From paper to practice: Strategies for improving antibiotic stewardship in the pediatric ambulatory setting

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Antibiotic stewardship aims to better patient outcomes, reduce antibiotic resistance, and decrease unnecessary health care costs by improving appropriate antibiotic use. More than half of annual antibiotic expenditures for antibiotics in the United States are prescribed in the ambulatory setting. This review provides a summary of evidence based strategies shown to improve antibiotic prescribing in ambulatory care settings including: providing education to patients and their families, providing education to clinicians regarding best practices for specific conditions, providing communications training to clinicians, implementing disease-specific treatment algorithms, implementing delayed prescribing for acute otitis media, supplying prescribing feedback to providers with peer comparisons, using commitment letters, and prompting providers to justify antibiotic prescribing for diagnoses for which antibiotics are not typically recommended. These various mechanisms to improve stewardship can be tailored to a specific practice's work flow and culture. Interventions should be used in combination to maximize impact. The intent with this review is to provide an overview of strategies that pediatric providers can take from paper to practice.

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Introduction

Antibiotic stewardship aims to better patient outcomes, reduce antibiotic resistance, and decrease unnecessary health care costs by improving appropriate antibiotic use. [1] While antimicrobial stewardship efforts to date have been primarily associated with inpatient antibiotic use, a larger proportion of use occurs in the ambulatory setting. Approximately 60% of annual antibiotic expenditures are for antibiotics prescribed in ambulatory settings,[2] and it is estimated that 20% of pediatric outpatient visits per year result in an antibiotic prescription.[3] In 2011, this amounted to 73.1 million outpatient prescriptions for children (<20 years).[4]

While many antibiotics are prescribed for bacterial conditions for which antibiotics are necessary – urinary tract infections, suppurative otitis media in infants, and Streptococcal pharyngitis – approximately one in three antibiotics prescribed in ambulatory pediatrics are prescribed for conditions for which antibiotics are not necessary, most notably viral acute respiratory conditions.[3,5] Antibiotic overprescribing can lead to increased adverse drug events in individual patients, and on a population level has led to alarming increases in antibiotic resistance.[6] In 2016, the Center for Disease Control and Prevention (CDC) published guidance for implementing antibiotic stewardship in outpatient settings organizing its recommendations around four *core elements* (Fig. 1).[7] The core elements' evidence-based approach provides a systematic method to monitoring and improving the way that antibiotics are prescribed in the ambulatory setting.

Strategies to improve antibiotic prescribing in ambulatory care settings include: providing education to patients and their families, providing education to clinicians regarding best practices for specific conditions, providing communications training to

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clinicians, implementing disease-specific treatment algorithms, implementing delayed prescribing for acute otitis media, supplying prescribing feedback to providers with peer comparisons, using commitment letters, and prompting providers to justify antibiotic prescribing for diagnoses for which antibiotics are not typically recommended. (Fig. 2).[8] This review will summarize the basis for each of these strategies, the evidence supporting their use, and suggestions for putting them into practice.

Strategies for practicing antibiotic stewardship in primary care pediatrics

Education for patients and families is a cornerstone of antibiotic stewardship

Informing patients, their families, and the general public about when antibiotics are and are not necessary and about the risks of using antibiotics unnecessarily engages them as partners in antibiotic stewardship. Several studies have shown that effective antibiotic education to patients and families enhances parental knowledge about appropriate antibiotic use, shifts their expectations for antibiotics, and ultimately reduces inappropriate antibiotic prescribing.[9–16] Effective education to patients and their families starts in the waiting room starts in the waiting room through paper materials such as educational pamphlets, posters, and/or videos, and continues throughout the visit through communication and messaging by providers as well as other members of the health care team.

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Simple informational booklets both educate patient caregivers and prompt clinicians to provide appropriate care

Francis and colleagues performed a cluster randomized control study in the United Kingdom comparing antibiotic prescribing by clinicians who used an interactive pictorial booklet about upper respiratory tract infections (URIs) during their visits with those who provided their usual care. Clinicians who used the booklet had a significantly lower antibiotic prescribing rate for URIs during the 18 months of the study compared to clinicians randomized to usual care (19.5% vs. 40.8%, P<.001).[9] The number of return visit within 2 weeks for the same condition and patient satisfaction did not differ between the two groups. By embedding this educational interaction into the clinic visit, the booklet served as a prompt guiding the clinician's management of the child with a URI.

Receiving education about antibiotics can shift patients and their families' perceptions and expectations regarding antibiotic use

Taylor et al assessed the effect an informational brochure about antibiotic use had on parental attitudes and beliefs about the importance of using antibiotics judiciously.[10] Clinics provided families in the intervention group with a copy of the CDC brochure "Your Child and Antibiotics" both at the time of randomization in the clinic and by mail 6 weeks later. The pamphlet explained the

FIG. 1. Summary of the CDC Core Elements of Outpatient Antibiotic Stewardship. Reprinted with author's permission from Core Elements of Outpatient Antibiotic Stewardship by Sanchez GV et al. *MMWR Recomm Rep* 2016;65(No. RR-6):1–12.

difference between viral and bacterial infections, described common conditions for which antibiotics are not needed, listed potential adverse consequences of antibiotic overuse, and encouraged discussing these topics with their child's doctor. A brief survey assessed parental attitudes and beliefs regarding antibiotic use and safety at baseline and 6 weeks later with the second mailing. Responses from parents who received the informational brochure showed an attitudinal change in support of judicious antibiotic use, while responses from those in the control group did not.[10]

Providing messages through videos in the clinic waiting room can supplement education to families in the exam room

Employing data gathered by focus group, literature review, and expert opinion, investigators developed a 20 minute educational video about antibiotics and their appropriate use. The video explained viral and bacterial etiologies of common pediatric infections and the differences between them, the reasons antibiotics do not work on viruses, and how inappropriate antibiotic use can lead to resistance. Parents who viewed the video demonstrated increased knowledge

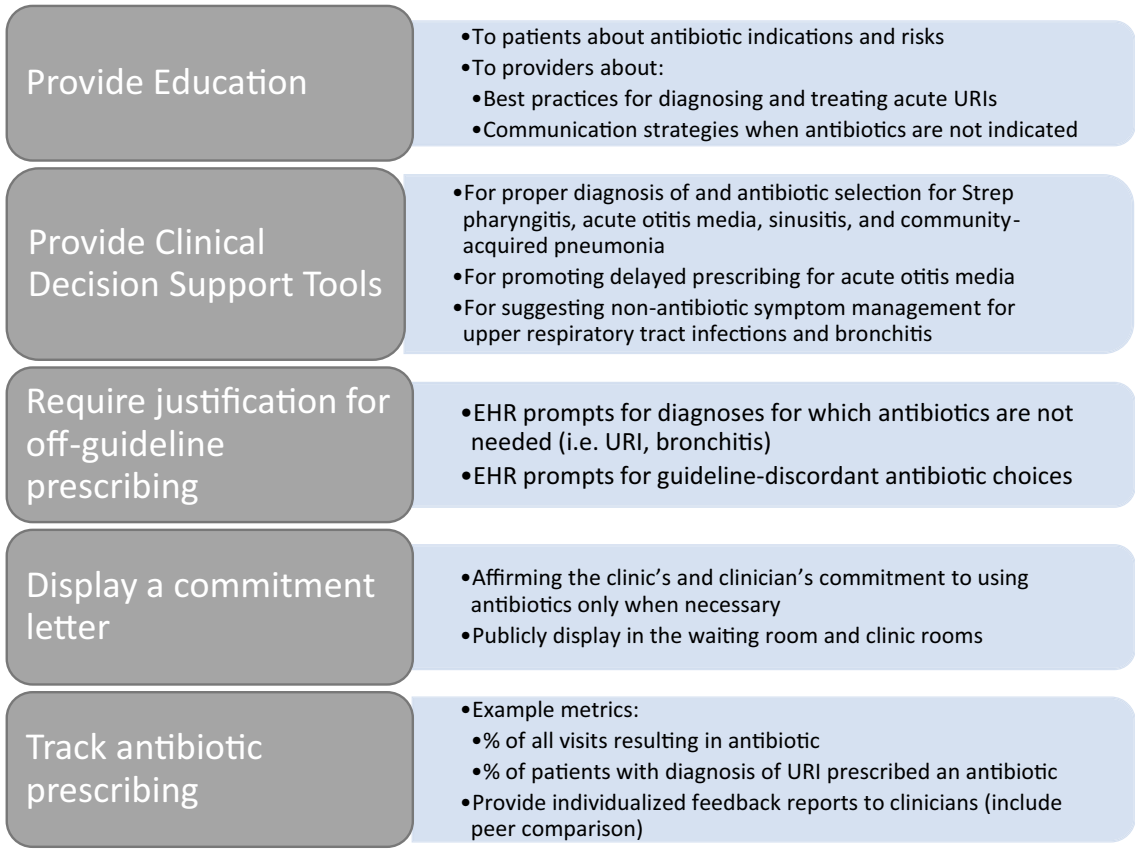

FIG. 2. Summary of interventions for practicing antibiotic stewardship in ambulatory pediatrics.

about antibiotics as assessed by a questionnaire at baseline and at two month follow up, and were significantly more likely to report that there were problems with children receiving too many antibiotics.[11] While the production of a video or comprehensive brochure may be cost prohibitive in many outpatient settings, educational materials regarding the use of antibiotics are freely available and accessible from the CDC,[17] WHO,[18] local health departments, as well as other organizations, and can be used as an important first step in ongoing interventions to improve stewardship.

Both content and communication strategies of messages affect their impact

Educational content should explain the etiology of an infectious condition, treatment options, as well as the associated risks and benefits. For conditions that are likely to be viral, clinicians should explain that antibiotics provide no benefit and can cause harm, and should couple this recommendation with suggestions for symptom management.[13,16] When clinicians combine these messages, patients are more likely to report high satisfaction with their visit.[13]

For bacterial infections for which antibiotics may not be needed, such as acute otitis media with non-severe symptoms in a child $>$ 2 years of age, clinicians should explain that the infection may improve without antibiotics and provide a contingency plan if antibiotics are not prescribed during the visit.[12,13] Patients and patients' caretakers who expected an antibiotic but did not receive one during a visit were more satisfied with their visit when a contingency plan was provided.[12] In the review accompanying this issue entitled "Judicious Antibiotic Prescribing in Ambulatory Pediatrics: Communication is Key", Poole provides an in-depth review of communication strategies and their effectiveness.[19]

Discussions should relay potential harm related to antibiotic treatment

As every medication prescribed has potential side effects, physicians typically provide anticipatory guidance about those possibilities for medications

they prescribe. Antibiotics are no different. Antibiotic-related side effects include diarrhea in 5-25% of individuals,[20] skin reactions in 2%,[21] and anaphylaxis in 1 in 5000 people.[22] Furthermore, a recent pediatric study compared broad vs narrow spectrum antibiotics for the treatment of acute otitis media, GAS pharyngitis, and acute sinusitis. While no difference was found in clinical or patient-centered outcomes, there was a higher rate of adverse events in those treated with broad-spectrum agents.[23] A qualitative study from the CDC explored the potential impact of education about antibiotic adverse drug events (ADEs) on patient and family perceptions and behaviors about antibiotic use. Through surveys and focus groups discussions about the common and severe side effects of antibiotics including diarrhea, rash, *C. difficile* infection, and anaphylaxis, mothers of young children expressed that knowledge about ADEs would heighten their concern and make them more likely to seek antibiotics only when deemed necessary by the physician. Nearly all mothers who participated in this study felt very strongly that information about ADEs should be shared with parents at the time a prescription is provided for their child.[24]

Educating healthcare providers is an essential element of effective multifaceted antibiotic stewardship interventions

In surveys, most providers indicate that they appreciate the importance of judicious antibiotic use and the need for ongoing education to effectively implement antibiotic stewardship.[25] Education alone is rarely sufficient to change prescribing practices,[22] but combining education with other interventions can be highly effective.[26,27] To that end, many published studies involving provider education have taken multifaceted approaches to improve antibiotic prescribing.[27–31] While most of the provider education research has involved prescribers, educating the entire healthcare team including nurses, medical assistants, and office staff could strengthen a practice's commitment to promoting stewardship.

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Education about best practices for specific conditions can improve both diagnosis and management

Since more than 70% of ambulatory pediatric visits for which antibiotics are prescribed are for acute respiratory conditions,[3] most effective educational interventions have targeted viral upper respiratory tract infections, pharyngitis, acute otitis media, and sinusitis. Interventions have focused on improving appropriate diagnosis of these conditions (Streptococcal pharyngitis, sinusitis, otitis media) and improving appropriate treatment (viral upper respiratory tract infection, acute otitis media). Various educational formats have been effective, including face-to-face educational opportunities such as grand rounds style lectures and small group discussions, or passive measures like distribution of educational materials and posting of guidelines in staff areas.[28–31]

"Academic detailing," defined as a one-on-one or small group session providing patient-centered, provider-specific education,[7,32,33] has been used successfully to improve antibiotic stewardship on inpatient services.[32] In a randomized control trial in the outpatient setting, Gjelstad et al utilized academic detailing in combination with individualized prescribing data and peer review to engage general practitioners during their continuing medical education meetings. Academic detailers first delivered educational sessions during which they reviewed national guidelines regarding antibiotic use in acute respiratory infections. Next, prescribing data gathered from clinic visits with codes associated with acute upper respiratory tract infections were provided to the general practitioners. The detailers facilitated group discussions one to two months following the initial educational session by incorporating the prescribing data of individual physicians. During these discussions, the general practitioners presented their own prescribing reports. This strategy proved effective in decreasing off-guideline antibiotic prescribing as well as overall antibiotic prescribing.[33]

Educators should tailor interventions to the specific provider setting, work flow, and practice culture. For

example, Hingorani et al designed and implemented a series of interventions tailored for internal medicine physicians and residents working in an internal medicine outpatient practice at a university affiliated community hospital. The series was developed using quality improvement methodology as part of a plan-do-study-act (PDSA) cycle that allowed the research group to evaluate each intervention before and after they were implemented, to better design and coordinate the next to meet the needs of their physicians and residents. Summaries of CDC antibiotic prescribing guidelines for URIs, sinusitis, and pharyngitis were distributed to providers as the first intervention. The next intervention included an educational session regarding use of antibiotics in acute respiratory infections (ARIs) delivered to residents and faculty as well as the distribution of CDC guidelines regarding ARIs throughout patient exam rooms, staff conference areas, and restrooms. Adherence to overall ARI guidelines increased significantly following the series of interventions.[29]

Combining guideline education with communication training enhances effectiveness

Educational interventions focusing on best practices for common infectious conditions for which antibiotics are frequently prescribed are more effective when combined with communications training. For example, clinicians would convene as part of their continuing education programs to review the latest evidence based guidelines for diagnosing and treating acute respiratory infections, including otitis media. That curriculum would be followed with sessions about motivational interviewing, shared family-physician decision making models, and communication tools.[27,31,32] Communications training can involve ways to better explore patients' concerns and their expectations around antibiotic use, and to better communicate rationale for symptomatic management without antibiotics (resistance, antibiotics can do more harm than good, number needed to treat to benefit).[31] The communications training programs have used role-playing case-based exercises promoting self-reflection,[32] in which clinicians are encouraged to ask questions probing for patient/family central concerns and expectations, followed by opportunities to practice aspects of motivational interviewing.[27] The impact of such combinations can be sustained after the intervention.[31,34]

The combined training programs can be further enhanced by incorporating individualized prescribing feedback. Some training programs have used prescribing feedback to generate discussion about clinician use of antibiotics in comparison to peers and in light of evidence based guidelines. Incorporating individualized prescribing data juxtaposed to those of peers promotes self-reflection and enhances a willingness to change. Showing changes in prescribing patterns frames the abstract concept of stewardship as a tangible problem that individual actions can directly impact.[27,35] These combined training programs have been shown to significantly reduce antibiotic use and overall expenditures.[27]

Clinical algorithms can be a useful tool to increase stewardship

Professional societies including the American Academy of Pediatrics (AAP), the Pediatric Infectious Diseases Society, and the Infectious Diseases Society of America (IDSA) have established national consensus guidelines establishing standardized criteria for the diagnosis and management acute otitis media,[36] sinusitis,[37,38] streptococcal infections,[39,40] and community acquired pneumonia.[41] Institutional adoption of standard guidelines in clinical management has been shown across multiple settings and diagnoses to improve quality of care and patient outcomes.[42–44] Incorporating clinical algorithms based on national consensus guidelines into practice can also curtail excessive antibiotic use. Algorithms or pathways provide guidance on diagnosis, antibiotic choice, and treatment duration. In a primary care network in Colorado, eight clinics were randomized either to usual care or to receive 1 page pathways for use in managing the following common adult and pediatric infections: nonspecific upper respiratory infection, acute bronchitis, acute rhinosinusitis, pharyngitis, acute otitis media, urinary tract infection, skin and soft tissue infections, and community acquired pneumonia (See Fig. 3). Decision trees flowed from initial presentation, to diagnosis, to treatment recommendations. Compared to practices in the control group, practices that employed the algorithms showed a significant reduction in antibiotic prescriptions for acute respiratory infections, and an overall decline in broad-spectrum antibiotic use.[45] In a rural primary care

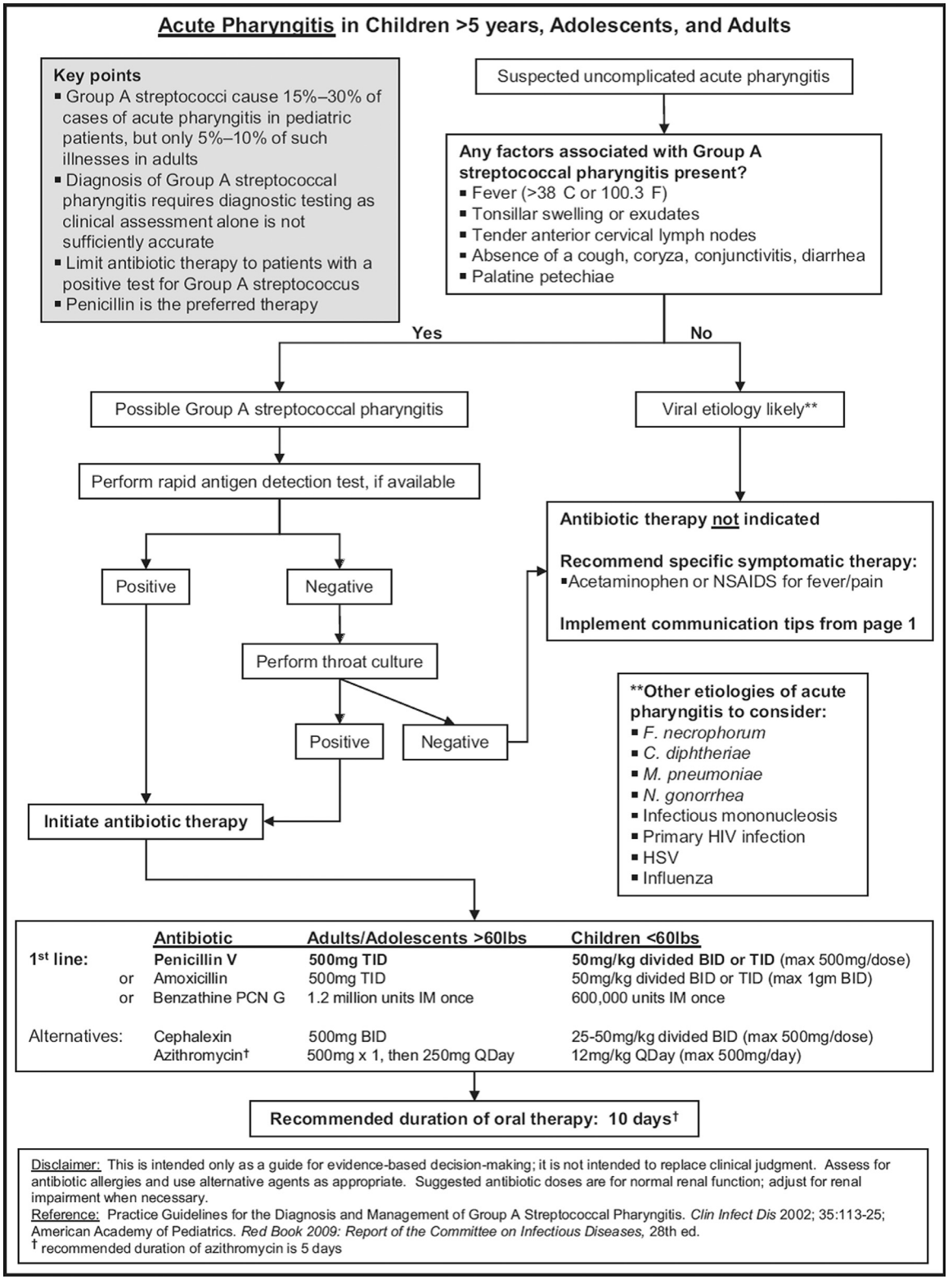

FIG. 3. The acute pharyngitis pathway as used by Jenkins et al. Reprinted with permission from Jenkins TC et al. *Am. J. Med.* **126,** 327–335.e12 (2013).

setting, a large cluster randomized trial found similar results, with a marked decrease in macrolide use in particular. Community-directed interventions were used in conjunction with a series of disease specific algorithms that helped to generate diagnostic and therapeutic recommendations tailored to patient specific information including age, weight, presenting signs and symptoms, and exam findings.[46]

Employing delayed prescribing can decrease unnecessary antibiotic use

The term *delayed prescribing* refers to the practice in which a clinician would provide a patient with a prescription along with instructions to fill the prescription only after a certain period of time or under specific circumstances. This intervention is tailored for joint decision making with patients and families.

Acute otitis media is an ideal diagnosis to apply the practice of delayed prescribing

Acute otitis media (AOM) is the most common diagnosis leading to an antibiotic prescription in pediatrics.[3,5] Spontaneous resolution without antibiotic therapy occurs in 70-90% of patients with AOM.[47] Some providers report choosing to treat AOM with antibiotics for fear of possible complication such as mastoiditis;[48] however, the link between preventing mastoiditis by systematically treating AOM with antibiotics has not been directly established.[49,50] Even assuming that treatment of AOM would prevent mastoiditis, a population study of 2.6 million children in the United Kingdom showed that over 4,000 children with suppurative acute otitis media would need to be treated to avoid one case of mastoiditis.[51] But only 13 children would need to be prescribed an antibiotic course to cause harm to 1 child (including allergy, rash, and other adverse drug events).[21,22,52] If antibiotic-associated diarrhea is included, then only 6 children would need to be treated to cause harm to 1 child.[20] For this reason, the 2013 American Academy of Pediatrics/American Academy of Family Practice clinical practice guideline for AOM recommends a period of observation in cases of non-severe unilateral AOM in children > 6 months and non-severe unilateral or bilateral AOM in children > 2 years of age.[36]

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In an effort to reduce unnecessary antibiotic prescribing for AOM, Siegel et al evaluated children between the ages of 1 and 12 years with uncomplicated AOM whose families were prescribed an antibiotic with instructions to fill only if symptoms worsened or failed to improve within 48 hours of the initial encounter. Families also received a handout regarding treatment and management of AOM, along with analgesics to use at home. One hundred and twenty (69%) of the 175 families who completed the study did not fill the antibiotic prescription.[53] Similar results were found in a study of children aged 2 to 12 years with AOM who were randomized to a period of observation with or without a prescription. The majority of enrolled families did not give their children antibiotics, reducing the total antibiotic use for the population.[54] With AOM representing an estimated healthcare expense of 2 billion dollars in the US in 2013,[55] any reduction in antibiotic use could have significant financial impact as well as the benefits associated with decreased antibiotic exposure. These different interventions yielded similar results even when they were implemented in a variety of ways, suggesting that even with some practice variation, goals of decreased antibiotic utilization can still be met.

Delayed prescribing involves cooperation and planning between provider and family

Strategies for employing delayed prescribing include: having the patient/family contact the clinic after a waiting period, post-dating a prescription (providing a prescription to be filled after a defined waiting period or under certain clinical circumstances), or providing the patient/family with a prescription at the initial contact with specific instructions about when/if to fill it. Patients randomized to four different delayed prescribing interventions ([1] calling the practice for a prescription, [2] providing a post-dated prescription, [3] having the patient physically return to collect a prescription, or [4] providing

a prescription at the time of the initial appointment) had no significant difference in duration and severity of symptoms, overall use of antibiotics, or risk of complications.[56] With delayed prescription practices clinicians are entrusting their patients and families to follow up as needed, and to follow instructions to wait 2-3 days before filling the prescription. Having different options for employing the strategy accounting for practice and family dynamics, can help in obtaining the active engagement and buy-in from patients and families that is key to this intervention. With the increasing use of electronic prescribing in many clinics, incorporating delayed prescribing into practice may pose some challenges. If the electronic prescription system does not allow for specifying the earliest date on the prescription, some strategies in the era of e-prescribing include making a separate note to pharmacy in the e-prescription, using paper prescriptions to facilitate post-dating, or instituting a separate protocol for families to call clinics to request an antibiotic after the waiting period.

Explaining the rationale for not immediately starting antibiotics can aid in successful implementation of delayed prescribing

Pshetizky et al. randomized families from two practices to either receive a prescription for antibiotics as part of routine care for AOM (control group), or to receive a structured explanation and an antibiotic prescription to fill if symptoms did not improve within 48 hours. The script included four points, (1) AOM is part of an upper respiratory tract infection, (2) in most cases children will recover regardless of antibiotic prescription, (3) dangerous late complications from AOM may occur regardless of whether antibiotics are or are not delivered in the course of the acute illness; and (4) in cases of high fever or severe pain acetaminophen may be administered according to the child's weight.[14] Of the families who received the explanation, approximately 33% filled the prescription compared to 67% of the families in the control group.[14]

Delayed prescribing does not affect patient/family satisfaction

Physicians have cited concern for patient/family dissatisfaction as a reason for providing antibiotic prescriptions even when they may not be necessary.[25] In a survey of 150 physicians from various specialties, more than half of respondents stated that they have knowingly prescribed what they felt to be an inappropriate antibiotic for fear of lower patient satisfaction ratings.[57] A Cochrane review examining stewardship practices in the context of acute respiratory infections found that patient satisfaction did not differ between groups who received delayed antibiotics and those who received immediate antibiotics (OR 0.65, 95% CI 0.39 to 1.10).[58] In addition, randomized control trials evaluating patient satisfaction as an outcome of delayed prescribing interventions have found no difference in patient satisfaction scores between patients and families assigned to delayed prescription and those assigned to observation therapy without a prescription.[54]

The electronic health record can integrate antibiotic stewardship into daily practice

Acute respiratory infections have well established clinical practice guidelines which lend themselves to electronic integration.[36,37,41] With most practices in the US today employing electronic health records (EHR),[59,60] building those guidelines into existing systems can facilitate their use by integrating the algorithms into a provider's typical work flow. Clinical decision support (CDS) tools have been used to aid providers in making guideline-concordant diagnostic and treatment decisions based on patient presentation, history, and exam. For example, EHR-based tools have provided prompts for diagnostic criteria in cases of Streptococcal pharyngitis or sinusitis, suggestions for supportive care measures for viral upper respiratory tract infections, analgesics in cases of otitis media, and weight based recommended first-line antibiotics based on the diagnosis entered by the clinician.[29,61–63] Use of these CDS tools increases guideline-concordant antibiotic prescribing and reduces inappropriate antibiotic prescribing.[29,62,63] However, it is important to note that when a CDS tool is not fully integrated into the EHR, clinician use of the tool is low.[61]

Interventions based in behavioral science and behavioral economics, which focuses on how people make decisions, have been integrated into the EHR to nudge clinicians toward appropriate antibiotic prescribing practices

Meeker et al performed a randomized controlled trial comparing strategies borrowed from behavioral

economics to improve appropriate care for patients with upper respiratory tract infections. In the first of these strategies, termed "accountable justification", an antibiotic order would trigger an alert in the EHR if the clinician-entered diagnosis was one for which antibiotics are not indicated (nonspecific upper respiratory tract infection, acute bronchitis, and influenza). When triggered, the EHR would provide a prompt to the clinician to briefly justify the rationale for prescribing an antibiotic for a diagnosis for which antibiotics are not indicated. The justification becomes part of the patient chart. If no justification is entered, the phrase "no justification given" appears in the patient's medical record. Meeker et al showed antibiotic prescribing for antibiotic-inappropriate acute respiratory tract infections declined significantly from 23.2% to 5.2% (P<.001) among the practices that received the accountable justification intervention described above, which was a significantly greater decline than that shown in the control group.[64] This intervention has the potential to cause diagnosis shifting, where the provider may change the treatment diagnosis (i.e. bronchitis to pneumonia) so that they do not have to provide a rationale for prescribing antibiotics. However, investigators analyzed the data specifically looking for this, and did not find any evidence of diagnosis shifting.[64]

This randomized controlled trial showed that accountable justification as well as peer comparison (discussed below) were highly effective in reducing inappropriate antibiotic prescribing for acute respiratory tract infections. This trial also tested a strategy termed "suggested alternatives." In this intervention, the entry of a diagnosis for a nonspecific upper respiratory tract infection, acute bronchitis, or influenza would prompt an alert in the EHR stating "Antibiotics are not generally indicated for [this diagnosis]. Please consider the following prescriptions, treatments, and materials to help your patient," followed by a list of alternative options including analgesics, cough suppressants, and patient information sheets. Among practices randomized to receive this intervention, antibiotic prescribing for antibiotic-inappropriate upper respiratory tract infections declined significantly from 22.1% to 6.1% (P<.001),[64] however the trajectory of this decline was not significantly different from the decline noted in the control group (24.1% to 13.1%). The authors concluded that the one strategy that lacked a social component (suggested alternatives) was not as effective as the two socially motivated interventions (accountable justification and peer comparison).

The commitment letter can be a powerful tool to increase antibiotic stewardship

Public declaration can influence prescribing habits. Borrowing from the field of behavioral economics that has shown public declaration encourages actualization of expressed intentions,[65,66] Meeker et al posted a commitment letter in some exam rooms and waiting areas to provide patients with information about antibiotics and as a public declaration that their physicians are dedicated to avoiding unnecessary antibiotic prescribing. The letter contained information about appropriate indications for antibiotics, the development of resistant bacteria, side effects of antibiotics, and an encouragement to follow their physicians' advice. It closed with the statement "we are

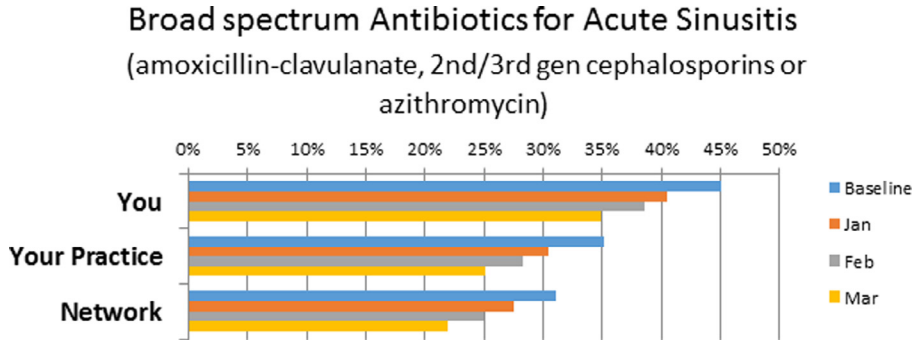

FIG. 4. Example of an antibiotic feedback report providing personal prescribing rates over time in comparison to others in same practice and network. Adapted with permission from Gerber JS et al. *JAMA* **312,** 2569–2570 (2014).

also dedicated to avoid prescribing antibiotics when they are likely to do more harm than good." Physicians in the study intervention group posted the letter along with their photograph and signature in their exam rooms. Antibiotic prescribing for viral upper respiratory tract infections decreased significantly in the intervention group compared to the control group.[67] An example commitment letter is included in Appendix A.

Peer comparison can inspire self-directed actions among physicians to improve stewardship

Behavioral science studies have demonstrated that when individuals are shown data suggesting that they are the outliers of a group, they move to bring their actions back in line with the social norm.[68,69] A randomized controlled study conducted within an affiliated network of 29 pediatric primary care sites in Philadelphia tested the effect of an educational intervention followed by audit and feedback with peer comparison on antibiotic prescribing. Physicians in the intervention group received feedback reports summarizing guideline-concordant antibiotic prescribing rates for viral infections, sinusitis, group A streptococcal pharyngitis, and pneumonia. The feedback reports included prescribing rates of the individual physician, the individual's practice, and the network of enrolled practices (see Fig. 4). The personalized feedback reports were kept private and were delivered every 4 months via secure office e-mail accounts and interoffice mail. Off-guideline prescribing rates decreased significantly in the intervention group. Off-guideline prescribing rates also decreased slightly among the control group of physicians who were aware of the ongoing study but did not receive feedback reports.[70] Importantly, when the feedback reports were no longer utilized the rate of inappropriate antibiotic prescribing returned to pre-intervention levels.[71] Similar studies providing peer comparisons with individualized prescribing reports have been used in several different countries worldwide with significant declines in inappropriate antibiotic prescribing.[33,72,73]

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Hallsworth et al. delivered peer comparisons to providers in the form of a letter addressed from England's Chief Medical Officer.[72] This intervention capitalizes on the idea that information delivered by high profile figures increases its credibility, and thereby its impact on the recipient.[74] Practitioners at participating practices received letters if their group was prescribing antibiotics at a rate higher than 80% of practices in the local area. The letters also contained three specific, feasible actions that could be done to reduce unnecessary prescriptions: giving patients self-care advice, utilizing delayed prescribing and having peer-discussion within the practice about the issue. In clinically relevant terms, researchers noted an estimated 73,406 fewer antibiotic courses prescribed for the intervention group, with an estimated savings of £92,356 for the public.[72] In the US, the insurance company Aetna recently adopted this approach, and began sending letters from their chief medical officer to providers who were noted to be prescribing antibiotics for bronchitis.[75]

To date, personalized feedback about antibiotic prescribing with peer comparisons is the most effective intervention to reduce inappropriate antibiotic prescribing

When compared head to head, the most effective strategy for reducing inappropriate antibiotic prescriptions is providing individualized feedback to clinicians about their antibiotic prescribing practices along with peer comparisons.[64] The enhanced perspective and introspection facilitated by this type of intervention seems to push providers toward guideline and peer concordance. Multiple studies have proven that individualized feedback reports,

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combined with provider education emphasizing best practices for antibiotic prescribing for the conditions being tracked, is effective in reducing inappropriate antibiotic prescribing.[63,70,76–78] However, in one instance, the decrease in inappropriate antibiotic prescribing was not sustained after the feedback reports were discontinued.[70] This does raise the concern that we do not know if there is a "right" amount of time interventions should be in place, or if they should be sustained indefinitely to become part of a culture. Metrics that have been used to provide feedback with peer comparison include: proportion of patients diagnosed with an upper respiratory tract infection who were prescribed an antibiotic; proportion of children diagnosed with Streptococcal pharyngitis who were prescribed an antibiotic other than penicillin or amoxicillin; and proportion of children diagnosed with community-acquired pneumonia who were prescribed an antibiotic other than amoxicillin.[70] Individualized reports provided monthly[64] as well as quarterly[70] (Fig. 3) have been shown to be highly effective in reducing off-guideline antibiotic prescribing.

Physician self-reflection on prescribing practices is a prominent theme in several antibiotic stewardship interventions

This concept underlies education based endeavors which include individual feedback encouraging physicians to examine their own prescribing habits in accordance with guidelines. Communications training incorporating self-reflection allows physicians to analyze their own prescribing patterns and patient interactions to develop as practitioners. In interventions using peer comparison, introspection is encouraged as providers review their own practices against those of colleagues. Regardless of the form stewardship practice undertaken, self-reflection should be included.

Financial compensation and accreditation may become new forces for promoting stewardship

Outside the US financial penalties have been used to change prescribing behavior

A state-sponsored study in China coupled audit and feedback report results with financial penalties for inappropriate antibiotic prescribing. A multidisciplinary antibiotic stewardship committee developed and disseminated local antibiotic guidelines for various pediatric conditions. This committee provided direct communication to physicians about antibiotic prescribing that was not guideline-concordant, as defined by the multidisciplinary committee, and monthly reports summarizing inappropriate antibiotic prescribing were provided to overseeing healthcare administrators. After public notice of a plan to fine physicians who prescribed antibiotics inappropriately, physicians were fined in one of 4 levels in accordance with the number of inappropriate antibiotic prescriptions they wrote. Physicians who received two high-level fines were subject to revocation of prescribing privileges and mandated to attend educational sessions on antibiotic use. A significant decline in antibiotic prescriptions and in antibiotic expenditures followed implementation of the financial intervention.[77] To our knowledge, financial repercussions related to antibiotic prescribing have not been studied or implemented in the US.

Financial incentives can be tied to quality and performance metrics

In April 2016 the National Health Service (NHS) in England began providing additional funding to clinical commissioning groups who reduce the number of antibiotics prescribed in primary care by 4% or down to the average performance level of 2013-2014.[79] The clinician groups also receive additional funds for reducing select broad spectrum antibiotics (amoxicillin-clavulanate, cephalosporins, and fluoroquinolones) to 10% of total antibiotics prescribed. In the US, the shift taken by several third party payors from fee-for-service to value-based contracting models adopts this same concept of incentivizing quality of care.[80–82]

Quality metrics are becoming integrated into reimbursement plans

In the US, physician payment models that depend on practices' performance metrics, including appropriate antibiotic prescribing, are becoming more common. The National Quality Form (NQF) has defined and endorsed a set of quality measures called the Healthcare Effectiveness Data and Information Set (HEDIS) measures. More than 90% of healthcare plans in the US use these metrics to measure performance. The National Committee for Quality Assurance (NCQA) uses HEDIS measures (in part) to: determine annual Health Insurance Plan Ratings for both accredited and non-accredited plans,[83] provide credentialing and accreditation for programs including ambulatory health care

organizations, and provide publicly published "report cards" for individual practices and providers.[84] As of 2018, at least three HEDIS measures directly relate to antibiotic prescribing in ambulatory care: 1) appropriate treatment for children with upper respiratory infection (no antibiotics prescribed), 2) appropriate treatment of adults with bronchitis (no antibiotics prescribed), and 3) appropriate testing for children with pharyngitis.[85] Both public (including the Centers for Medicare & Medicaid Services) and private health care plans have developed value-based care reimbursement protocols that hold providers accountable for meeting HEDIS measures.[86] In addition to affecting a practice's reimbursement, guideline-concordant prescribing and testing contributes to a practice's credentialing and accreditation status.

Summary

Antibiotic stewardship is needed in the pediatric ambulatory setting. Opportunities to implement antibiotic stewardship tools into practice include education to patients and families; education to providers; use of algorithms embedded into clinician work flow; and providing opportunities for clinicians to observe and reflect on comparative data regarding their prescribing practices. Each of the numerous evidence backed interventions reviewed in this article can have a positive effect on antibiotic stewardship and can be customized to fit particular practice styles and needs. Different combinations can function synergistically, and are generally better than any single intervention. The framework provided in this review can be used to start or build upon existing antibiotic stewardship initiatives; moving from paper, to practice.

Appendix A. Sample commitment poster

Antibiotics are Not Always the Answer:

An Important Message from Your Clinicians

Dear Parents,

We want to give you some important information about antibiotics.

Antibiotics only flight infections caused by bacteria.

Antibiotics will NOT help your child feel better if they have a viral infection like:

- Cold or runny nose
- Chest cold
- Flu
- Sore throat not caused by Strep

If you take antibiotics when you do not need them, they can cause more harm than good:

- Your child might feel worse.
- Your child can get diarrhea, rashes, or yeast infections
- Antibiotics may NOT work when you really need them, because antibiotics make bacteria more resistant to them. This can make future infections harder to treat.

What can you do as a parent? Talk to me about the treatment that is best for your child. Follow the treatment plans we discuss

As your clinician, I will give you the best care possible. I am dedicated to avoid prescribing antibiotics when they are likely to do more harm than good. If you have any questions, please ask me, your nurse, or your pharmacist.

Children's National

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