's hospitals.[24]

Include Antibiotic Stewardship as an Element of Training in Pediatric Pharmacy Residencies and Include Pediatrics as an Element of Training in Infectious Diseases Pharmacy Residencies. Per ASHP pharmacy residency requirements, those completing PGY2 pediatric pharmacy residency programs will receive at least some pediatric antibiotic stewardship/ID training. Alternatively, exposure to pediatric pharmacotherapy is not guaranteed from completing a PGY2 ID pharmacy residency program, and currently, only approximately 45% of PGY2 ID pharmacy residency programs mention pediatrics in description materials.[24] In a 2019 survey, 101 PGY2 ID pharmacy residency programs reported fewer than 30% requiring a pediatric antibiotic stewardship/ID experience, and approximately 30% did not offer pediatric antibiotic stewardship/ID experiences.[25] In the absence of pediatric ID-dedicated residencies and fellowships, the PPA supports the following minimum training requirements for pediatric antibiotic stewardship/ID pharmacists: (1) the completion of a pediatric residency AND additional antibiotic stewardship/ID-focused education, or (2) the completion of an ID residency AND additional pediatric focused education (Table 2). Given the rarity of pediatric-focused antibiotic stewardship/ID pharmacy post-graduate training to bridge the gap until more training programs are available, the PPA recommends including comprehensive antibiotic stewardship/ID training within the established core areas of PGY1 pharmacy residencies, PGY2 pediatric pharmacy residencies, and pediatric experiences incorporated into PGY2 ID pharmacy residencies. The current required and elective core areas/patient care experiences for these residencies are extensive (Table 1) and may already be challenging to achieve within the course of a single specialized residency year.[18,19] Although comprehensive training in antibiotic stewardship/ID during pediatrics residency and pediatrics during ID residency is optimal, excessive additional required experiences risk diminishing overall quality, increase residency-related stress, and reduce the feasibility of goal achievement. To minimize requirements, pediatric antibiotic stewardship should be discussed in PGY1 programs, pediatric PGY2 programs should designate antibiotic stewardship/ID as a required rotation (standard month-long block or longitudinal), and PGY2 antibiotic stewardship/ID adult programs should incorporate required pediatric-specific experiences to ensure sufficient education is attained (Table 2). For residency programs without pediatric antibiotic stewardship/ID-specific resources, we encourage collaboration between other health systems or residency programs (Table 2).

For pharmacists who received primary training in adult antibiotic stewardship/ID and have limited pediatric experience, the PPA recommends seeking additional training or mentorship in pediatrics. Similarly, pharmacists with specialty training in pediatrics and limited antibiotic stewardship/ID experience should find additional training or mentorship in antibiotic stewardship/ID. Table 3 provides examples of additional training and resources that are available. These include certificate programs, live didactic sessions, professional conferences, specialty board certification, and/or self-study modules. Antibiotic stewardship certification programs offered by various large organizations include the Society of Infectious Diseases Pharmacists, the CDC, and the Making A Difference in Infectious Diseases (See Table 3). Another excellent resource for increasing pediatric antibiotic stewardship/ID proficiency for pediatric- or ID-trained pharmacists is the Sharing Antimicrobial Reports for Pediatric Stewardship (SHARPS) Collaborative.

Antibiotic Stewardship Services. ***Ensure Pediatric Stewardship Services are Provided for Every Pediatric Patient, Including Those Who Are Admitted to an Adult Acute Care Hospital, Via In-House or Remote Consultation With Pediatric Antibiotic Stewardship/ID Pharmacist.*** Available literature has demonstrated a clear benefit of inpatient ASP services to children.[26–28] Prospective audits with feedback with or without preauthorizations are foundational activities of inpatient ASPs and are considered "priority" interventions by the CDC's Core Elements.[21] Core Element interventions should be prioritized for all patients admitted to an acute care setting, including pediatrics, regardless of the primary population served at the institution (ie, freestanding vs combined pediatric/adult hospital). The methodology of implementing these foundational stewardship practices will be dependent

Table 2. Pediatric Pharmacy Association Recommended Pediatric and/or Infectious Diseases Topics Recommended to be Added for those Completing Post-Graduate Year-2 (PGY2) Pharmacy Residencies

PGY2 Pediatric	PGY2 Infectious Diseases
Infectious Diseases Topics • Antibiotic resistance • Antimicrobial susceptibility testing • Antibiotic stewardship metrics • Diagnostic stewardship • Pediatric immunizations	**Pediatric Topics** • Introduction to pediatric pharmacokinetic/pharmacodynamics across the pediatric age continuum • Medication dosing in special populations • Medication formulation considerations and challenges • Medication adverse drug reactions/side effects/contraindications and precautions in special populations **Infectious Diseases Topics** • Bone and joint infections* to include acute hematogenous osteomyelitis • Intraabdominal infections to include NEC • Pediatric immunizations • Respiratory infections: upper and lower* to include community acquired pneumonia, croup, acute otitis media, periorbital and orbital cellulitis, retropharyngeal abscesses, respiratory syncytial virus bronchiolitis, sinusitis, and complications (eg, intracranial extension) • STIs, including chlamydial ophthalmia and chlamydial pneumonia, congenital syphilis, gonococcal ophthalmia, and perinatal HIV treatment • Sepsis including neonatal sepsis (early/late onset) • Neonatal HSV

HSV, herpes simplex virus; NEC, necrotizing enterocolitis; STI, sexual transmitted infection

* Although these topics (eg, bone and joint, respiratory) are covered in the infectious diseases' curriculum, the bulleted sub-topics may be specific to pediatric patients or have pediatric specific considerations that should be discussed.

Table 3. Continuing Education Resources for Antibiotic Stewardship Pharmacists

Program	Offerings	Links
British Society for Antimicrobial Chemotherapy	Multiple online on demand offerings	https://bsac.org.uk/education/
CDC	13 module training program on antibiotic stewardship (1 module specific to otitis and pharyngitis)	https://www.train.org/cdctrain/training_plan/3697
MAD-ID	Antimicrobial stewardship program with an elective in pediatrics	https://mad-idtraining.org/certification/
PIDS	Toolkit with links to various programs and trainings	https://pids.org/pediatric-asp-toolkit/inpatient-settings/inpatient-cdc-core-elements/drug-expertise-pharmacist-leader/
PPA	Continuing education on-demand offerings: all are pediatric-specific, some are infectious disease-related. Additionally, infectious diseases/ASP content is often part of the live meetings.	https://www.ppag.org/?pg=OnDemandCE
SHARPS	Listserv, annual live educational event, and research collaborative specific to pediatric infectious diseases	https://sharps.wustl.edu/
SIDP	ASP Training Certificate Program with pediatric elective	https://www.sidp.org/Stewardship-Certificate

ASP, antibiotic stewardship program; CDC, Centers for Disease Control and Prevention; MAD-ID, Making a Difference in Infectious Diseases; PIDS, Pediatric Infectious Diseases Society; PPA, Pediatric Pharmacy Association; SHARPS, Sharing Reports for Pediatric Stewardship; SIDP, Society of Infectious Diseases Pharmacists

on the institution's available resources and stewardship culture.

The PPA believes that every pediatric patient admitted to an acute care hospital should benefit from the services provided by the institution's ASP. Freestanding children's hospitals should not only have an ASP that incorporates the CDC's 7 Core Elements but additionally should include at least 1 pharmacist with training in pediatric antibiotic stewardship/ID as described above.[21] Children admitted to an adult institution with pediatric services should still have access to a pediatric antibiotic stewardship/ID pharmacy specialist, whether available locally or via consultation (eg, collaboration with a regional health system). Collaborations to develop pathways/processes or assist on a personal patient care level can be individualized based on the institution's needs and resources but may include telehealth services from pediatric health systems or contracting with local experts for in-depth support.

Recommend Inclusion of Pediatric ASP Consult Services for Institutions With Limited Pediatric Patients and No In-House Pediatric ASP. Institutions with limited pediatric expertise should create collaborations or consultations with institutions or organizations that have pediatric antibiotic stewardship experts. These experts can assist in developing pediatric ASP initiatives and outcomes specific to the institution (Tables 4 and 5). For example, experts can assist in developing pediatric-specific clinical pathways and any pediatric-specific antimicrobial restrictions or preauthorizations. As per the TJC standards, institutions should use national and internationally recognized guidelines, and if pediatric guidance is lacking, the pediatric antibiotic stewardship/ID pharmacy expert can help direct recommendations from additional pediatric-focused literature and/or guidelines.[9] Additionally, these individuals can provide insight into how local pediatric susceptibility data impacts pediatric ID treatment recommendations.[10] Further, performance of inpatient ASP services provided to pediatric patients should be routinely evaluated by an ASP team member as part of standards outlined for all stewardship programs.[21] Process and outcome measures should be appropriate for the given population and in-

Table 4. Recommended Pediatric Antibiotic Stewardship Program Services for Institutions With Limited Pediatric Expertise

Service	Priority	Additional Guidance
Institution-specific clinical pathways for common pediatric infectious diseases	High	Consultation and collaboration with pediatric ASPs are highly recommended. Consider prioritizing based on commonly encountered ID admissions in pediatric patients at the institution within the last year (eg, bronchiolitis, CAP, appendicitis).
Antimicrobial therapeutic drug monitoring	High	Consultation and collaboration with pediatric antibiotic stewardship pharmacists highly recommended. Consider developing pediatric-specific monitoring guidelines and/or goals of therapy.
Restricted antimicrobials and preauthorization process	Medium	Consultation and collaboration with pediatric antibiotic stewardship pharmacists is highly recommended.
Rapid diagnostic testing	Medium	For applicable rapid diagnostics available at an institution, include specific recommendations for interpretation and application within the pediatric population (eg, rapid Group A *Streptococcus* testing for pharyngitis, meningitis/encephalitis PCR panel).
Pediatric antibiogram	Medium	Development of a pediatric-focused antibiogram, depending on the number of available cultures in pediatric patients, should be completed when possible. Consultation with microbiology colleagues is highly recommended. Provide guidance for clinicians on appropriate use of focused antibiograms in settings of combined adult and pediatric patient populations.
Structured peer education	Medium	Education can be provided through daily interventions made by antibiotic stewards. Consultation and collaboration with pediatric antibiotic stewardship pharmacist is recommended, especially when considering formal education on pediatric topics.

ASP, antibiotic stewardship program; CAP, community-acquired pneumonia; ID, infectious diseases; PCR, polymerase chain reaction

Table 5. Recommended Pediatric Antibiotic Stewardship Outcomes to be Measured for All Institutions[21,33]

Area of Practice	Outcome	Guidance
Inpatient		
	Indication for antibiotic	Indication for use should be documented on all antibiotics prescribed, preferably incorporated into the order for pharmacist review upon verification.
	Percent of common pediatric infections (eg, CAP, SSTI, UTI) with evidence-based treatments (i.e., antibiotic selection, dose, and durations)	Evidence-based recommendations should be specific to pediatrics. For example, for pediatric CAP, measure the percent of narrow antibiotics (eg, ampicillin, penicillin), percent with appropriate dosing (based on local pneumococcal resistance) and total duration of therapy (eg for uncomplicated CAP 5–7 days)
Ambulatory*		
	Percent of patients with viral illness (eg, URI, including bronchiolitis) not receiving antibiotic therapy	Viral respiratory infections should not receive antibiotic therapy. Families' education that antibiotics do not treat viruses is also recommended.
	Percent of patients where watchful waiting can be recommended (eg, AOM)	Watchful waiting is highly recommended and often underutilized for older children with nonsevere AOM
	Percent of common pediatric infections (eg, AOM, ABS, CAP, SSTI) with evidence-based treatments (ie, antibiotic selection, dose, and durations)	Evidence-based recommendations should be specific to pediatrics. For example, a major shift in recent years is the evolving evidence supporting shorter durations. For example, most mild cases of pediatric CAP and SSTI can be successfully treated with 5 days of therapy.
	Percent of group A Streptococcal pharyngitis that is treated without testing or with negative results	The primary reason to treat Group A Streptococcal pharyngitis is to prevent acute rheumatic fever. Most cases of pharyngitis are caused by viruses and young children can be colonized. Antibiotics for treatment of GAS pharyngitis should be done where testing is appropriate, performed, and resulted positive.

AOM, acute otitis media; ABS,acute bacterial sinusitis; CAP, community-acquired pneumonia; GAS, group A streptococcus; SSTIs, skin and soft tissue infections; URI, upper respiratory infection; UTI, urinary tract infection

* Including Emergency Medicine Departments

tervention with special attention to differences in the pediatric population (eg, The CDC's National Health and Safety Network's Standardized Antimicrobial Administration Ratio has different categories of antibiotic groups for neonates, pediatrics, and adults). The PPA recommends that the pediatric antibiotic stewardship/ID pharmacist has unique expertise and should be at least consulted to inform recommendations, pathways, and outcomes for pediatric patients managed at the hospitals.

Support Appropriate Funding and Allocation of Resources for Inpatient Pediatric Antibiotic Stewardship Pharmacists. Antibiotic stewardship programs require support from senior administrators. Support is vital not only through allocating full-time equivalent (FTE) funding for both pediatric antibiotic stewardship physician(s) and pediatric antibiotic stewardship pharmacist(s) but also to foster acceptance of the ASP and its mission. Recent recommendations for ASP FTE allocation and support are provided in Table 6.[29–31] Doernberg and colleagues[30] reported a relationship between physician and pharmacist FTE and self-reported effectiveness of the ASP, which was attributed mostly to programs that specifically had pharmacist support for postantibiotic review and feedback. The authors conclude that an ID physician-to-infectious diseases pharmacist ratio of 1:3 provides the highest value use of available resources.[30]

The PPA recommends hospital leaders provide funding for all components (eg, physician time, information technology requirements, data analyst) of ASPs, including pediatric antibiotic stewardship/ID-trained pharmacists to lead and manage ASPs based on the number of neonatal and pediatric beds regardless of

Table 6. Summary of Minimum Recommended Personnel Support of (Pediatric) Inpatient Antibiotic Stewardship Programs[29–31]

Source	Minimum Pharmacist	Minimum Physician	Minimum Data Analyst
USNWR, Best Children's Hospitals[31]	0.4 FTE for hospitals <250 beds; 1 FTE hospitals ≥250	0.3 FTE medical director	0.2 FTE
CMS (average 124-bed hospital)[29]	0.25 FTE	0.1 FTE	0.05 FTE
Doernberg, 100–300 beds, necessary FTE for effectiveness[30]	1 FTE	0.4 FTE	—

CMS, Centers for Medicare & Medicaid Services; FTE, full-time equivalent; USNWR, US News & World Report

classification in a free-standing children's or combined adult and children's hospital. As provided in Table 6, the PPA supports US News and World Reports Best Children's Hospital minimum pediatric pharmacist FTE for stewardship of 0.4 FTE for hospitals less than 250 beds and 1 FTE hospital with 250 beds or more.[31] The PPA also recommends that pediatric antibiotic stewardship pharmacists' FTE support should be provided in-house or as a consultant at 0.1 FTE for hospitals with less than 20 pediatric licensed beds and 0.4 FTE for institutions with 20 to 250 licensed pediatric beds. In rare instances when a primarily adult institution has more than 250 licensed pediatric beds, the PPA recommends following recommendations for a similar-sized children's hospital with at least 1 FTE.

Investigate Pediatric Pay for Performance or Other Payment Methods to Allow for Sufficient Pharmacist Time and Resources for Expansion of Ambulatory Antibiotic Stewardship Services for Pediatric Patients. The importance of antibiotic stewardship in the ambulatory care setting has been recognized and regulatory authorities, like the CDC and TJC, have mandated it to ensure the safe and effective use of antibiotics in the ambulatory setting.[32,33] One report suggested that more than 60% of antibiotic expenditures occur in outpatient pharmacies and clinics.[34] More than 1 in 5 pediatric ambulatory visits results in an antibiotic being prescribed.[2] Many of these prescriptions are for broad-spectrum antibiotics (50%) to treat respiratory conditions where antibiotic therapy is often unnecessary.[2] Several publications have outlined strategies (eg, feedback to prescribers, commitment posters, delayed prescribing, communications training, documentation, diagnostic confirmation) and metrics (eg, percent of bronchiolitis visits with antibiotics prescribed, percent of all antibiotics where amoxicillin was prescribed) for pediatric ambulatory ASP services.[35–40] Of note, many of the potential metrics are claims related and, as such, are often available for tracking.[37] Because these metrics can be tracked via claims and there is strong evidence for specific quality measures (eg, percentage of bronchiolitis visits with antibiotic prescribed) and/or evidence-based guidelines for many common pediatric ID-related conditions (eg, bronchiolitis, otitis media, pharyngitis, pneumonia, skin infections), they lend themselves well to value-based payment and potential pay-for-service models.

Pediatric patients in the ambulatory setting would benefit from pediatric antibiotic stewardship pharmacist services to reduce inappropriate prescribing, optimize antibiotic choice, and dose, and limit adverse drug events. Literature supports the role of pediatric pharmacists in cost avoidance in ambulatory settings. In 1 study, pediatric pharmacist interventions resulted in approximately $307,210 of cost avoidance over a 4-month period; more than half of the costs avoided were due to the prevention or management of adverse drug events, and other costs avoided included unnecessary medications, prevention or management of allergic reactions, and drug interactions.[41] Several antibiotic stewardship approaches have successfully improved antibiotic use in the ambulatory setting. Further, the TJC requires antibiotic stewardship in its accredited ambulatory health care organizations.[32] The PPA recommends dedicating resources to support pediatric antibiotic stewardship pharmacists in developing, tracking, reporting, and sharing metrics for effective pediatric ambulatory antibiotic stewardship. We further support pilot projects investigating unique payment models, such as pay-for-performance, for pharmacists engaged in these evolving roles.

Pediatric Antibiotic Stewardship Research. ***Invest Adequate Time and Resources for Pediatric Pharmacists to Participate in Antibiotic Stewardship Scholarly Projects Including Presentation of Research and Quality Improvement Initiatives at Local, State, or National Conferences and Publication of Results.*** While publications in pediatric antibiotic stewardship have increased, many questions regarding optimal practices remain unanswered. Systematic evaluation of stewardship practices and dissemination of that information is key to moving the field forward and providing optimal patient care. Without

quality publications evaluating antibiotic stewardship interventions and treatment of ID, the uptake of effective practices will be delayed, and ineffective or unproven practices will continue.[10] Areas of particular focus include the pharmacist's role in pediatric ASPs, pediatric ASP activities in expanded settings (eg, ambulatory, community hospitals, smaller children's hospitals), specific disease-state evaluations of (including optimal antibiotic choice, dose and frequency, duration, and clinical outcomes), strategies for outpatient parenteral antimicrobial therapy/complex outpatient antimicrobial therapy, and pediatric antibiotic stewardship management in special pediatric populations (eg, neonates, cystic fibrosis, transplant, immunocompromised host).[10,42,43] Although PGY2-trained pharmacists are not specifically trained to complete research, all must complete at least 1 research project that helps to provide some experience if they have completed an ASHP-accredited residency program. Thus, clinician-researchers should aim to determine optimal implementation strategies and the factors contributing to high-intervention uptake and sustainability across settings.[42,44]

Colleagues representing the Society of Infectious Diseases Pharmacists have made a strong argument for pharmacist involvement in antibiotic stewardship quality improvement activities and research, and the PPA supports their recommendations.[42] Published reports are encouraged to describe the pharmacist's role in ASP, the pharmacy practice model, and details about the specific pediatric population served.[42] The PPA further recommends health care systems provide time for the continued development of pharmacists' quality improvement and research skills, encourage and reward research contributions, and provide sufficient time to perform scholarly activities. Additionally, the PPA supports participation in pediatric-specific collaborative networks between multiple institutions, such as the Sharing Antimicrobial Reports for Pediatric Stewardship network, to create robust and quality data.[45]

Pharmacist Burnout. ***Protect Antibiotic Stewardship Pharmacists From Burnout Through Management of Workload and Expectations.*** Like other health care providers, stewardship pharmacists are at risk of burnout and should be protected from it. Burnout drivers specific to antibiotic stewardship pharmacists have not been well studied, but many factors contribute to overwork, emotional exhaustion, depersonalization, and lack of professional accomplishment.[46] Therefore, it is vital that hospital leadership works to retain talent within ASP, particularly pediatric antibiotic stewardship talent, as they are a limited resource. Ensuring pediatric antibiotic stewardship pharmacists have adequate time off and resiliency skills are important, but these are band-aids for underlying issues. The PPA recommends hospital leadership consider actions that address the underlying drivers to prevent or minimize burnout when possible. Some potentially helpful actions to protect and retain pediatric antibiotic stewardship pharmacists include clearly communicating stewardship activities are supported and prioritized, encouraging other ID and pharmacy colleagues to support ASP activities, ensuring that the work expectations of the antibiotic stewardship pharmacists are realistic based upon available time and resources, prioritizing protected time for the administrative and scholarly ASP work activities, providing specific job descriptions for stewardship pharmacists (rather than generic "clinical specialist" position descriptions), and providing a path for career growth. Ensuring ASP activities are efficient and well-prioritized may help expand and protect current person resources.[47] The PPA recommends that efforts should be made to support the role of the pediatric antibiotic stewardship pharmacist, providing them sufficient time, resources, and continuous training to effectively conduct the program while minimizing burnout.

Conclusions

Pediatric pharmacists with dedicated expertise in antibiotic stewardship are essential to optimizing antibiotic drug therapy, in order to improve outcomes, avoid adverse effects, and limit resistance development. To improve and expand upon this, it is essential that student pharmacists and postdoctoral trainees have content focused on pediatric antibiotic stewardship/ID. Further, those who will be expected to lead or practice as pediatric antibiotic stewardship pharmacists should optimally complete an ID PGY2 pharmacy residency at a children's hospital or a pediatric ID fellowship training program. Until enough of these programs exist, it is recommended that current pediatric and ID training programs expand education surrounding ID or pediatric core competencies, respectively. For clinical pharmacists already practicing, participation in developing quality CE or certificate programs in pediatric antibiotic stewardship will help provide the expertise and guidance needed to confidently care for this patient population.

The PPA also recommends that all pediatric inpatients receive a high level of pediatric ID care that is informed by a pediatric antibiotic stewardship pharmacist (in-house or via consultation). As ambulatory ASP programs evolve, it is recommended that pediatric antibiotic stewardship pharmacists are highly involved in supporting optimal care of the ambulatory pediatric patient. Further, it is recommended that institutions investigate additional payment models to support ambulatory efforts. Knowledge sharing is essential to the improvement and expansion of important pediatric ASP efforts, and, as such, pediatric antibiotic stewardship pharmacists should be given resources and time to conduct scholarly activities. Last, it is important not to lose well-trained pediatric antibiotic stewardship

pharmacists to burnout. The PPA recommends strategies to help protect these individuals and their efforts.

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