A Baker’s Dozen of Top Antimicrobial Stewardship Intervention Publications in Non–Hospital Care Settings in 2021

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The scope of antimicrobial stewardship programs has expanded beyond the acute hospital setting. The need to optimize antimicrobial use in emergency departments, urgent, primary, and specialty care clinics, nursing homes, and long-term care facilities prompted the development of core elements of stewardship programs in these settings. Identifying the most innovative and well-designed stewardship literature in these novel stewardship areas can be challenging. The Southeastern Research Group Endeavor (SERGE-45) network evaluated antimicrobial stewardship–related, peer-reviewed literature published in 2021 that detailed actionable interventions specific to the nonhospital setting. The top 13 publications were summarized following identification using a modified Delphi technique. This article highlights the selected interventions and may serve as a key resource for expansion of antimicrobial stewardship programs beyond the acute hospital setting.

Keywords. antibiotics; antimicrobial stewardship; emergency department; nursing homes; outpatient.

The original Infectious Diseases Society of America (IDSA) and Society for Healthcare Epidemiology of America (SHEA) antimicrobial stewardship (AS) guidelines were published over 15 years ago [1]. These guidelines focused on the development of successful inpatient antimicrobial stewardship programs (ASPs) as few data at the time were available to inform best practices in other health care settings. The importance of AS beyond the hospital has been evident, with most antimicrobial use (AU), >60% in the United States, occurring in outpatient care settings [2]. Approximately 30% of antibiotics prescribed at outpatient visits are unnecessary, with 50% of those being prescribed inappropriately [2–4]. Similar estimates of inappropriate long-term care antibiotic prescribing are as high as 75% [5, 6]. Prescribing practices in these settings significantly influence antimicrobial resistance (AR) patterns of organisms regardless of patient care location. Non–hospital care AS challenges vary widely, however. For example, the Centers for Disease Control and Prevention (CDC) Core Elements of outpatient ASPs is intended for application to primary and urgent care settings, dental practices, specialty clinics, emergency departments (EDs), and transitions of care (TOC) between settings, while separate guidance supports ASPs in nursing homes (Figure 1) [2, 7]. Similar to early acute hospital ASPs, successful nonhospital AS interventions to date have included provider education, prescribing guidelines, and prescription audit with feedback [8–11]. Outpatient and nursing home ASPs have demonstrated improvements in antimicrobial prescribing; however, lack of enduring and dedicated resources may limit overall impact [12, 13]. In addition to the CDC Core Elements, other national organizations have focused on AS in non–hospital care settings, such as The Joint Commission and the Centers for Medicare & Medicaid Services [14, 15]. While these initiatives represent progress toward improved AS in non–hospital care settings, data detailing specific, actionable, high-quality interventions within these settings are in their infancy and slowly accumulating.
The Southeastern Research Group Endeavor (SERGE-45) has published the top overall AS interventions across all practice settings in recent years [16–21]. SERGE-45 is composed primarily of infectious diseases (ID) and AS clinical pharmacists, representing >50 individual health care institutions across all 13 Southeastern states and Washington DC, supporting a diverse mix of both community and academic medical centers. Each year, the number of AS intervention articles of interest outside of the acute hospital setting has grown, necessitating a separate evaluation of nonhospital interventions. This article highlights selected high-quality AS interventions specific to non–hospital care settings to assist newly formed or growing outpatient and nursing home ASPs in developing strategies to optimize antimicrobial use.

METHODS

Using a modified Delphi technique, members of the SERGE-45 network identified nonhospital AS publications from 2021 considered to be significant using the following inclusion criteria: (1) published in 2021, including electronic, “early-release” publications, and (2) included an actionable intervention [22]. An actionable intervention was defined as an AS strategy that was implemented in practice and resulted in measurable outcomes. Clinical practice guidelines, preprints, official statements, review articles, and articles without an actionable intervention were excluded.

A PubMed search using “antimicrobial stewardship” for 2021 revealed 1740 potential publications. Abstracts were screened to ensure that all relevant articles were considered, that electronic publications before 2021 were removed, and publications were appropriately stratified between acute hospital and non–hospital care settings. Thirty-seven nonhospital publications were submitted by the network, and those meeting criteria and not identified previously were also included for consideration. A total of 50 articles were distributed to the SERGE-45 network for ranking via a REDCap survey of the top 13 articles based on contribution and/or application to ASPs [23]. Follow-up email reminders were sent to encourage participation in the voting process. Of note, no conflict of interest disclosure was required of participating voters.

Of the 84 network members at the time of the survey, 27 rank lists (32% participation) were submitted. The group ranks were reviewed by C.M.B., P.B.B., A.H.M., and S.B.G. via teleconference. This group reviewed articles with the same ranking based on inclusion criteria and diversity of topics included, and a final consensus on the top 13 articles was established. Included articles are presented in the discussion in a random order and are not ranked according to placement. Figure 2 is a flowsheet of the article selection process, and Table 1 provides a summary of the selected articles.

RESULTS

Peer Feedback for Respiratory Tract Infection Prescribing in Primary Care

Inappropriate antibiotic prescribing for respiratory tract infections (RTIs) is common in primary care [37]. Dutcher and colleagues evaluated the impact of an education and feedback–based intervention to improve prescribing for respiratory tract diagnoses (RTDs) [24]. The first phase of the intervention consisted of an educational session on appropriate prescribing for common RTIs and effective patient communication strategies, particularly for when not prescribing an antibiotic. The second component consisted of monthly email reports of individual and peer comparison feedback on antibiotic prescribing for all RTDs and Tier 3 RTDs. Tier 1 and 2 diagnoses were defined as those for which an antibiotic is always and may be indicated,
respectively, while Tier 3 diagnoses included those for which an antibiotic is rarely indicated.

The study assessed 185,755 unique office visits for RTDs across 30 primary care offices in the University of Pennsylvania Healthcare System from July 2016 to October 2018. Overall antibiotic prescribing decreased in the postintervention period (35.2%–23.0%; \( P < .001 \)), driven by decreases in antibiotic prescribing for Tier 2 and Tier 3 RTDs. This study demonstrates that an education and feedback–based intervention can significantly reduce overall antibiotic prescribing for RTDs without affecting the prescribing of RTIs in which antibiotics are always indicated.

**Antimicrobial Stewardship at Hospital Discharge**

Improvements in antimicrobial prescribing are needed at TOC [38–41]. Hospital ASPs are uniquely poised to impact antimicrobial prescribing at discharge; however, discharge prescribing is infrequently addressed by inpatient AS teams [3, 4, 37]. Parsels and colleagues evaluated the impact of infectious diseases (ID) pharmacist review of discharge prescriptions on drug-related problems (DRPs) [25].

A total of 803 discharge prescriptions were reviewed, most completed in <15 minutes (87.9%). The most common antimicrobial indications were prophylaxis (20.9%), skin and soft tissue infection (19.8%), cystitis/pyelonephritis (14.9%), and intra-abdominal infection (14.9%), and the medication was prescribed by adult medicine (58%) and general pediatric (15.2%) services. The most common DRPs were inappropriate duration (35.9%), typically due to excessive durations of therapy (88.4%). Upon acceptance of recommendations to reduce duration, the median number of antimicrobial days decreased from 8 to 4 (\( P < .001 \)). This study demonstrated benefits of review of antimicrobial prescribing at time of discharge, but outpatient pharmacy infrastructure and adequate resources may limit its generalizability. Notably, hospital readmissions were not assessed.

**Education and Data Feedback for Outpatient Urinary Tract Infections**

Urinary tract infections (UTIs) are the most diagnosed infection in the outpatient setting [12, 42]. Funaro and colleagues
Table 1. Summary of Top 13 Antimicrobial Stewardship Intervention Papers in the Nonhospital Setting, 2021

| Study Citation                                                                 | Study Design                                                                 | Intervention Summary                                                                 | Primary and Key Secondary Outcomes                                                                                                                                                                                                 |
|-------------------------------------------------------------------------------|------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Improving Outpatient Antibiotic Prescribing for Respiratory Tract Infections in Primary Care: A Stepped-Wedge Cluster Randomized Trial. Dutcher et al. [24] | Stepped-wedge cluster randomized trial evaluating the impact of an education and feedback–based intervention to improve prescribing for RTIs | Educational session on RTI prescribing and patient communication strategies, followed by monthly electronic individual and peer comparison feedback                                                                                     | Primary outcome:  
- Overall antibiotic prescribing was reduced from 35.2% to 23.0% ($P < .001$)  
- Decreased odds of antibiotic prescribing by univariate analysis (OR, 0.47; 95% CI, 0.45–0.48)  
- Decreased odds of antibiotic prescription for Tier 2 (OR, 0.57; 95% CI, 0.52–0.62) and 3 (OR, 0.57; 95% CI, 0.53–0.61) but not for Tier 1 (OR, 0.98; 95% CI, 0.83–1.16) in multivariate analysis  |

Hospital Discharge: An Opportune Time for Antimicrobial Stewardship. Parsels et al. [25] | Retrospective, descriptive, single-center study evaluating impact of ID pharmacist review of discharge prescriptions on DRPs | Oral, discharge antimicrobial prescriptions sent to the hospital’s outpatient pharmacy were reviewed for appropriateness by an ID pharmacist                                                                                                            | Primary outcome:  
- ≥ 1 DRP identified in 43.1% of prescriptions  
- Most common DRP was inappropriate duration (35.9%)  
- 42.8% of discharge prescriptions required at least 1 intervention; 75.6% acceptance rate  
- 4-reduction in antimicrobial days (8 vs 4; $P < .001$)  |

Impact of Education and Data Feedback on Guideline-Concordant Prescribing for Urinary Tract Infections in the Outpatient Setting. Funaro et al. [26] | 2-phase, prospective, quasi-experimental study evaluating impact of a multifaceted AS intervention on guideline-concordant antibiotic prescribing for UTIs in an urgent care clinic and a primary care clinic | Phase I: development of clinic-specific antibiogram and guideline, education  
Phase II: education, provision of provider- and clinic-specific feedback                                                                                           | Primary outcome:  
- Guideline-concordant prescribing increased by 22% after Phase I, with 0.5% decrease every 2 wk thereafter  
- Phase II stabilized guideline-concordant prescribing  
Secondary outcomes:  
- UTI diagnoses decreased 21% after Phase I (RR, 0.79; 95% CI, 0.67–0.93)  
- 52.1% relative reduction in fluoroquinolone use  
- Encounters meeting 4-factor guideline concordance increased from 19% to 23.2% and 28% in Phase I and Phase II, respectively  
- Low rates of treatment failure and adverse effects  |

Retrospective Assessment of Antimicrobial Stewardship Initiative in Outpatient Use of Ertapenem for Uncomplicated Extended Spectrum Beta Lactamase Enterobacteriaceae Urinary Tract Infections. Wong et al. [27] | Quasi-experimental study assessing a stewardship initiative for outpatient usage of ertapenem or aminoglycosides for ESBL UTIs | Intervention consisted of interdisciplinary education for prescribers to enhance adherence to formulary restriction of ertapenem and encourage consideration of aminoglycosides as an alternative                                                                 | Primary outcome:  
- No difference in recurrent UTIs ($P = .57$) or adverse effects in either treatment group  
Secondary outcomes:  
- Ertapenem utilization decreased from 0.145 DOT/1000 APD to 0.0078 DOT/10 000 APD ($P < .01$)  
- Mean monthly ertapenem DOT declined 19% between the pre- and postintervention periods ($P < .01$)  |

Implementation of Veterans Affairs Primary Care Antimicrobial Stewardship Interventions for Asymptomatic Bacteruria and Acute Respiratory Infections. Mortrude et al. [28] | Stepped-wedge trial evaluating the impact of multifaceted educational interventions on antibiotic prescribing for RTIs and ASB in 5 Veterans Affairs primary care clinics | Multifaceted ASP intervention including provider scorecard, peer comparisons, clinical decision support, patient-facing resources, and educational sessions to promote improvements in antimicrobial prescribing in RTIs and ASB | Primary outcome:  
- No difference in overall antibiotic prescription rate as a composite of prescriptions for RTIs and ASB (56% vs 49%)  
Secondary outcomes:  
- No difference in antibiotic prescription rate for ASB (3% vs 2%)  
- Decrease in antibiotic prescription rate for acute bronchitis (21% vs 13%; $P = .0003$)  
- No difference in antibiotic prescription rate for upper respiratory infections (9% vs 6%), uncomplicated sinusitis (17% vs 22%), uncomplicated pharyngitis (5% vs 5%)  
- No difference in the composite safety outcomes of related health care visits within 4 wk (9% vs 9%)  
- Improvement in appropriateness of prescriptions overall (2% vs 10%; $P = .0004$), uncomplicated sinusitis (OR, 4.96; 95% CI, 1.79–13.75; $P = .0021$), and uncomplicated pharyngitis (OR, 5.36; 95% CI, 1.93–14.90; $P = .0013$)  
- No difference in patient satisfaction scores (91/100 vs 89/100)
### Table 1. Continued

| Study Citation | Study Design | Intervention Summary | Primary and Key Secondary Outcomes |
|----------------|--------------|----------------------|------------------------------------|
| **Effectiveness of a Tailored Intervention to Reduce Antibiotics for Urinary Tract Infections in Nursing Home Residents: A Cluster, Randomised Controlled Trial.** Arnold et al. [29] | Open-label, parallel-group, cluster randomized controlled trial evaluating a tailored intervention on UTIs in 22 nursing homes | Interactive 75-min educational sessions were conducted for nursing staff on how to distinguish between UTIs and ASB, how to evaluate symptoms, and how to use the dialogue tool. A dialogue tool was provided for nursing staff and included a reflection tool based on the Loeb minimum criteria for ordering a urinary culture and questions for staff to reflect on the next step as well as a communication tool based on the ISBAR concept for diagnosing UTIs in nursing homes | **Primary outcome:**  
- Decrease in the number of antibiotic prescriptions for UTIs (134 vs 228), resulting in an adjusted RR of 0.42 (95% CI, 0.31–0.57)  
**Secondary outcomes:**  
- No change in the number of appropriate antibiotic treatments for UTIs (22 vs 24), resulting in an adjusted RR of 0.65 (95% CI, 0.41–1.06)  
- Decrease in the number of inappropriate antibiotic treatments for UTIs (32 vs 62), resulting in an adjusted RR of 0.33 (95% CI, 0.23–0.49)  
- A trend toward an increase in all-cause hospitalizations (246 vs 175), resulting in an adjusted RR of 1.28 (95% CI, 0.95–1.74)  
- No change in all-cause mortality (79 vs 75), resulting in an adjusted RR of 0.91 (95% CI, 0.62–1.33) |
| **Improving Delayed Antibiotic Prescribing for Acute Otitis Media.** Frost et al. [30] | Multisite, quasi-experimental, before-and-after intervention study evaluating the impact of a bundled antimicrobial stewardship intervention on rates of delayed prescribing for AOM | Practice sites received monthly education plus audit and feedback as well as access to online resources and content expertise, and monthly site-specific PDSA cycles were completed | **Primary outcomes:**  
- Percentage of delayed antibiotic prescriptions increased from 2% to 21% (RRR, 8.96; 95% CI, 4.68–17.17)  
- Improved rates of delayed antibiotic prescriptions were sustainable up to 6 mo (RRR, 6.69; 95% CI, 3.53–12.65)  
- 100% of practice site champions reported improved confidence in the use of QI methods and using PDSA cycles to implement change  
- Study participants highly valued the ability to earn CE credit from education, access to content expertise, and receipt of monthly data reports |
| **A Pragmatic Randomized Trial of a Primary Care Antimicrobial Stewardship Intervention in Ontario, Canada.** McIsaac et al. [31] | Pragmatic, randomized trial evaluating a primary care provider–focused antimicrobial stewardship intervention | A multifaceted initiative including an initial 1-hour educational session, provider education modules, clinical decision aids, patient information leaflets, local clinic ASP support, and financial incentives for providers aimed at reducing antimicrobial prescribing in 5 target disease states | **Primary outcomes:**  
- No difference in overall antibiotic prescribing between intervention and control clinics  
- 22% reduction in odds of antibiotic prescribing at intervention when adjusted for clinic differences  
**Secondary outcomes:**  
- Proportion of prescriptions issued as delayed antibiotic prescriptions increased in the intervention group 22.1% compared with 11.7% (P < .01)  
- Prescriptions for >7 d were reduced in the intervention group 21.3% compared with 29.3% (P < .0001)  
- First-line antibiotic of choice was higher in the intervention group (92.2% and 84.9%, respectively) |
| **Impact of Pharmacist-Led Selective Audit and Feedback to Reduce Antibiotic Prescribing for UTIs and SSTIs.** Choi et al. [32] | Retrospective, quasi-experimental, before-and-after intervention study comparing appropriateness of antibiotic prescribing for UTIs and SSTIs at 2 outpatient clinics | An ambulatory care, pharmacist-led feedback and audit of antibiotics prescribed for UTIs and SSTIs were performed every 2 weeks at an internal medicine and family medicine clinic | **Primary outcome:**  
- Appropriateness composite (selection, dose, duration, and therapy indication per institutional empiric therapy guidelines): 27.5% vs 50.5% (P < .0001)  
**Secondary outcomes:**  
- ADR: 2% vs 2% (P = .736)  
- CDI: 0% vs 0% (P > .999)  
- Clinic revisit at 7 d: 12% vs 22% (P = .005)  
- Hospitalization at 30 d: 1% vs 0% (P = .248) |
| **Population-Wide Peer Comparison Audit and Feedback to Reduce Antibiotic Initiation and Duration in Long-Term Care Facilities with Embedded Randomized Controlled Trial.** Daneman et al. [33] | DD antibiotic utilization study on peer comparison audit and feedback for prescriptions in all long-term care facilities in Ontario | Peer comparison antibiotic prescribing metrics, including the percentage of initiated antibiotics and antibiotic durations over 7 d, were reported quarterly on a volunteer | **Primary outcome:**  
- DD analysis on average of quarterly proportion of residents initiated on antibiotics (0.10%; 95% CI, −0.51 to 0.67%; P = .735)  
- DD analysis on average of quarterly proportion of residents on antibiotic duration >7 d (−2.65%; 95% CI, −4.93% to −0.28%; |
conducted a 2-phase, prospective, quasi-experimental study examining the impact of a multifaceted AS intervention on guideline-concordant antibiotic prescribing (GCAP) for UTIs in 2 outpatient clinics [26]. Phase I included provision of clinic-specific antibiograms, guidelines, and education. Phase II included education and provision of clinic- and provider-specific feedback. Patients were identified via diagnosis codes of acute cystitis or pyelonephritis. Patients were excluded if they experienced recurrent UTIs, received antibiotics within 30 days of diagnosis, reported allergies to guideline-preferred antibiotics and on family practice residents in LTC facilities.
therapies (GPTs), presented with concomitant infection warranting antibiotics, warranted treatment of asymptomatic bacteriuria (ASB), or demonstrated culture results within 1 year that were resistant to all GPTs.

In Phase I, a 21.8% increase in GCAP occurred; this subsequently diminished by 0.5% per 2-week period postintervention. GCAP stabilized upon provision of feedback in Phase II. A decrease in diagnosis of UTIs was observed. Overall, there was a 52.1% relative reduction in fluoroquinolone use. Of note, there were low rates of treatment failure with GCAP. Inappropriate duration was the most common reason for guideline divergence. This study demonstrated that multifaceted AS in the outpatient setting can increase GCAP while limiting use of high-risk agents. However, implementation of 2-phase interventions may not be feasible at certain institutions.

Ertapenem Outpatient Parenteral Antibiotic Therapy Reduction Initiative
Ertapenem is frequently selected as an outpatient treatment agent due to its relative ease of administration [43, 44]. However, overuse of ertapenem can lead to carbapenem resistance [45]. Therefore, Wong and colleagues conducted a quasi-experimental study in adult female patients prescribed either ertapenem or an aminoglycoside for uncomplicated UTIs caused by extended-spectrum beta-lactamase (ESBL)–producing organisms in the outpatient parenteral antibiotic therapy (OPAT) setting [27].

A total of 183 patients were enrolled, with 101 in the preintervention group vs 83 in the postintervention group. The 90-day intervention period consisted of interdisciplinary educational presentations given to hospitalists, emergency medicine/urgent care physicians, intensivists, and pharmacists. The core strategy of the implementation, driven by pharmacists, included 3 items: (1) prospective audit and feedback, (2) formulary restriction/preauthorization, (3) clinical decision support for ASB. The goal was to assess the need for treatment and consider use of aminoglycosides when appropriate. The primary outcome of recurrent UTIs occurred in 28% treated with ertapenem vs 18% treated with aminoglycosides (P = .57). Acute kidney injury was not reported in any aminoglycoside-treated patients, and adverse effects did not differ between groups (P = .99). Additionally, monthly ertapenem DOT declined by 19% between the pre- and postintervention groups (P < .01). This study demonstrated that an AS intervention for UTIs in the OPAT setting can lead to reduced utilization of ertapenem without an effect on recurrent UTIs; there was reassuringly no observed increase in aminoglycoside-resistant isolates.

Educational Interventions for Common Bacterial Infections in Primary Care
Inappropriate antibiotic prescribing in the outpatient setting for treatment of RTIs and ASB has been associated with increases in both antibiotic expenditure and subsequent resistance [2, 46]. Mortrude and colleagues conducted a stepped-wedge trial to evaluate the impact of multifaceted educational interventions targeting providers on antibiotic prescribing for RTIs and ASB in 5 Veteran Affairs primary care clinics [28]. Individualized report cards featuring peer prescribing comparisons, pocket cards with local prescribing guidelines, symptomatic relief prescription pads, clinical decision support order sets, and local ASP patient brochures were implemented. Additionally, in-person educational sessions focused on guideline recommendations for antibiotic utilization, local antibiograms, and ASP resources were provided.

A total of 405 and 482 patients were included pre- and postintervention, respectively. There was no difference in the overall antibiotic prescription rate. However, decreases in prescriptions for acute bronchitis and improvements in the overall appropriateness of prescriptions, driven primarily by uncomplicated sinusitis and pharyngitis, were noted. The composite safety outcome of hospitalization, ED visit, or primary care visit within 4 weeks did not differ between groups. Lastly, patient satisfaction scores remained the same. This study showed that multifaceted educational interventions can improve antibiotic prescribing for acute bronchitis, which rarely requires antibiotics, in primary care clinics without adversely impacting related health care visits or patient satisfaction. Limitations include the retrospective study design and potential Hawthorne effect as providers were aware that their prescribing patterns were being monitored.

Nurse Education for Urinary Tract Infections in Long-term Care
Antibiotics are commonly prescribed inappropriately to treat ASB and UTIs in the LTC setting [7, 46]. Arnold and colleagues conducted an open-label, parallel-group, cluster randomized controlled trial to evaluate the impact of an educational intervention targeting nursing staff on antibiotic prescribing for UTIs in 22 nursing homes in Denmark [29].

In this study, a total of 11 nursing homes received interactive educational sessions and a dialogue tool for decision support, while 11 nursing homes continued standard practice. The primary outcome was the number of antibiotic prescriptions for UTIs per resident per days at risk, which were defined as the number of days the resident spent at the nursing home during the trial period. A total of 765 residents (84 035 days) and 705 residents (77 817 days) were assessed for the primary outcome for the intervention and control groups, respectively. There was a substantial decrease in the number of antibiotic prescriptions for UTIs per resident per days at risk in the number of inappropriate antibiotic treatments for UTIs for the intervention group. However, there was no change in the number of appropriate antibiotic treatments for UTIs. While there was a trend toward an increase in all-cause hospitalizations in the intervention group, there was no change in all-cause mortality. This study showed that a nurse-driven intervention can decrease antibiotic prescribing and inappropriate treatments for UTIs in
nursing homes without significantly increasing all-cause hospitalizations and mortality. Limitations include the study location, which may limit the external validity of the study, the open-label design, which could have resulted in ascertainment bias, and the convenience sampling and voluntary participation of nursing homes.

**Delayed Antibiotic Prescribing for Acute Otitis Media**

Delayed antibiotic prescribing involves providing a prescription to fill in the event that symptoms worsen or fail to improve after 48–72 hours. This strategy is recommended for select patients with acute otitis media (AOM), including those 6 months older with mild to moderate unilateral AOM [47]. Frost and colleagues performed a multisite, quasi-experimental, before-and-after intervention study evaluating the impact of bundled antimicrobial stewardship intervention on rates of delayed prescribing for AOM [30].

The bundled AS intervention included monthly education plus audit and feedback as well as access to online resources and content expertise. Practice site champions received guidance on suggested stewardship strategies, but they could tailor their approaches according to practice needs. After the 6-month intervention period, access to online resources and content expertise continued, but monthly education plus audit and feedback was stopped. The most commonly utilized stewardship strategies across all practices included provider and patient education, tracking rates of delayed prescribing, and reporting provider-level data to practitioners.

Delayed antibiotic prescriptions for AOM increased from 2% at baseline to 21% at intervention end. This improvement was sustainable up to 6 months postintervention. From this project, a free, publicly available resource package was developed to assist other practices with improving outpatient antibiotic prescribing for children [48]. Delayed antibiotic prescribing may reduce antibiotic use for AOM, but further research should investigate how often these prescriptions are filled. Overall, this study highlights a low-cost intervention to increase rates of delayed antibiotic prescribing for AOM across a diversity of settings.

**Primary Care Provider Education Modules**

Canada has shown minimal improvement in outpatient antibiotic prescribing over the past 10 years despite early ASP efforts, reporting 666 prescriptions dispensed per 1000 patient visits in 2012 compared with 658 prescriptions per 1000 patient visits in 2017 [49]. McIsaac and colleagues enrolled 6 Ontario-based family medicine clinics in a pragmatic, controlled trial of a primary care provider–focused AS initiative [31].

After an initial educational session on AS, resistance, and strategies for reducing antibiotic prescribing, providers were asked to complete education modules related to the 5 targeted disease states: RTIs, tonsillitis, pharyngitis, acute bronchitis, and acute uncomplicated cystitis. Additionally, providers were given clinical decision aids, patient information leaflets, local clinic ASP support, and financial incentives to support appropriate antimicrobial prescribing. At the end of the 5-month study period, there was no difference in overall antibiotic prescribing between control and intervention clinics. However, the number of delayed antibiotic prescriptions increased, and antibiotic prescriptions for durations >7 days decreased. Study limitations included lack of participation by all clinic providers at intervention clinics and heterogeneity among study clinics.

**Ambulatory Care Pharmacist Prescription Audit and Feedback**

Similar to inpatient ASPs, antibiotic prescription audit and feedback are recommended as core elements of outpatient ASPs [2]. Inpatient ASPs usually involve an infectious disease pharmacist or physician for these activities. However, ambulatory care pharmacists (ACPs) are uniquely situated to support this intervention at outpatient clinics.

Choi and colleagues performed a quasi-experimental, retrospective study at 2 primary care offices focusing on the ACP-led feedback and audit of antibiotic prescriptions [32]. Adults with documented International Classification of Diseases, Tenth Revision, codes for UTIs or skin and soft tissue infections (SSTIs) were included in the study. The ASP team provided education to providers and were available for consultation to the ACPs during the postintervention period. The ACPs provided audit and feedback to providers once every 2 weeks during that period.

The study’s primary outcome was comparing antibiotic appropriateness before and after the process was implemented, defined as a composite of appropriate drug, dose, duration, and following local empiric therapy guidelines. There was a statistically significant increase in antibiotic appropriateness in the postintervention group. No differences in the secondary outcomes were found regarding rates of adverse drug reactions (ADRs), treatment failure, hospitalization within 30 days, or *Clostridium difficile* infections. This study shows that even limited resources can have major impacts on antimicrobial prescribing in outpatient settings.

**Peer Comparison via Antimicrobial Utilization Reporting in Long-term Care**

Residents in LTC facilities are at greater risk for infection and antibiotic-associated adverse effects as compared with other health care settings, and according to some studies, the majority of antibiotic prescribing is inappropriate [5, 6, 50]. To improve prescription practices, Daneman and colleagues added 2 antibiotic variables, including the percentage of residents started on antibiotics and antibiotic prescriptions with a duration >7 days, to a province-wide, voluntary reporting system for quarterly peer comparison audit and feedback [33]. The authors included a randomized controlled trial component within the reporting system through comparing an online dynamic reporting system with the previously mentioned static method. Outcomes were compared...
between residents treated by physicians enrolled and not enrolled in the quarterly reports. A difference-in-differences (DD) analysis was utilized to compare prescription outcomes between the 4 quarters of the pre-intervention year (2018) with those of the intervention year (2019).

The DD analysis did not find a significant decline in antibiotic initiation, but did show a decline of 2.65% in extended antibiotic prescriptions associated with the audit and feedback. The authors estimated that the intervention reduced total antibiotic use by 335 912 days in 2019. Despite being limited by selection bias due to the voluntary enrollment of the reporting system and by practicality—as not all health care systems have similar large-scale reporting systems available—the use of peer comparison audit and feedback was shown to improve antibiotic prescribing practices in a complicated patient population.

**Drug Recovery Assistance and Outpatient Parenteral Antibiotic Therapy**

Management of serious bacterial infections in people who inject drugs (PWID) is complicated by concerns with utilizing OPAT. Gelman and colleagues describe a novel approach to managing drug recovery assistance and outpatient parenteral antibiotic therapy (DRA-OPAT) for PWID [34]. They established a multidisciplinary Comprehensive Care of Drug Addiction and Infection (CCDAI) team including an ID physician, hospitalist, psychiatrist, case manager, ID pharmacist, home health care nurse, and a representative from the partner detoxification facility. The CCDAI team met weekly to review management of infections in PWID and determine eligibility for patients to transfer to the detoxification facility for combined DRA-OPAT. Medications for opioid use disorder (MOUD) were offered during hospitalization when appropriate. The hospital system subsidized detoxification facility costs for the DRA-OPAT program.

Over a 1-year period, the team identified 87 patients as DRA-OPAT candidates. Thirty-five patients (40.2%) were successfully enrolled in the DRA-OPAT program. Of these 35 patients, 16 (45.7%) were able to complete the full course of OPAT. Medications for opioid use disorder were associated with successful OPAT completion. When compared with a historical cohort, there were observed reductions in median length of stay and median cost per patient. A limitation of this study is the difficulty in establishing a partnership with an outpatient drug recovery facility that will accommodate OPAT and enrolling all multidisciplinary stakeholders in the CCDAI team. Elements of this integrated program may be useful in management of infections in PWID, such as early provision of MOUD and hospital sponsorship of drug recovery facility costs for patients.

**Text Messaging to Maintain Urinary Tract Infection Stewardship Efforts in the Emergency Department**

In the ED, an estimated 15.7% of patients are discharged home with an antibiotic [51]. Zalmanovich and colleagues conducted a quasi-experimental before-and-after study to compare adherence to a UTI treatment protocol for patients discharged from the ED [35]. The primary objective was to improve overall adherence to the treatment protocol, with a specific focus on antibiotic selection and treatment duration; a secondary objective was to decrease fluoroquinolone prescribing.

The study design involved 3 different time periods: a 3-month pre-intervention period; a 3-month intensive intervention period, which involved disseminating guidelines, providing short lectures, incorporating order sets into the electronic ED charting system, and providing weekly personal audit and feedback; and an 11-month “booster” period in which monthly text messages of the treatment protocol were sent to ED providers. Adherence to the protocol was compared between the pre-intervention period and the last 2 months of the intensive intervention period, and compared with the last 2 months of the booster period. A total of 427 patients were included: 177 in the pre-intervention period, 156 in the intensive period, and 94 in the booster period. Adherence to the overall treatment protocol, selection of the appropriate antimicrobial agent, and appropriate treatment duration all increased significantly between the pre-intervention and intensive intervention periods and remained significantly increased in the booster period. Fluoroquinolone prescriptions also significantly decreased in the intensive and booster periods. Overall, this study supports that an ASP in the ED results in improved adherence to treatment protocols and uniquely demonstrates that a targeted monthly reminder can preserve the effects of the intervention over a prolonged period of time.

**Rapid Patient Education to Reduce Antibiotic Expectations for Respiratory Tract Infections**

Perera and colleagues evaluated the impact of providing a short, electronic tablet–based presentation about antibiotic treatment of upper RTIs on patients’ expectations for antibiotics and subsequent antibiotic prescribing behavior [36]. Patients were randomized to view a 1-minute presentation immediately before their consultation highlighting either (1) the futility of antibiotics for upper RTIs, (2) potential adverse effects of antibiotics, or (3) healthy lifestyle choices (active control). Before and after the presentations, patients utilized a Likert scale to rate the strength of their belief that antibiotics are effective for treating upper RTIs and their desire to be prescribed an antibiotic.

Postpresentation, participants had a significant reduction in expectation to receive an antibiotic in those who viewed the futility and adverse effects presentations when compared with the control group. Additionally, there was a significant reduction in Likert scores for those who before consultation had agreed with the statement “I think antibiotics are a helpful treatment for cold/flu” in the futility presentation and adverse effect presentation groups than in those who viewed the control presentation.
However, there were no significant reductions in antibiotic prescribing, dispensing, or patient satisfaction. Overall, this study highlights an innovative approach to providing education that was well received and impactful to patients; however, we must also intervene upon prescriber practices as well. All stakeholders require engagement to affect sustainable change.

**DISCUSSION**

The majority of ASP interventions have been evaluated in inpatient settings, despite the vast majority of antimicrobial prescriptions being written and ultimately dispensed to patients in non-hospital settings [4]. Now that regulatory agencies require ASPs outside of acute care hospitals, data are emerging to inform ASP practice in these settings. Numerous research interventions have directed management of UTIs and RTIs [24, 26–29, 32, 35, 36]. This is not surprising considering that these are 2 of the top infectious syndromes for which excessive antimicrobial prescribing occurs, often due to colonization, lack of true infection (ASB), or viral etiology (upper RTIs). Interventions to improve prescribing within these diseases included education and feedback, specific guidelines and order sets, antibiogram development, and de-escalation of carbapenem usage for patients with UTIs. Some creative educational measures including text messages with protocol reminders and patient-facing rapid education videos were included [35, 36]. Interventions at the time of discharge also led to significant shortening of duration of therapy [25].

Higher-quality data will continue to help establish and grow robust non-hospital ASPs. As ASPs continue to mature in outpatient and nursing home settings, a focus on a greater variety of infectious diseases as well as technological interventions and implementation would be welcome.

**Acknowledgments**

**Author contributions.** C.M.B., P.B.B., A.H.M., and S.B.G. all supported idea and content development. All authors provided written content and edits for the manuscript.

**Disclaimer.** The views and opinions expressed in this paper represent those of the authors and do not necessarily reflect the position or policy of any previous, current, or potential future employer.

**Patient consent.** This study does not contain factors necessitating patient consent.

**Financial support.** Financial support for publication fees for this article was secured via a South Carolina Office of Rural Health Grant.

**Potential conflicts of interest.** All authors: no reported conflicts of interest. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

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