CHAPTER 5: SUPPLEMENTAL MATERIAL

These materials were compiled by CDPH to supplement the References Section of the IDPH Antibiotic Stewardship Toolkit.

Included:

1. **Additional Information: IDPH and CDPH Links**
   Links to Illinois Department of Public Health and Chicago Department of Public Health websites. Here you can find digital versions of guidance documents, tools, and templates for developing an Outpatient Antimicrobial Stewardship Program.
2. **Article: An Evaluation of Dental Antibiotic Prescribing Practices in the United States (2017)**
   Underlines the importance of having evidence-based antibiotic references readily available during patient visits and not prescribing based on non-evidence-based historical practices, patient demand, convenience, or pressure from colleagues.
3. **CDC Report: 2017 Antibiotic Use in the United States**
   Describes the US landscape of antibiotic prescribing in addition to current public health programs and resources available to support healthcare providers and patients in their efforts to improve antibiotic prescribing and use.
4. **CDC Core Elements Appendix A**
   Provides a summary of additional literature to help implement each of the four CDC Core Elements of Outpatient Antimicrobial Stewardship.

ADDITIONAL INFORMATION

Please see the links below for additional information and digital copies of all toolkit resources. For additional questions about antimicrobial stewardship, please reach out to the CDPH HAI/AR Unit at CDPHHAIAR@cityofchicago.org.

Digital toolkit and links to materials:

www.chicagohan.org/antimicrobialstewardship/dentaltoolkit

CDPH's Antimicrobial Stewardship website:

www.chicagohan.org/antimicrobialstewardship

IDPH's Precious Drugs and Scary Bugs materials:

www.tinyurl.com/drugsandbugs

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An evaluation of dental antibiotic prescribing practices in the United States

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Author Contributions:

Michael J. Durkin contributed to all aspects of the project.

Kevin Hsueh contributed to the design of the study, interpretation of the results, and drafting the manuscript

Ya Haddy Sallah, Qianxi Feng, and S. Reza Jafarzadeh contributed the design of the study, analysis of the results, and revising the manuscript.

Kiraat Munshi and Rochelle Henderson assisted design of the study, acquisition of the data, analysis of the results, and revising the manuscript.

Peter Lockhart and Martin Thornhill served as content experts; they contributed to the design of the work, analysis and interpretation of the results, and critically revising the manuscript.

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Abstract

Background—Antibiotic prescribing practices among dentists and dental specialists in the United States (US) remains poorly understood. The purpose of our study is to compare prescribing practices between dental specialties, evaluate the duration of antibiotics prescribed by dentists, and determine variation in antibiotic selection among dentists.

Methods—We performed a retrospective cross-sectional analysis of dental provider specialties linked to de-identified antibiotic claims data from a large pharmacy benefits manager during the 2015 calendar year.

Results—As a group, general dentists and dental specialists were responsible for over 2.7 million antibiotic prescriptions, higher than several other medical and allied health provider specialties. Antibiotic treatment duration was generally prolonged and commonly included broad-spectrum agents, such as amoxicillin-clavulanate and clindamycin. Although amoxicillin was the most commonly prescribed antibiotic among all dental specialties, there was significant variation among other antibiotics selected by each specialty. The most common antibiotic treatment durations were for 7 and 10 days.

Conclusions—This study demonstrates that dentists frequently prescribe antibiotics for prolonged periods of time and often use broad-spectrum antibiotics. Further studies are necessary to evaluate the appropriateness of these antibiotic prescribing patterns.

Practical Implications—The significant variation in antibiotic selection and treatment duration identified among all dental specialties in this study population implies that further research and guidance into the treatment of dental infections is necessary to improve and standardize antibiotic prescribing practices.

Background

Antibiotics are the most commonly used medications for the treatment and prevention of bacterial infections, and account for $10.7 billion in healthcare expenditure in the United States (US).[1, 2] However, antibiotic misuse is widespread in outpatient and inpatient clinical settings. For example, the Centers for Disease Control and Prevention (CDC) conservatively estimate that 47 million prescriptions for antibiotics (30% of all outpatient antibiotic prescriptions) are unnecessary.[3] Excessive antibiotic use contributes to the development of antibiotic-resistant bacteria, such as *Clostridium difficile* and carbapenem-resistant Enterobacteriaceae, which are recognized as urgent threats to the US healthcare system.

Serious antibiotic-resistant bacteria are estimated to cause 23,000 deaths and 2 million illnesses in the US annually.[1]

A number of organizations have initiated strategies to improve antibiotic utilization, including the CDC, which has set a national goal to reduce the number of inappropriate antibiotic prescriptions by half by the year 2020.[4] In 2003, the CDC launched the *Get Smart about Antibiotics* campaign, aimed at educating healthcare providers and consumers about appropriate antibiotic prescribing and use.[5] More recently, the CDC released guidance to hospitals,[6] nursing homes,[7] and outpatient clinics[8] on how to improve antibiotic prescribing practices. As of January 1st 2017, The Joint Commission (a national hospital accreditation agency in the US) requires that all acute-care hospitals have an antimicrobial stewardship program to improve antibiotic prescribing practices.[9] Moreover, the Centers for Medicare and Medicaid Services (CMS) has proposed formal antibiotic stewardship programs in all acute-care hospitals as a condition of participation.[10] Many of these initiatives are aimed at physicians, but antibiotic prescribing practices by other healthcare providers, including dentists, are likely to be closely evaluated in the future.

There is a lack of published data on the antibiotic prescribing practices of dentists. Current studies suggest that inappropriate antibiotic prescribing by dentists may be common. For example, a self-reported survey of dentists found that 70% of dentists reported inappropriate prescription of prophylactic antibiotics prior to a dental procedure.[11] Moreover, dentists' adherence to current antibiotic prescribing guidelines likely remain suboptimal. In a case-based survey, adherence to prescribing guidelines among pediatric dentists in North Carolina varied by 10–42%.[12] In a UK study of antibiotic prescribing among general dental practices, only 19% of antibiotics were prescribed in situations where their use was indicated by clinical guidelines. A similar study in the oral surgery acute dental clinic of a major London hospital reported only 30% of antibiotic prescriptions complied with clinical guidelines.[13]

To our knowledge, there has been only one nation-wide epidemiologic investigation of antibiotic prescribing practices by dentists in the U.S.[14] Roberts et al reported data on the number and type of antibiotics prescribed by general dentists. However, there is little data on the antibiotic prescribing practices among dental specialists for prophylaxis *versus* treatment purposes and the length of antibiotic treatment courses prescribed by dentists. In this study we evaluated the antibiotic prescribing practices of dentists in the US by analyzing dental antibiotic prescription claims data for a large nationally representative sample of commercially-insured individuals.

Methods

Express Scripts Holding Company (ESHC) is the largest independent prescription benefits manager in the United States, with detailed prescription data for over 80 million American lives. Data on outpatient antibiotic prescriptions from dentists from January 1, 2015 through December 31, 2015 was obtained from the ESHC database. Data included prescribing dental provider specialty and location, as well as the prescribed antibiotic's name, dose, and days' supply (treatment duration). Members with missing claims information, including provider information, were excluded. Topical antibiotics, systemic or topical antifungals,

antiparasitics, and antivirals were excluded. Antibiotics with the same active ingredient, but a different formulation (e.g., extended release tablets) were combined. Antimicrobials with antibacterial properties (e.g., methenamine) were included.

Provider specialties were ranked by percentage of total antibiotic prescriptions, and the top 10 were displayed (Table 1). For this initial analysis, general dentists and all dental specialists were grouped together. The number of prescribers, prescriptions, patients, and eligible beneficiaries in the database were also obtained. The number of eligible beneficiaries was defined as the total number of individuals within the ESHC database at the midpoint of the 2015 calendar year. In other words, this value represents the number of individuals who are eligible for prescription benefit coverage through ESHC. This number does not reflect the number of people who received dental care or filled any antibiotic prescriptions. The percentage of total prescribers was calculated by dividing the number of providers within each specialty by the total number of prescribers. The percentage of antibiotic prescriptions was calculated using a similar method. The number of antibiotic prescriptions per prescriber was calculated to evaluate for high-volume antibiotic prescribing groups with fewer providers and low-volume antibiotic prescribing groups with several providers.

We reviewed the most common antibiotics prescribed by all dental providers and stratified the results by dental specialty. The number of dental specialty prescribers, number of prescriptions, number of patients, the rate of prescriptions per provider, and the rate ratio of antibiotic prescriptions compared to general dentists were analyzed from the available data. Antibiotic selection was explored by listing the top 10 most commonly prescribed antibiotics for each dental specialty. Pairwise chi-square tests were conducted to compare prescribing rates by specialty with general dentists.

Antibiotic treatment duration (number of days) was presented in a histogram. In order to distinguish antibiotic prescriptions provided for prophylaxis purposes from those provided for treatment purposes we defined antibiotic prophylaxis prescriptions as those written for ≤1 days' supply of antibiotics, and we defined treatment prescriptions as those written for >1 days' supply of antibiotics. US maps were used to evaluate for variation in state-level antibiotic prescribing practices for overall antibiotic use, antibiotic use for prophylaxis, and antibiotic use for treatment purposes. Antibiotic prescriptions were calculated by antibiotic prescription count per 100,000 eligible beneficiaries in each state to adjust for variation in the state population.

The analyses were performed with SAS (v9.4, Cary, NC, USA) and R (v3.3.1). This study was approved by the Washington University's Human Research Protection Office.

Results

A total of 22,299,629 antibiotic prescriptions were prescribed by 866,916 providers out of the 38,988,099 eligible member database for the calendar year 2015. On average, 0.57 antibiotics were prescribed per beneficiary in 2015. Accounting for 17.93% of providers (155,462), dentists prescribed the third highest number of antibiotics (2,937,494

prescriptions) (Table 1). After adjusting for number of prescriptions per provider, dentists prescribed fewer antibiotics than most medical specialties (18.90 prescriptions per provider), and ranked ninth among the top 10 antibiotic prescribing specialties by prescription count, after obstetric and gynecologic providers (20.72 prescriptions per provider).

When examining antibiotic prescriptions by dental providers only, the most common antibiotics prescribed were amoxicillin, clindamycin, penicillin, azithromycin, and cephalexin (Figure 1). However, several unusual antibiotics were identified including erythromycin, an agent that is no longer recommended in the American Dental Association (ADA) guidelines, which was identified as the 10th most-commonly prescribed antibiotic. Prescriptions that lack significant antimicrobial activity against typical oral flora were also identified. Atypical antibiotics prescribed that are not optimal for treating oral infections included drugs like ciprofloxacin (n=14,451; 0.49%), trimethoprim-sulfamethoxazole (n=3,318; 0.11%), nitrofurantoin (n=835; 0.03%), and methenamine (n=59; <0.01%).

There was a significant variation in antibiotic prescribing practices by dental specialty (Table 2). Although general dentists prescribed the highest volume of antibiotics, they had lower prescribing rates than some other dental specialists. As a specialty, Oral and Maxillofacial Pathology was much more likely to prescribe antibiotics than other dental specialties. Other high-volume dental prescribing specialties included Oral and Maxillofacial Surgery, Oral and Maxillofacial Radiology, Endodontics, and Periodontics. Orthodontists prescribed the fewest antibiotics per prescriber.

All dental providers commonly prescribed broad spectrum antibiotics, such as clindamycin and amoxicillin-clavulanate. However, antibiotic prescribing patterns varied by dental specialty for several antibiotics (Table 3). For example, periodontists prescribed doxycycline more than their peers, whereas orthodontists prescribed azithromycin more often. Interestingly, oral and maxillofacial surgeons more frequently prescribed narrower spectrum antibiotics such as penicillin and amoxicillin compared to other dental specialties.

A histogram depicting antibiotic prescription duration demonstrated that most antibiotics were prescribed for 5, 7, or 10 days (Figure 2a). There were very few prescriptions for fewer than 5 days; some prescriptions for 30 days or longer were identified, but these were rare. These findings were largely driven by amoxicillin, which showed a similar prescribing pattern (Figure 2b). Histograms stratified by common antibiotics demonstrated similar findings (Supplemental Figure). Amoxicillin, the most common antibiotic prescribed in our data, was generally written for 7 or 10 days. Similar prescribed durations were demonstrated for penicillin and amoxicillin-clavulanate. Azithromycin, clindamycin and cephalexin – recommended alternatives to amoxicillin for endocarditis prophylaxis – were rarely prescribed with fewer than 5 days of supply.

Significant variation in antibiotic prescribing rates are demonstrated by state maps (Figures 3a, 3b, and 3c). Specifically, overall antibiotic prescribing, and antibiotic prescribing rates for treatment, were highest in the southern regions (Alabama, Mississippi, Louisiana, and Arkansas) and the Northeast (New York, Massachusetts, and New Jersey). In contrast,

prescribing rates for antibiotic prophylaxis were highest in the Great Plains (Kansas, Nebraska, Iowa, and South Dakota).

Discussion

To our knowledge, this study is the first to provide national estimates for antibiotic treatment selection by both general dentists and dental specialists in the United States. When taken together, general dentists and dental specialists are the third highest prescribers of antibiotics in the nation by volume. This study is also the first to examine dental antibiotic treatment duration in the US. Results of this study suggest that most antibiotics prescribed by dentists in the United States are likely for the treatment of odontogenic infections, rather than antibiotic prophylaxis. Many treatment courses utilize broad-spectrum agents such as amoxicillin-clavulanate and clindamycin. This study demonstrated that dentists occasionally prescribed antibiotics unsuited for antibiotic prophylaxis or the treatment of dental infections and with spectra of antimicrobial activity suited only for non-dental conditions, such as urinary tract infections.

Several studies have previously demonstrated that antibiotic prescribing among dentists is comparable to many medical specialties. Using national antibiotic prescribing estimates for the US in 2011, Hicks et al. identified that general dentists were responsible for 10% of antibiotic prescriptions and were the 4th highest prescriber of antibiotics in the US by volume.[15] In fact, general dentists in that study prescribed slightly fewer antibiotics than pediatricians (12%) and internal medicine physicians (12%). Dentists in other countries also contribute to a large percentage of antibiotic prescriptions. For example, dentists provided approximately 11.3% of all outpatient antibiotic prescriptions in British Columbia, Canada in 2013[16] and nearly 10% of all antibiotic prescribing in primary care in England.[17]

Antibiotic prescribing among dentists appears to be increasing in some countries. National antibiotic prescribing rates increased by 50% among dental practitioners in Australia between 2001 and 2012.[18] Similar findings were observed in British Columbia, Canada, where dental antibiotic prescribing increased over 60% between 1996 and 2013, whereas overall antibiotic prescribing by physicians declined;[19] by the end of the study, the proportion of all antibiotics prescription by dentists increased from 6.7% to 11.3%. This rise in antibiotic prescriptions among dentists may be related to a number of reasons. First, individuals may be receiving better access to dental care. Second, dental providers may be performing more procedures to salvage infected teeth - rather than performing extractions. Finally, as the patient population ages, dental problems are likely becoming more common. However, regardless of the prescribing trends, some of these antibiotic prescriptions may be unnecessary.

To our knowledge, no studies have evaluated individual dental antibiotic prescriptions to determine how often antibiotics are prescribed inappropriately in the US; however, two surveys demonstrate that inappropriate antibiotic prescribing is common.[11, 12] Furthermore, significant geographic variation in antibiotic prescribing practices, suggests that inappropriate antibiotic prescribing is a national problem. For example, general dentists in the District of Columbia prescribed nearly twice as many antibiotics as general dentists in

Delaware.[14] In the UK, inappropriate antibiotic prescribing appears to be common.[13, 20] For example, in a 2016 cross-sectional study analyzing antibiotic prescribing of 568 patients among general dentists, less than 20% of antibiotics were prescribed in situations consistent with clinical guidelines.[21] However, these issues are not limited to just the US and UK, inappropriate antibiotic prescribing practices among dentists is a worldwide problem.[22–24]

Self-described issues that contribute to unnecessary antibiotic prescriptions among dentists include antibiotics to treat dental pain associated with periapical abscesses, increase in use of dental implants, slow adoption of guidelines, decreasing skill-set of the average dentist, use of antibiotics as a substitute for surgery, aging populations, and increased competition (more dentists per capita).[16, 25] Other important factors include failure of previous operative treatment, shortage of clinical time, and patient pressure.[21, 26]

Inappropriate antibiotic prescriptions have important costs. Unnecessary antibiotic use contributes to the selection of multidrug resistant organisms,[27] wastes healthcare resources,[28] and likely leads to a significant number of adverse patient events annually.[29, 30] Thornhill et al. identified that even short antibiotic treatment durations associated with endocarditis prophylaxis are associated with adverse reactions, including *Clostridium difficile*.[31] Furthermore, narrower spectrum agents, such as amoxicillin had a significantly safer side effect profile for patients than clindamycin.

Several investigators have explored methods to improve antibiotic prescribing practices among dentists. Through a combination of audit, education and feedback on prescribing practices in England, Chate et al. reduced antibiotic use by 43% among 212 general dental providers.[32] A similar audit, education and feedback intervention in a London hospital dental department, improved antibiotic prescribing guideline compliance from 30% to 80%. Several other studies have also demonstrated improvements in antibiotic prescribing practices after antimicrobial stewardship interventions.[13, 20, 33, 34] These audit and feedback interventions appear to be well-received by participants. In a follow-up survey after an antibiotic audit and feedback intervention, a majority of general dentists found the experience to be both understandable and worthwhile.[35]

Additional studies are required to better evaluate antibiotic prescribing behavior among dentists in the US. Specific areas for further investigation include longitudinal prescribing trend analyses, evaluations of indeterminate antibiotic treatment durations (e.g., 2–4 days' supply) and prolonged treatment durations (e.g., beyond 10 days), better insights into prescriber behavior rationale, and the effect of antimicrobial stewardship interventions – such as audit and feedback in the US. Ultimately, improved antibiotic prescribing may likely require a combination of clear treatment guidelines by the ADA and/or the CDC along with comprehensive antimicrobial stewardship efforts targeted to dental prescribers.

Our study had some limitations. First, despite using one of the largest prescription databases available in the US, our cohort only included privately insured Americans and may not be generalizable to the entire US population. Specifically, most individuals with commercial insurance benefits tend to be younger and employed, married to someone who is employed, or the child of someone who has private insurance. Second, only claims that were processed

and reimbursed by the payer were included in the analysis. Some enrollees may have paid for their antibiotic prescriptions without using their insurance benefits. In particular, shorter duration (and less expensive) antibiotic prescriptions, such as antibiotics for prophylaxis may be under-represented in our data. Third, the prescription claims data lacked diagnosis or indication information. As a result, it was difficult to determine if prolonged antibiotic treatment durations were being prescribed for prophylaxis for several days following a dental procedure, non-specific conditions such as undifferentiated dental pain, or non-dental conditions like sinusitis, upper respiratory tract infections, urinary tract infections, or skin and soft tissue infections. Finally, the antibiotic prescriptions in this study are limited to those processed by one large pharmacy benefit management company and do not provide a complete picture of the antibiotic prescribing patterns for a dental provider. Thus, antibiotic prescription rates per provider do not represent the true national prescribing rates for the average dental provider.

Conclusions

Our findings suggest that dentists and dental specialists are significant contributors to outpatient antibiotic prescriptions in the US. Many of these antibiotic prescriptions are written for prolonged periods of time and include broad-spectrum antibiotics. Some prescribed antibiotics appear to be for non-dental infections or unsuitable for treating dental infections. Further analyses are needed to understand, and eventually improve, antibiotic selection practices among dental providers.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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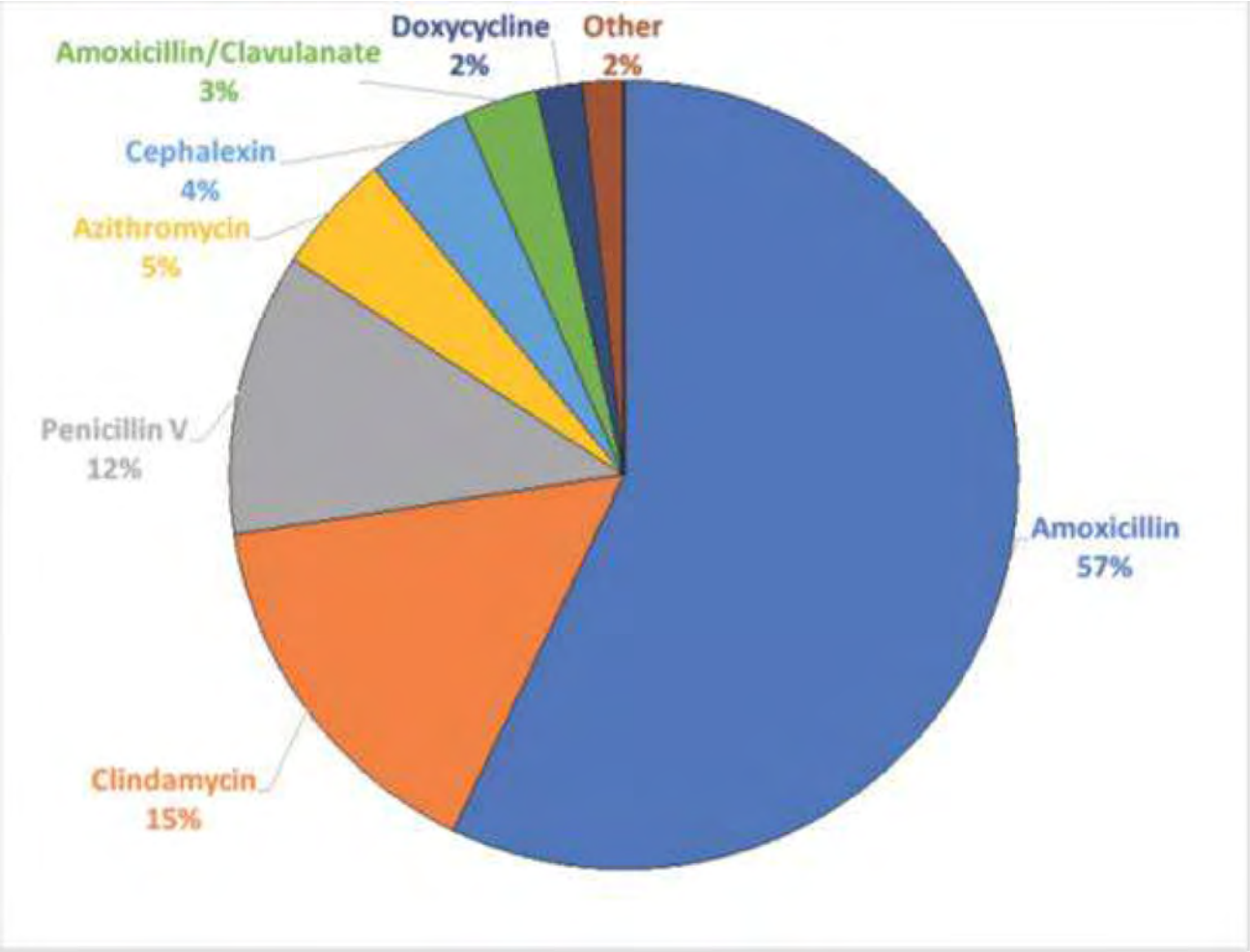

Figure 1.

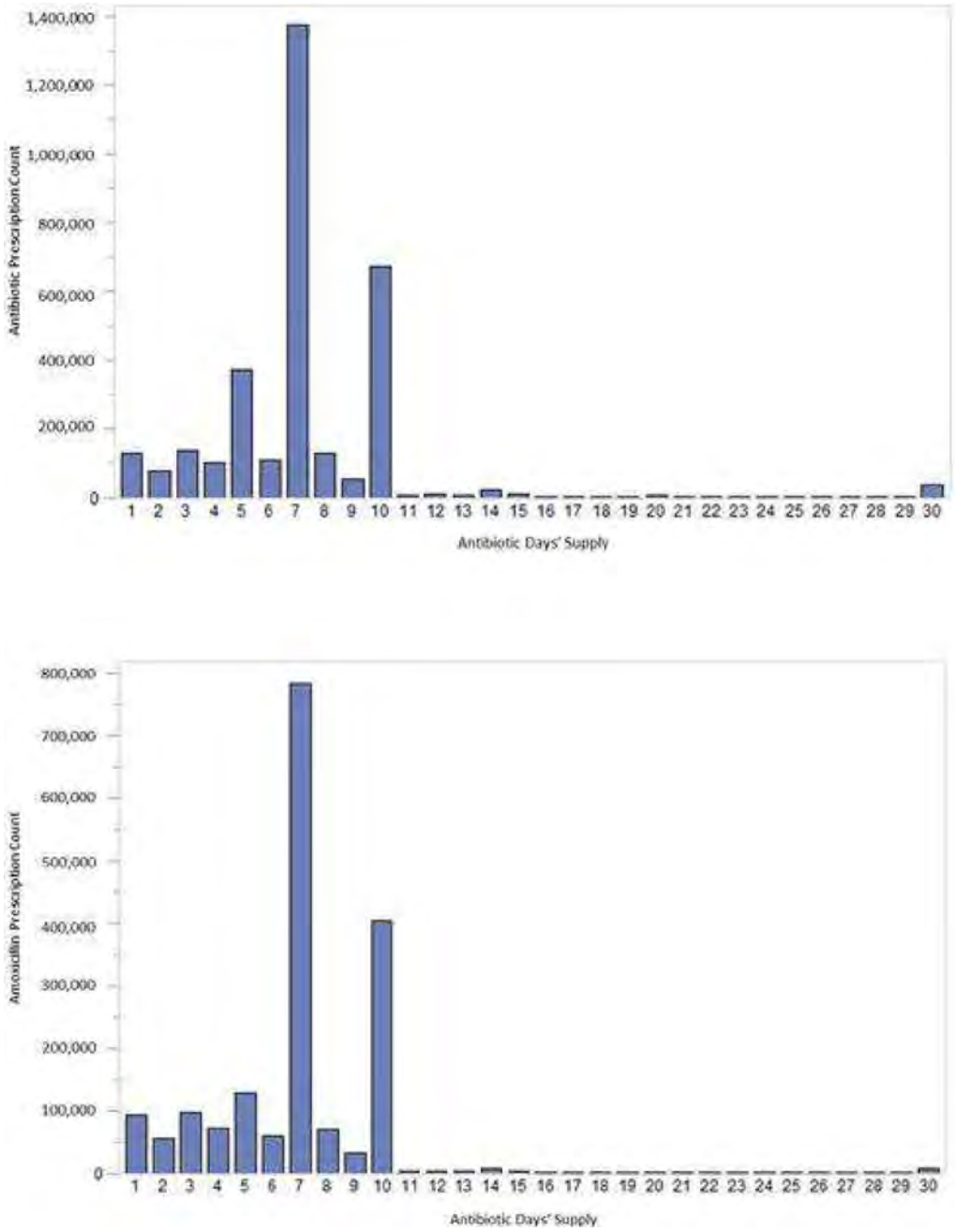

Figure 2.

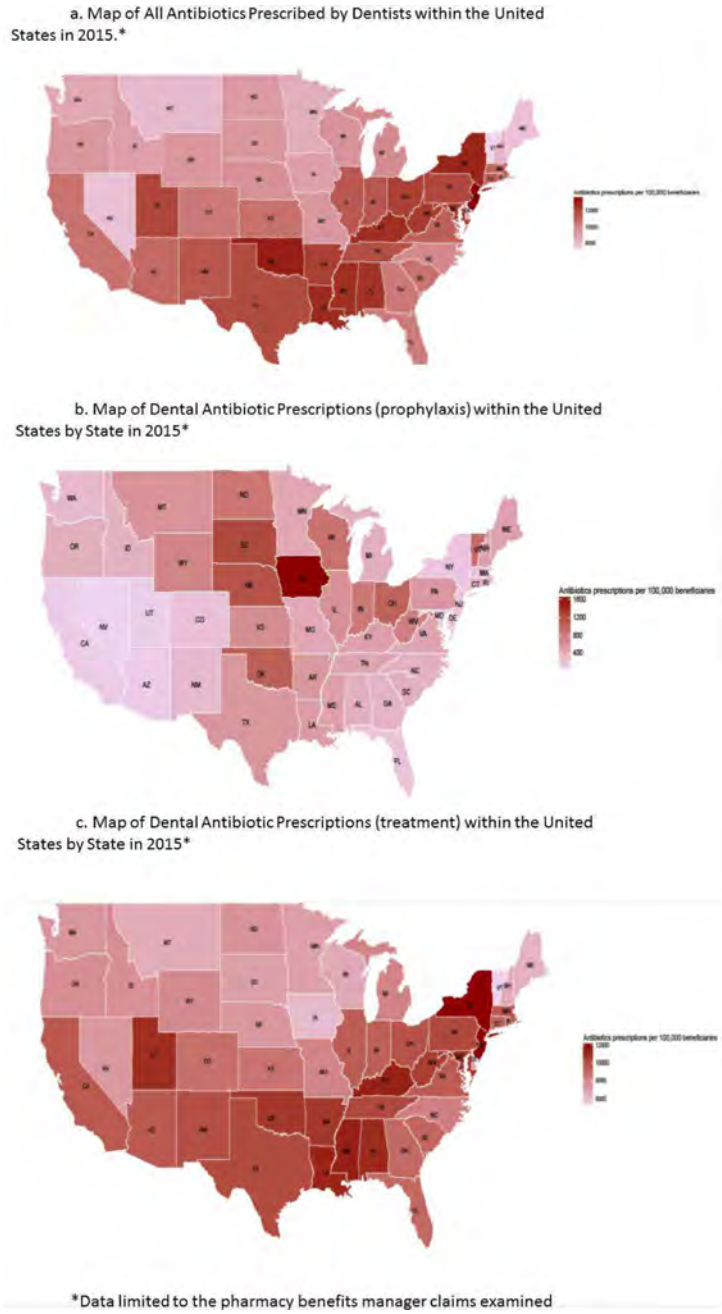

Figure 3.

Table 1

Top 10 Antibiotic Prescribing Provider Specialties within the United States in 2015, Ranked by Count of Prescriptions.

Rank	Specialty	No. of Prescribers	Percent of Total Prescribers	Count of Rxs*	Percent of Total Rxs	No. of Patients	Rxs Per Prescriber*
1	Family Medicine	96,754	11.16%	5,864,247	26.30%	3,727,615	60.61
2	Internal Medicine	153,893	17.75%	4,202,961	18.85%	2,397,039	27.31
3	Dentist	155,462	17.93%	2,937,494	13.17%	2,085,777	18.90
4	Pediatrics	53,269	6.14%	2,337,232	10.48%	1,415,760	43.88
5	Emergency Medicine	42,698	4.93%	1,309,737	5.87%	1,081,099	30.67
6	Dermatology	10,822	1.25%	724,701	3.25%	322,883	66.97
7	Obstetrics & Gynecology	33,945	3.92%	703,454	3.15%	482,140	20.72
8	Urology	9,210	1.06%	596,529	2.68%	299,768	64.77
9	Otolaryngology	9,146	1.06%	409,820	1.84%	283,154	44.81
10	Surgery	23,842	2.75%	240,370	1.08%	162,968	10.08

Note. Number of eligible members within the Express Scripts database was 38,988,099. Data limited to the pharmacy benefits manager claims examined.

*Rxs: Prescriptions

Table 2

Antibiotic Prescription Data by Dental Specialty within the United States in 2015, Ranked by Count of Prescriptions.

Dental Specialty	Count of Prescriptions	Percent of Prescriptions	Number of Prescribers	Prescriptions per Prescriber	Prescription Rate Ratio (95% CI)	P-value
Dentist (general)	2,136,776	72.74%	133,382	16.02	Ref	Ref
Oral and Maxillofacial Surgery	394,871	13.44%	5,506	71.72	4.48 (4.46–4.49)	<0.001
Periodontics	173,316	5.90%	4,328	40.05	2.50 (2.49–2.51)	<0.001
Endodontics	148,198	5.05%	4,204	35.25	2.20 (2.19–2.21)	<0.001
Oral and Maxillofacial Pathology	30,659	1.04%	404	75.89	4.74 (4.68–4.79)	<0.001
Pediatric Dentistry	25,892	0.88%	4,207	6.15	0.38 (0.38–0.39)	<0.001
Prosthodontics	18,402	0.63%	1,779	10.34	0.65 (0.64–0.66)	<0.001
Dental Public Health	5,464	0.19%	444	12.31	0.77 (0.75–0.79)	<0.001
Orthodontics and Dentofacial Orthopedics	3,315	0.11%	1,198	2.77	0.17 (0.17–0.18)	<0.001
Oral and Maxillofacial Radiology	601	0.02%	10	60.10	3.75 (3.46–4.06)	<0.001
Total	**2,937,494**	**100.00%**	**155,462**	**18.90**		

Note. Data limited to the pharmacy benefits manager claims examined.

Table 3

Most Common Antibiotics Prescribed by Dental Specialty within the United States in 2015, Ranked by Count of Prescriptions.

Antibiotic Rank	Dentist (general)	Oral and Maxillofacial Surgery	Periodontics	Endodontics	Oral and Maxillofacial Pathology	Pediatric Dentistry	Prosthodontics	Dental Public Health	Orthodontics and Dentofacial Orthopedics	Oral and Maxillofacial Radiology
1	Amoxicillin (56.53%)	Amoxicillin (58.10%)	Amoxicillin (60.12%)	Amoxicillin (47.43%)	Amoxicillin (56.33%)	Amoxicillin (72.30%)	Amoxicillin (63.39%)	Amoxicillin (53.44%)	Amoxicillin (38.22%)	Amoxicillin (80.03%)
2	Clindamycin (15.64%)	Penicillin V (14.96%)	Doxycycline (10.40%)	Clindamycin (22.59%)	Penicillin V (16.45%)	Penicillin V (8.13%)	Clindamycin (14.40%)	Clindamycin (16.23%)	Azithromycin (24.34%)	Clindamycin (11.48%)
3	Penicillin V (11.52%)	Clindamycin (14.48%)	Clindamycin (9.24%)	Penicillin V (11.77%)	Clindamycin (13.19%)	Clindamycin (6.50%)	Penicillin V (6.21%)	Penicillin V (14.77%)	Clindamycin (10.59%)	Azithromycin (2.83%)
4	Azithromycin (4.97%)	Amoxicillin/ Clavulanate (4.26%)	Azithromycin (6.61%)	Amoxicillin/ Clavulanate (6.25%)	Azithromycin (4.73%)	Azithromycin (5.86%)	Azithromycin (6.00%)	Azithromycin (4.04%)	Penicillin V (5.07%)	Amoxicillin/ Clavulanate (2.83%)
5	Cephalexin (4.73%)	Azithromycin (3.17%)	Amoxicillin/ Clavulanate (3.52%)	Azithromycin (5.58%)	Cephalexin (3.24%)	Amoxicillin/ Clavulanate (2.79%)	Amoxicillin/ Clavulanate (2.82%)	Cephalexin (4.00%)	Amoxicillin/Clavulanate (4.43%)	Penicillin V (1.50%)
6	Amoxicillin/ Clavulanate (2.61%)	Cephalexin (2.81%)	Penicillin V (3.44%)	Cephalexin (3.06%)	Amoxicillin/Clavulanate (2.83%)	Cephalexin (2.22%)	Cephalexin (2.79%)	Amoxicillin/Clavulanate (2.27%)	Cephalexin (3.83%)	Ciprofloxacin (0.67%)
7	Doxycycline (1.53%)	Doxycycline (0.52%)	Metronidazole (2.41%)	Metronidazole (1.94%)	Doxycycline (1.17%)	Cefadroxil (0.35%)	Doxycycline (1.35%)	Doxycycline (1.89%)	Doxycycline (3.38%)	Levofloxacin (0.33%)
8	Metronidazole (0.74%)	Metronidazole (0.51%)	Cephalexin (2.22%)	Ciprofloxacin (0.40%)	Ciprofloxacin (0.49%)	Ciprofloxacin (0.35%)	Metronidazole (0.74%)	Ciprofloxacin (1.00%)	Ciprofloxacin (2.41%)	Cephalexin (0.17%)
9	Ciprofloxacin (0.51%)	Ciprofloxacin (0.29%)	Ciprofloxacin (0.71%)	Doxycycline (0.36%)	Metronidazole (0.46%)	Doxycycline (0.27%)	Ciprofloxacin (0.64%)	Metronidazole (0.66%)	Sulfamethoxazole/Trimethoprim (1.74%)	Metronidazole (0.17%)
10	Erythromycin (0.40%)	Levofloxacin (0.28%)	Levofloxacin (0.32%)	Levofloxacin (0.15%)	Levofloxacin (0.29%)	Cefdinir (0.25%)	Erythromycin (0.47%)	Erythromycin (0.60%)	Metronidazole (1.21%)	n/a

Note. Data limited to the pharmacy benefits manager claims examined

2017 ANTIBIOTIC USE IN THE UNITED STATES

PROGRESS AND OPPORTUNITIES

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

Antibiotic Use in the United States, 2017: Progress and Opportunities is a publication of the National Center for Emerging and Zoonotic Infectious Diseases within the Centers for Disease Control and Prevention.

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EXECUTIVE SUMMARY

The Centers for Disease Control and Prevention (CDC) focuses on helping healthcare providers deliver the best possible care for patients every day. Research shows that one way we can improve patient care is through better use of antibiotics.

Modern medicine depends on antibiotics to protect people against infection. These powerful drugs have transformed health care, but as with any medicine, antibiotics carry risks. When antibiotics are needed, the benefits usually outweigh the risks. However, when a patient takes an antibiotic when it is not needed, the patient gets no benefit and is unnecessarily exposed to preventable, and potentially serious, health problems. Each time an antibiotic is used, it can increase the risk that a future infection will be resistant to antibiotics.

Antibiotic resistance occurs when bacteria do not respond to the drugs designed to kill them. It is one of the most serious public health problems in the United States and threatens to return us to the time when simple infections were often fatal. Improving the way we prescribe and use antibiotics, a concept referred to as “antibiotic stewardship,” is critical for all healthcare settings. When we optimize the treatment of infections, we protect patients from harm and combat antibiotic resistance.

Antibiotic Use in Healthcare Settings: Current Status

The United States has made progress in understanding antibiotic prescribing and use in health care and in the community. But there are many opportunities to improve.

Outpatient Settings: Nationally, antibiotic prescribing in outpatient settings like clinics, doctor's offices, and emergency rooms decreased by five percent from 2011 to 2014, but variations among age groups and geographic locations point to areas where prescribing can be improved. CDC estimates that 30 percent of all antibiotics prescribed in outpatient clinics are unnecessary. Even when antibiotics are needed, prescribers often favor drugs that may be less effective and carry more risk over more targeted first-line drugs recommended by national guidelines.

Nursing Homes: More data are needed to understand antibiotic use in nursing homes, where approximately four million Americans receive care each year. A small CDC study of nine nursing homes showed that 11 percent of nursing home residents were taking antibiotics on any single day, and nearly 40 percent of orders for antibiotics lacked important prescribing information. CDC is launching a larger study with more nursing homes across the country and pursuing partnerships with nursing home networks, pharmacies, and other companies to identify where action is needed most.

Hospitals: Hospital antibiotic use data point to opportunities to improve prescribing practices. For example, use of the most powerful antibiotics increased significantly from 2006 to 2012, by nearly 40 percent for carbapenems and more than 30 percent for vancomycin. Data also indicate that roughly 30 percent of antibiotics used in hospitals are unnecessary or prescribed incorrectly.

Improving Antibiotic Use: CDC's Role

Improving antibiotic prescribing and use is part of **CDC's Antibiotic Resistance Solutions Initiative**, a comprehensive approach to combat antibiotic resistance that includes aggressive responses to outbreaks, groundbreaking approaches to research, and new investments in state and local infection prevention and control. To accelerate improvements and help healthcare facilities and providers make the best decisions to treat and protect their patients, CDC provides technical expertise and tools for implementation, data for action, support for innovation, and education resources.

Evidence and Tools for Implementation: CDC's Core Elements of Antibiotic Stewardship provide frameworks for antibiotic stewardship programs and practices in **outpatient settings**, **nursing homes**, and **hospitals**, including **small hospitals in rural areas**. CDC works with public health and healthcare partners including health systems, hospital associations, professional organizations, academic investigators, private industry, patient and consumer organizations, state and local health departments, and federal partners to promote and facilitate implementation of the Core Elements. For example, CDC worked with local, state, and national experts to create the **National Quality Partners Playbook: Antibiotic Stewardship in Acute Care**, a practical guide to help hospitals and health systems of all sizes implement the Core Elements. When **CDC's National Healthcare Safety Network (NHSN)** annual survey data indicated that smaller hospitals were less likely to implement all of the Core Elements, CDC worked with rural health, hospital, and federal partners to tailor the Core Elements to support implementation in small hospitals and address their specific needs.

Measuring Antibiotic Use in Healthcare: Data for Action: One of the most important ways CDC helps improve antibiotic use is producing and analyzing data to support healthcare facilities and providers in making the best choices for their patients. Healthcare facilities can use these data to identify opportunities to ensure appropriate antibiotic use, assess the impact of antibiotic stewardship efforts, and improve patient care. CDC is working with partners in all settings to identify, track, and understand antibiotic use data.

Hospitals participating in **CDC's NHSN Antibiotic Use Option** can compare their antibiotic use to others, monitor use over time, and direct hospital antibiotic stewardship programs. CDC continues to work with clinical experts on ways to use these data for improvement. For example, CDC collaborated to develop an assessment tool to help hospitals identify opportunities to improve antibiotic use.

Innovation: CDC is constantly looking for novel ways to improve antibiotic prescribing and use, and including exploring innovations related to treatment and diagnostics. One example is CDC's partnership with industry to investigate mechanisms to protect and restore the **microbiome** (the community of naturally occurring bacteria in and on the body) when antibiotics are used. Through the CDC and Food and Drug Administration (FDA) **Antibiotic Resistance Isolate Bank**, CDC is helping advance the development of diagnostic tests to identify and characterize resistant bacteria and accelerating research and development for new antibiotics.

Education: CDC leads **Get Smart: Know When Antibiotics Work** to educate parents of young children, the general public, and outpatient healthcare providers about antibiotic resistance and optimal antibiotic prescribing and use. This work is being refreshed in 2017. In addition, CDC is undertaking a national educational effort to support healthcare providers' knowledge about early sepsis recognition and treatment, including starting antibiotics quickly when sepsis is suspected and reassessing therapy within 48 hours when the patient's culture results are back.

Moving Forward

Everyone plays a critical role in improving antibiotic use and preventing infections across health care: healthcare providers; patients and their families; health systems, hospitals, clinics, and nursing homes; healthcare quality organizations; health insurance companies; healthcare provider professional organizations; and federal, state, and local health agencies. CDC is committed to working with partners, supporting implementation of programs and practices that optimize antibiotic prescribing and use, using data for action, supporting innovation, and educating patients and healthcare providers about the benefits and risks of antibiotics. Working together, we can improve and protect the health and well-being of everyone who receives health care and help ensure that life-saving antibiotics will be available for generations to come.

EVERYONE HAS A ROLE TO PLAY IN IMPROVING ANTIBIOTIC USE

Healthcare providers

- ❑ Follow clinical guidelines when prescribing antibiotics.
  - ▶ Use the right antibiotic, at the right dose, for the right duration, and at the right time.
- ❑ Talk to patients and families about when antibiotics are and are not needed, and discuss possible harms such as allergic reactions, *Clostridium difficile (C. difficile)*, and antibiotic-resistant infections.
  - ▶ Ask patients if they have ever had a *C. difficile* infection, and tailor antibiotic treatment accordingly.
- ❑ Be aware of antibiotic resistance patterns in your facility and community; use the data to inform prescribing.
- ❑ Follow hand hygiene and other infection prevention measures with every patient.

Patients and families

- ❑ Talk to your healthcare provider about when antibiotics will and won't help, and ask about antibiotic resistance.
- ❑ Talk to your healthcare provider about how to relieve symptoms.
- ❑ Ask what infection an antibiotic is treating, how long antibiotics are needed, and what side effects might happen.
  - ▶ Take antibiotics only when prescribed and exactly as prescribed.
  - ▶ Don't save an antibiotic for later or share the drugs with someone else.
- ❑ Insist that everyone cleans their hands before touching you.
- ❑ Stay healthy and keep others healthy by cleaning hands, covering coughs, staying home when sick, and getting recommended vaccines.

Health systems, hospitals, clinics, and nursing homes

- ❑ Adopt and implement antibiotic stewardship policies and strategies, including CDC's Core Elements of Antibiotic Stewardship.
- ❑ Designate staff members to coordinate antibiotic stewardship activities.
- ❑ Monitor antibiotic prescribing data to identify areas for improvement, and assess the impact of antibiotic stewardship efforts.
- ❑ Educate staff about antibiotic resistance and strategies to optimize antibiotic prescribing.

Healthcare quality organizations

- ❑ Develop and implement standards requiring antibiotic stewardship programs and practices.
- ❑ Develop and adopt standards measuring the success of antibiotic stewardship programs and practices.

Health insurance companies

- ❑ Incentivize implementation of antibiotic stewardship programs and practices.
- ❑ Use clinical performance data on quality measures for appropriate prescribing, such as the Healthcare Effectiveness Data and Information Set (HEDIS®) measures.

Healthcare provider professional organizations

- ❑ Create and share clinical practice guidelines for the diagnosis and management of common conditions.
- ❑ Incorporate antibiotic stewardship principles into antibiotic use guidelines.
- ❑ Provide continuing medical education opportunities about antibiotic stewardship for members.
- ❑ Bolster national, local, and regional initiatives promoting appropriate antibiotic prescribing and use.
- ❑ Highlight new research and technologies to support antibiotic stewardship.

Federal, state, and local health agencies

- ❑ Set expectations for the implementation of antibiotic stewardship activities across the spectrum of health care.
- ❑ Provide data and tools to help guide stewardship activities.
- ❑ Connect local stakeholders and coalitions.
- ❑ Support partners, healthcare providers, and patients through development and dissemination of educational resources.
- ❑ Support innovations and research, such as diagnostic test development, that facilitate optimal antibiotic use.

HOW TO USE THIS REPORT

Antibiotic Use in the United States 2017: Progress and Opportunities provides an overview of the current state of antibiotic use in human healthcare settings including programs and resources to support healthcare providers and patients in their efforts to improve antibiotic prescribing and use. The purpose of this report is to raise awareness about the need for antibiotic stewardship. Antibiotic stewardship is the systematic effort to improve antibiotic use to improve patient outcomes in order to help patients and combat antibiotic resistance. Antibiotic resistance occurs when bacteria do not respond to the drugs that are meant to kill them. Antibiotic stewardship in agriculture and animal health is also an important topic; however, this report focuses solely on antibiotic use and stewardship in human health care.

INTRODUCTION

Antibiotics are powerful drugs that have transformed health care around the world—making once deadly diseases treatable and saving millions of lives. Antibiotics are the foundation of modern medicine. We rely on antibiotics to treat people with the most serious infections, such as pneumonia or sepsis (a complication caused by the body's overwhelming and life-threatening response to infection), and those at high risk for developing infections.

ANTIBIOTICS ARE CRITICAL TO TREAT PATIENTS MOST AT RISK FOR SEVERE INFECTIONS

SURGERY

Patients undergoing any type of surgery, including cardiac bypass and joint replacements, are at risk of surgical site infections, which can be very serious and even life threatening.

DIALYSIS FOR END-STAGE RENAL DISEASE

Infection risk is high in patients with end-stage renal disease (a condition in which the kidneys are no longer working) because the patients have weakened immune systems and because dialysis requires access to their bloodstream.

CANCER CHEMOTHERAPY

Patients receiving chemotherapy (a type of cancer treatment) are often at risk for developing serious infections because the treatment weakens their immune systems.

TREATMENT FOR INFLAMMATORY CONDITIONS

Patients with inflammatory conditions, such as rheumatoid arthritis and inflammatory bowel disease, are often treated with medicines that can be associated with an increased risk of infection.

ORGAN TRANSPLANTS

Patients receiving organ transplants are at high risk for infections because they may undergo complex surgery and most receive medicines that weaken their immune system as part of their treatment.

Like other powerful drugs, antibiotics carry a variety of risks. When antibiotics are needed, the benefits outweigh the risks. However, when a patient takes an antibiotic they do not need, the patient gets no benefit and is unnecessarily put at risk for side effects and reactions to drugs. Additionally, antibiotics disrupt the **microbiome**, the community of naturally occurring bacteria in and on the body. The microbiome is very important for staying healthy and preventing disease. When a patient takes antibiotics, the drugs are used with an intent to kill the infection-causing "bad" bacteria, but "good" bacteria that protect against infection can also be destroyed for several months.

ESTABLISHED RISKS OF ANTIBIOTIC USE

INCREASED INFECTION RISK

Even though antibiotics are used to treat infections, they can also increase the risk of some types of infections. For example, people who have recently taken an antibiotic are at more risk of diarrhea caused by bacteria while traveling (i.e., traveler's diarrhea) or are at more risk of infection during outbreaks of foodborne illness caused by bacteria. In addition, infections caused by *C. difficile* bacteria and Candida fungi are common when taking antibiotics.

Clostridium difficile (C. difficile)

Each year nearly half a million illnesses and 15,000 deaths are caused by *C. difficile* infections. People taking antibiotics are 7 to 10 times more likely to get *C. difficile* while on the drugs, or in the month after taking them, than people not taking antibiotics.[1-4]

Candida

When a person's microbiome is disrupted by taking an antibiotic, there is increased risk for fungus (yeast) such as *Candida* species to grow. Common types of *Candida* infection are diaper rashes caused by yeast, vaginal yeast infections, and infections of the mouth and throat (also called thrush). In patients hospitalized for serious conditions or who have weak immune systems, *Candida* can cause severe illness, including bloodstream infections, or death.

ALLERGIC REACTIONS

Among children, antibiotics are the most common cause of emergency department visits for reactions to drugs. Most of these visits are for allergic reactions, which can range from mild rashes and itching to life-threatening swelling of the face and throat and breathing problems (called anaphylaxis).

DRUG INTERACTIONS

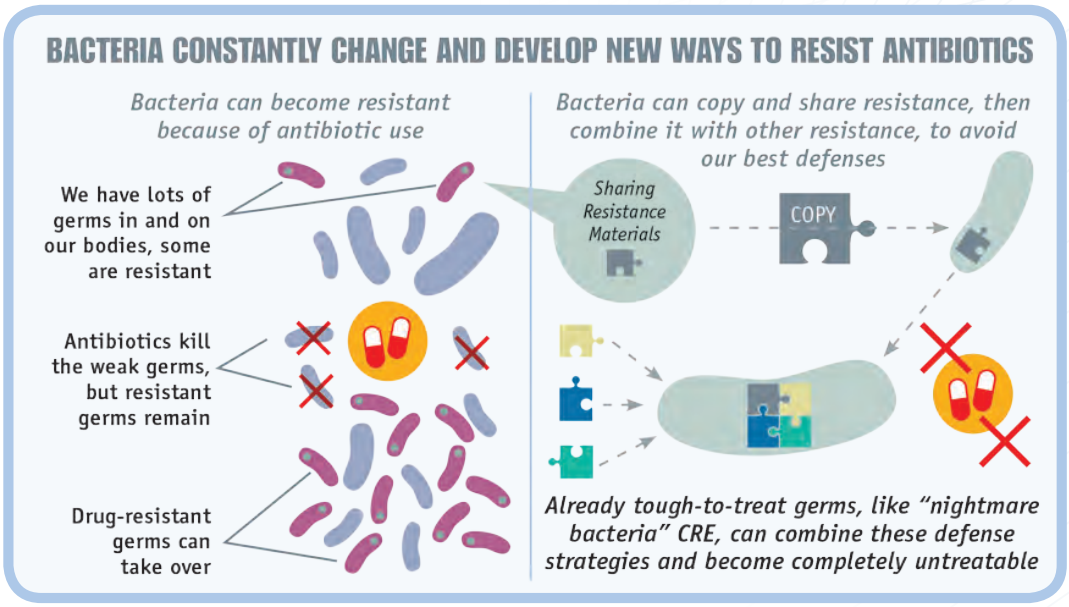
Antibiotics can interact with other drugs patients take. Then, those drugs, or the antibiotics, become less effective or the patient has worse side effects.

ANTIBIOTIC RESISTANCE

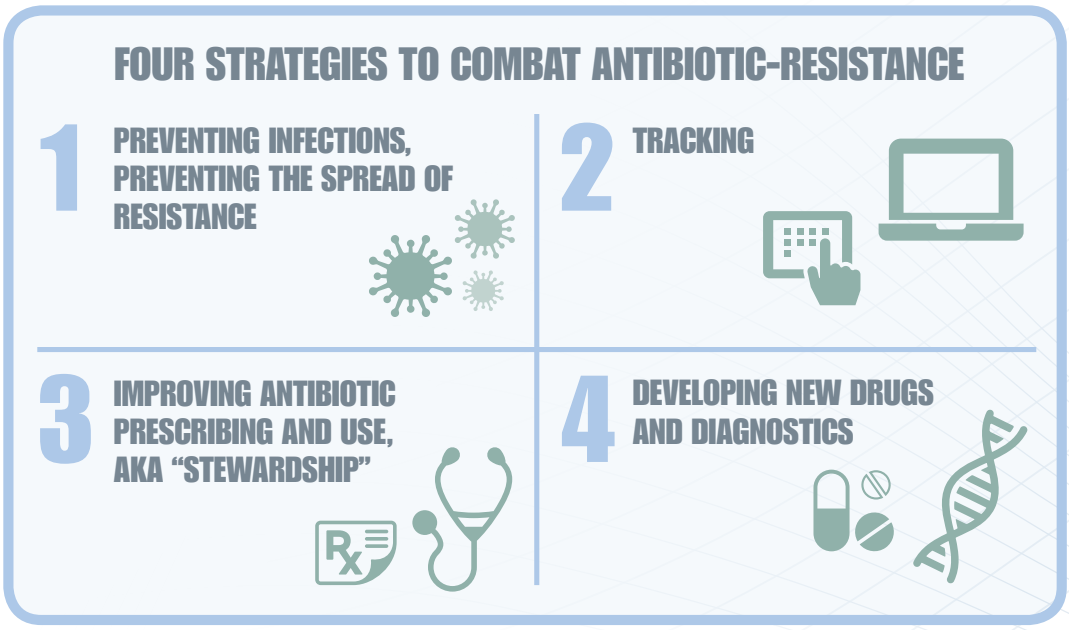
When a patient takes an antibiotic, the bacteria it is fighting might adapt to develop new resistance against the drug. The resistant bacteria can then cause resistant infections in that patient and/or spread to other people.

Improving Antibiotic Use to Combat Antibiotic Resistance

Improving antibiotic use is a core component of fighting antibiotic resistance. Antibiotic resistance, when bacteria do not respond to the drugs designed to kill them, threatens to return us to the time when simple infections were often deadly. CDC estimates that each year, in the United States alone, antibiotic-resistant bacteria cause more than 2 million illnesses and about 23,000 deaths. Antibiotic resistance is a threat to every person, to modern medicine, and to the healthcare, veterinary, and agriculture industries.



In 2013, CDC published ***Antibiotic Resistance Threats in the United States, 2013***, a first-ever snapshot of the size of the problem and threats posed by antibiotic-resistant pathogens.



The National Action Plan for Combating Antibiotic-Resistant Bacteria guides action by the U.S. government and public health partners to protect Americans from serious and urgent antibiotic-resistant threats. In 2016, Congress recognized the urgent need to combat antibiotic resistance and appropriated $160 million for CDC to implement the **Antibiotic Resistance Solutions Initiative**, which is improving U.S. capacity to 1) detect, respond to, and contain emerging resistance, 2) prevent and stop spread of resistant infections in healthcare settings and the community, and 3) improve antibiotic use. To accelerate improvements, CDC provides data for action, technical expertise, and tools for implementation, innovation, and education to help healthcare facilities and providers make the best decisions to protect and treat their patients.

Improving the way we use antibiotics, often referred to as "antibiotic stewardship," is part of the National Action Plan. Appropriate antibiotic use means using the right antibiotic, at the right dose, for the right duration, and at the right time. Antibiotic stewardship has a number of proven benefits. Antibiotic stewardship can protect patients from unintended consequences, improve treatment of infections, and help fight antibiotic resistance. Antibiotic stewardship is also critical to protect new and existing antibiotics so they continue to be effective.

ANTIBIOTIC STEWARDSHIP PROGRAMS AND ACTIVITIES CAN:

IMPROVE PATIENT OUTCOMES

By reducing unnecessary antibiotic prescribing, antibiotic stewardship programs and activities can improve the treatment of infections and prevent avoidable side effects, reactions, and other problems for patients.

DECREASE *C. DIFFICILE* INFECTIONS

Antibiotic stewardship programs and activities significantly reduce *C. difficile* infections. For example, reducing the use of high-risk antibiotics (fluoroquinolones) by 30 percent can lower *C. difficile* infections by 26 percent in hospitals.[6] Reducing overall antibiotic prescribing in outpatient settings by 10 percent could lower *C. difficile* infections in the community by 17 percent.[2]

DECREASE ANTIBIOTIC RESISTANCE

Preventing infections and improving antibiotic prescribing could save 37,000 lives from antibiotic-resistant infections over 5 years.

DECREASE COSTS

Antibiotic stewardship programs have consistently demonstrated annual savings of $200,000 to $400,000 in hospitals and other healthcare facilities. According to a University of Maryland study, implementation of an antibiotic stewardship program saved one hospital a total of $17 million over 8 years.

Antibiotic stewardship is necessary in all healthcare settings where antibiotics are prescribed. It is a cornerstone of efforts aimed at improving antibiotic-related patient safety and slowing the development of antibiotic resistance. Efforts to improve antibiotic use will succeed only if everyone plays a role. When everyone plays their part, patient safety is protected and life-saving antibiotics will be preserved for generations to come.

CDC'S APPROACH TO IMPROVING ANTIBIOTIC USE

EXAMPLES OF CDC'S APPROACH TO IMPROVING ANTIBIOTIC USE

DATA FOR ACTION

- ❑ Providing data about facility-level antibiotic use in outpatient settings, hospitals, and nursing homes to help healthcare providers identify opportunities to improve prescribing.
- ❑ Working with partners to develop a benchmark for hospitals to assess their antibiotic use and monitor the impact of antibiotic stewardship programs.

IMPLEMENTATION

- ❑ Providing recommendations for antibiotic stewardship programs and practices in multiple healthcare settings.
- ❑ Providing tools to help organizations incorporate antibiotic stewardship principles into antibiotic use guidelines.
- ❑ Developing tools and providing expertise to support and expand local implementation.
- ❑ Providing expertise to, and coordinating with, other federal partners to develop guidance and tools to implement antibiotic stewardship.
- ❑ Engaging a broad network of partners in healthcare, such as healthcare professional organizations, hospitals, health systems and industry, to implement antibiotic stewardship.

INNOVATION

- ❑ Funding universities and healthcare partners to identify novel ways to implement stewardship activities and improve the implementation of CDC's Core Elements of Antibiotic Stewardship in **hospitals**, **nursing homes**, **outpatient settings**, and **small hospitals in rural areas**.
- ❑ Advancing the development of diagnostic tests to identify and characterize resistant bacteria by accelerating research and development for new antibiotics.

EDUCATION

- ❑ Leading a national effort to educate Americans about appropriate antibiotic use, and strategies to protect themselves from antibiotic resistance.
- ❑ Spearheading an annual global observance promoting appropriate prescribing and use.
- ❑ Developing an educational effort to emphasize the early recognition, treatment, and reassessment of therapy of sepsis as an important part of antibiotic stewardship.

Implementing Antibiotic Stewardship Programs and Improving Antibiotic Use

Data for Action

One of the most important ways CDC can help improve antibiotic use is to produce and analyze data to support healthcare facilities and providers in making the best choices for their patients. CDC's approach to measuring antibiotic use includes many components, such as national, regional, and state data to determine larger trends and issues; hospital data to explore areas for improvement and assess the impact of specific stewardship activities; and appropriate antibiotic use and antibiotic stewardship program data. Healthcare facilities can use these data to identify opportunities for improvement, assess the impact of antibiotic stewardship efforts, and improve patient care.

CDC is working with partners in all settings where health care is delivered. For outpatient settings, health systems can use their own electronic health record data and track quality measure data, such as those from the Healthcare Effectiveness Data and Information Set (HEDIS), to examine the quality of antibiotic prescribing. This gives facilities, systems, and providers the information they need to improve the care they provide. At the national level, CDC uses **multiple data sources** to track outpatient antibiotic prescribing and appropriateness. For example, CDC uses the National Ambulatory Medical Care Survey (NAMCS) and the National Hospital Ambulatory Medical Care Survey (NHAMCS) to assess appropriateness of outpatient antibiotic prescribing and proprietary data from QuintilesIMS (formerly IMS Health) to measure outpatient oral antibiotics dispensed in U.S. community pharmacies.

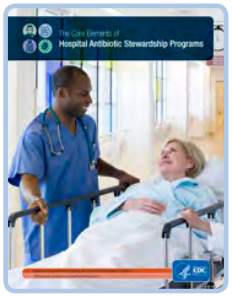
For hospitals, **CDC's National Healthcare Safety Network (NHSN)**, the nation's most widely used healthcare-associated infection (HAI) tracking system, allows hospitals to electronically track and benchmark their antibiotic use data using the Antimicrobial Use (AU) Option.

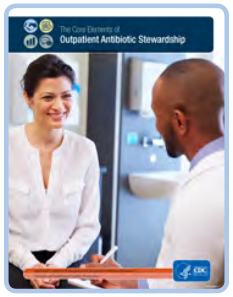
CDC is also gathering data and building partnerships with urgent care centers and retail health clinics in order to better understand antibiotic prescribing and improve use in these unique settings. Urgent care centers and retail health clinics are experiencing tremendous growth. Incorporating antibiotic stewardship activities in these settings will be an important factor in optimizing antibiotic use.

Implementation

To help healthcare facility leaders and providers implement stewardship activities in their facilities, CDC developed The Core Elements of Antibiotic Stewardship. **The Core Elements of Antibiotic Stewardship in Outpatient Settings** (2016), **The Core Elements of Antibiotic Stewardship for Nursing Homes** (2015) and **The Core Elements of Hospital Antibiotic Stewardship Programs** (2014) provide recommendations for antibiotic stewardship programs and practices in outpatient settings, nursing homes, and hospitals. Most recently, CDC released **Implementation of Antibiotic Stewardship Core Elements at Small and Critical Access Hospitals (2017)** as a framework for initiating and/or expanding antibiotic stewardship activities. More details on each set of Core Elements are outlined in the following sections of the report.

Partners are crucial to the successful implementation of CDC's Core Elements. For example, CDC is working directly with several of the nation's largest healthcare systems so they can both monitor and improve antibiotic use. Furthermore, CDC has strong relationships with partner organizations reaching infectious disease providers, pharmacists, and hospitals and is forming new collaborations with dentists, nurses, critical care providers, urgent care centers, and retail health clinics.





Innovation

CDC is driving innovation by looking for novel ways to implement and improve stewardship activities. For example, CDC is exploring ways public health and private industry can work together to protect and restore the **microbiome** by encouraging work to help understand: 1) how antibiotics disrupt the healthy microbiome, 2) how a disrupted microbiome puts people at risk, and 3) how that risk might be reduced.

Additionally, CDC is supporting the use of new diagnostic tools to rapidly identify antibiotic-resistant threats and to inform healthcare providers about appropriate antibiotic treatments.

For example, CDC is developing and evaluating rapid antimicrobial susceptibility testing methods to more quickly identify effective treatments for bacteria that could potentially be used in an act of bioterrorism. These same methods, which can reduce the time it takes to get results from 20 hours to less than 5 hours, could also be used to test bacteria that cause everyday infections.

CDC is also helping advance the development of diagnostic tests to identify and characterize resistant bacteria by accelerating research and development for new antibiotics through the CDC and Food and Drug Administration (FDA) **Antibiotic Resistance (AR) Isolate Bank**. The AR Isolate Bank is designed to provide curated drug-resistant isolates to industry, academics, and state partners working on innovative efforts to combat antibiotic resistance.

Education

CDC has led **Get Smart: Know When Antibiotics Work** (Get Smart), educating parents of young children, the general public, and outpatient healthcare providers about antibiotic resistance and best practices in antibiotic use. To support communication between healthcare providers and their patients, the program offers resources such as posters, fact sheets, brochures, videos, and graphics.

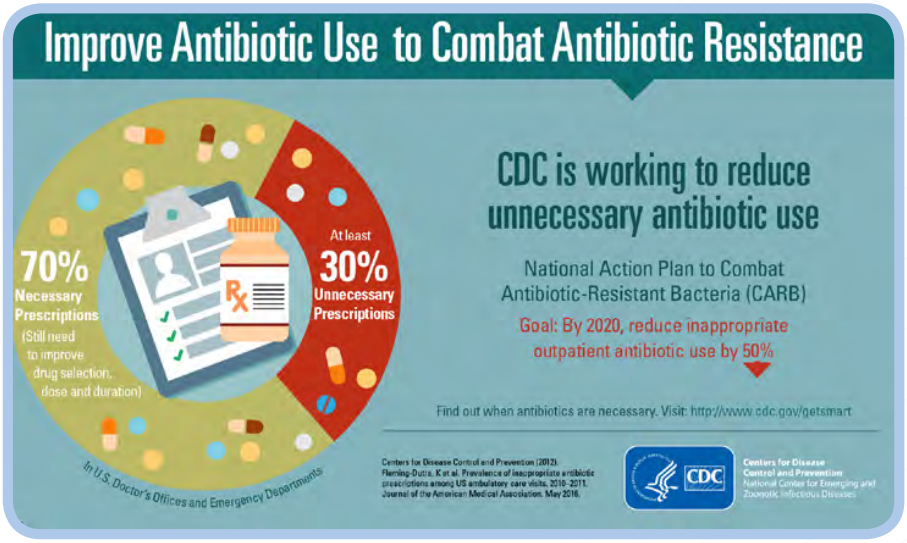
CDC also collaborates with international partners during the annual observance of **U.S. Antibiotic Awareness Week** (formerly Get Smart Week) to raise awareness of the threat of antibiotic resistance and the importance of appropriate antibiotic prescribing. The week coincides with European Antibiotic Awareness Day, Australia's Antibiotic Awareness Week, Canada's Antibiotic Awareness Week, and the World Health Organization's (WHO) World Antibiotic Awareness Week. The goal is to engage professional societies, advocacy groups, for-profit companies, state and local health departments, the general public, and the media around improving antibiotic prescribing and use.

Additionally, there is a critical need to emphasize that the early recognition and treatment of sepsis, followed by reassessing therapy within 48 hours once the patient's culture results are back, as an important part of antibiotic stewardship. CDC is building new educational efforts to ensure that healthcare providers know the importance of early recognition in patients who might have sepsis and of starting them on the right antibiotic quickly.

ANTIBIOTIC USE BY HEALTHCARE SETTING

WHAT DO WE KNOW ABOUT ANTIBIOTIC USE IN OUTPATIENT SETTINGS?

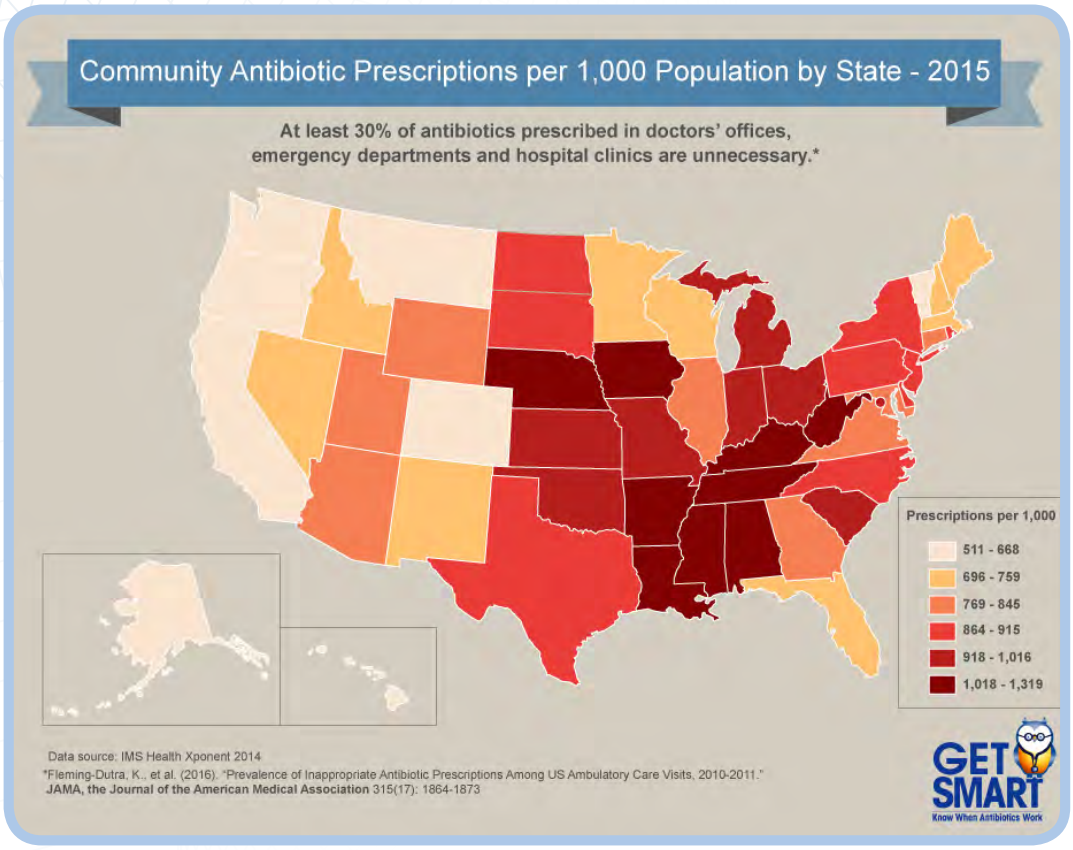
Outpatient settings include healthcare providers (e.g., physicians, dentists, nurse practitioners, and physician assistants) and clinic leaders in primary care, medical and surgical specialties, emergency departments, retail health and urgent care settings, and dental offices. In 2015 alone, approximately 269 million antibiotic prescriptions were dispensed from outpatient pharmacies in the United States, enough for five out of every six people to receive one antibiotic prescription each year. At least 30 percent of these antibiotic prescriptions were unnecessary.[7]



PERCENT OF ANTIBIOTIC PRESCRIPTIONS THAT WERE UNNECESSARY		
	All conditions*	Acute respiratory conditions**
0-19 year olds	29%	34%
20-64 year olds	35%	70%
≥65 year olds	18%	54%
All ages	30%	50%

*All conditions included acute respiratory conditions, urinary tract infections, miscellaneous bacterial infections, and other conditions.

**Acute respiratory conditions included ear infections, sinus infections, sore throats, pneumonia, acute bronchitis, bronchiolitis, upper respiratory infections (i.e., common colds), influenza, asthma, allergy, and viral pneumonia.



Each year, there are 47 million unnecessary antibiotic prescriptions written in U.S. doctors' offices and emergency departments.[7] Most of these unnecessary prescriptions are for respiratory conditions most commonly caused by viruses (including common colds, viral sore throats, and bronchitis) which do not respond to antibiotics, or for bacterial infections that do not always need antibiotics (like many sinus and ear infections). CDC estimated that at least 50 percent of antibiotic prescriptions for these acute respiratory conditions are unnecessary.[8–10] These excess prescriptions each year put patients at needless risk for reactions to drugs or other problems, including *C. difficile* infections. In 2011 alone, one-third of the nearly 500,000 *C. difficile* infections in the United States were community-associated, or happening in patients who had no recent overnight stay in a healthcare facility.[1–4]

The good news is that antibiotic prescribing nationally has improved with a five percent decrease from 2011 to 2014. However, while there have been noticeable declines in antibiotic prescribing in children (0–19) (the population targeted by the Get Smart program) from 75 million prescriptions in 2011 to about 64 million prescriptions in 2014, antibiotic prescription rates for adults have risen slightly from about 192 million in 2011 to 198 million in 2014. Children under two and adults 65 and older still receive the most antibiotic prescriptions. Data also show that antibiotics are prescribed more frequently in states in the Southern and Appalachian regions.

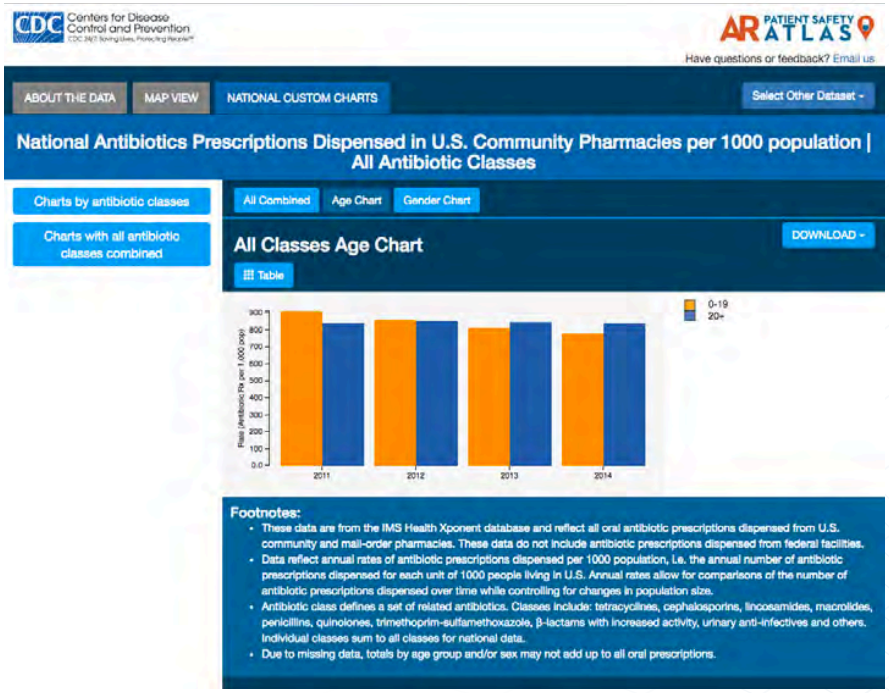
Prescribing the correct antibiotic is another area that requires attention. A CDC and Pew Charitable Trusts study found among outpatient visits in 2010– 2011, when an antibiotic was needed, patients were often prescribed an antibiotic not recommended by current clinical guidelines. For example, for sinus and middle ear infections and sore throats, recommended first-line antibiotics were only used half (52 percent) of the time.[11]

PERCENT OF PATIENTS RECEIVING THE RECOMMENDED FIRST-LINE ANTIBIOTIC BY CONDITION, UNITED STATES, 2010-2011*

	Adults (20+ years of age)	Children (0–19 years of age)
Sinus infection	37%	52%
Pharyngitis (sore throat)	37%	60%
Middle ear infection	N/A	67%

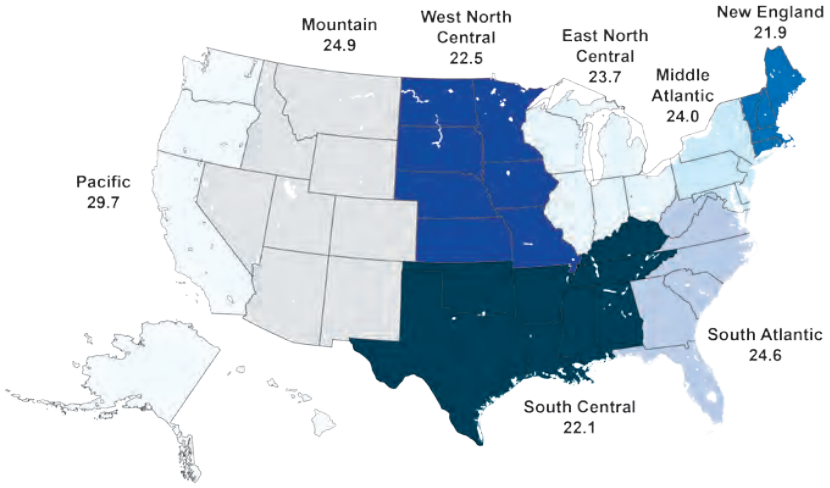
*Based on the prevalence of allergy to first-line antibiotics and estimated treatment failures after first-line antibiotics, at least 80% of patients presenting with these conditions should receive first-line antibiotics. Analysis is based on NAMCS and NHAMCS data.

CDC's Antibiotic Resistance Patient Safety Atlas contains data on antibiotic prescriptions dispensed in outpatient pharmacies per 1,000 people. This interactive database provides information on how antibiotic prescribing varies by state, age group, and over time from 2011–2014.



GEOGRAPHIC VARIABILITY IN HEDIS MEASURES RELATED TO APPROPRIATE ANTIBIOTIC USE

Avoidance of antibiotic treatment in adults with acute bronchitis (average), by Census division, 2008–2012



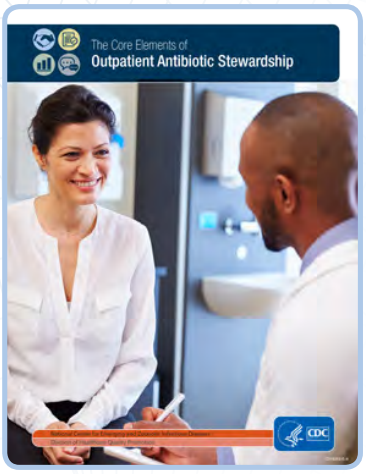
CDC experts found that healthy adults with acute bronchitis only received the right treatment—meaning they did not get an antibiotic—just over 20 percent of the time. This shows that nearly 80 percent of the time, patients were getting an antibiotic unnecessarily.

Improving Antibiotic Use in Outpatient Settings

Over the years there has been little progress made in prescribing for adults, indicating a clear need to better support healthcare providers who prescribe for adults. Family practice physicians prescribe the most antibiotics, but nurse practitioners, physician assistants, internal medicine physicians, pediatricians, and dentists also prescribe antibiotics, making these providers important audiences to reach. Because antibiotics are prescribed more frequently in the Southern and Appalachian regions, there is a need to target antibiotic stewardship efforts to providers and patients in these areas.

ORAL ANTIBIOTIC PRESCRIBING BY PROVIDER TYPE IN THE UNITED STATES IN 2014

Provider type	Number of antibiotic prescriptions in 2014 (millions)
Family Practice Physicians	58.1
Physician Assistants & Nurse Practitioners	54.4
Internal Medicine	30.1
Pediatricians	25.4
Dentistry	24.9
Surgical Specialties	19.9
Emergency Medicine	14.2
Dermatology	7.6
Obstetrics/Gynecology	6.6
Other	25.0
All Providers	266.1



Improving antibiotic prescribing involves implementing effective strategies that follow evidence-based recommendations for diagnosis and management. In 2016, CDC released **The Core Elements of Outpatient Antibiotic Stewardship,** which were published in the ***Morbidity and Mortality Weekly Report (MMWR) Recommendations and Reports***. The Core Elements provides a framework for antibiotic stewardship for outpatient providers and facilities that routinely provide antibiotic treatment. This report augments existing guidance for other clinical settings and is intended for any outpatient provider, clinic or health system interested in improving antibiotic prescribing and use.

CORE ELEMENTS OF OUTPATIENT ANTIBIOTIC STEWARDSHIP

COMMITMENT
Demonstrate dedication to and accountability for optimizing antibiotic prescribing and patient safety.

ACTION FOR POLICY AND PRACTICE
Implement at least one policy or practice to improve antibiotic prescribing, assess whether it is working, and modify as needed.

TRACKING AND REPORTING
Monitor antibiotic prescribing practices and offer regular feedback to providers, or have providers assess their own antibiotic prescribing practices themselves.

EDUCATION AND EXPERTISE
Provide educational resources to providers and patients on antibiotic prescribing, and ensure access to needed expertise on optimizing antibiotic prescribing.

INTENDED AUDIENCES FOR OUTPATIENT ANTIBIOTIC STEWARDSHIP

Primary care clinics and providers: These clinics and providers prescribe approximately half of all outpatient antibiotics in the United States. This includes providers specializing in family practice, pediatrics, and internal medicine, all of whom treat a wide variety of patients and conditions that might benefit from antibiotic treatment.

Outpatient specialty and subspecialty clinics and providers: These clinics and providers focus on treatment and management of patients with specialized medical conditions that sometimes benefit from antibiotic therapy. These specialty clinics include gastroenterology, dermatology, urology, obstetrics, and otolaryngology.

Emergency departments (EDs) and emergency medicine providers: EDs and emergency medicine providers are positioned between acute care hospitals and the community and encounter unique challenges, including lack of continuity of care and higher concentration of patients who might need urgent or even immediate care, as well as unique opportunities for stewardship interventions, such as greater provider access to diagnostic resources and the expertise of pharmacists and consultants.

Retail health clinics and providers: These clinics and providers provide treatment for routine conditions in retail stores or pharmacies and represent a growing category of healthcare delivery in the United States.

Urgent care clinics and providers: These clinics and providers specialize in treating patients who might need immediate attention or need to be seen after hours but might not need to be seen in EDs.

Dental clinics and dentists: Dental clinics and dentists use antibiotics as prophylaxis before some dental procedures and for treatment of dental infections.

Nurse practitioners and physician assistants: These providers work in every medical specialty and subspecialty involved in antibiotic prescribing and should be included in antibiotic stewardship efforts.

Healthcare systems: Healthcare systems plan, deliver, and promote healthcare services and often involve a network of primary and specialty outpatient clinics, urgent care centers, EDs, acute care hospitals, and other facilities that provide healthcare services. Healthcare systems can use existing antibiotic stewardship programs or develop new ones to promote appropriate antibiotic prescribing practices in their outpatient facilities as well as across the system.

CDC collaborates with partners to implement appropriate antibiotic use efforts at a local level. CDC funds and supports many state and local health departments and other partners across the country to implement targeted antibiotic stewardship improvements in outpatient settings.

Illinois Department of Public Health: Precious Drugs and Scary Bugs

In 2015, the Illinois Department of Public Health (IDPH) developed the **Precious Drugs and Scary Bugs** program to improve the appropriate use of antibiotics, particularly for acute respiratory infections, in primary care, urgent care, and community health centers. IDPH asked healthcare providers to:

- Display a poster in exam rooms stating their commitment to appropriate antibiotic prescribing.
- Participate in educational webinars.
- Track their antibiotic prescribing data.
- Complete baseline and follow-up surveys.

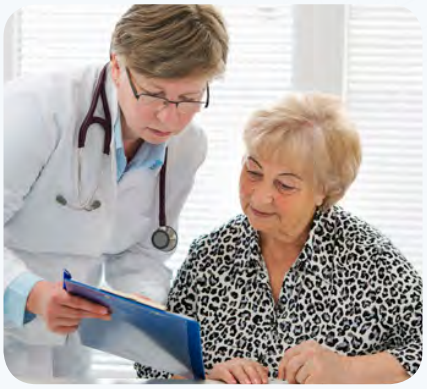
Thirty-eight outpatient practices participated representing 239 healthcare providers. More than 500 commitment posters were printed and distributed. Participating healthcare providers reported that the poster improved communication, addressed patient expectations regarding antibiotics for acute respiratory infections, and reinforced a uniform message.

New York State Department of Health: Commitments to Appropriate Antibiotic Prescribing

In 2016, the New York State Department of Health (NYSDOH) offered a **"Get Smart Guarantee" poster** for healthcare providers to pledge to only prescribe antibiotics when they are needed. The "Guarantee" poster could be personalized with the provider's photo and signature. Some providers indicate patients expect antibiotics even if the illness is viral (where antibiotics would not be effective) so NYSDOH developed a **"Get Smart Guarantee" palm card**. This takeaway serves in lieu of a prescription for antibiotics so patients understand their concerns have been heard and validated. The poster and palm card are offered in English and Spanish.

Utah Department of Health: Using Data to Identify Best and Worst Performing Clinics

The Utah Health Department shared data publicly on the **Open Data Catalog** website to show which clinics in the state had the best and worst performance on the HEDIS® measure: Avoidance of antibiotic treatment in adults with acute bronchitis (which usually does not require antibiotics). Utah used its All Payer Claims Database, which combines eligibility, medical claims, pharmacy claims, and provider files each month, to compile 2013-2014 data.



HEALTHCARE PROVIDERS, PATIENTS, AND FAMILIES PLAY A CRITICAL ROLE IN SUPPORTING OPTIMAL ANTIBIOTIC USE AND PREVENTING INFECTIONS IN OUTPATIENT SETTINGS.

What can healthcare providers do to support appropriate antibiotic use and prevent infections in outpatient settings?

- ❑ Follow clinical guidelines when prescribing antibiotics.
  - ▶ Use the right antibiotic, at the right dose, for the right duration, and at the right time.
- ❑ Place written commitments in support of improving antibiotic use in exam rooms to help facilitate patient communication about appropriate antibiotic use.
  - ▶ Give patients information and materials on appropriate antibiotic use to reference. See examples of **print materials for everyone**.
- ❑ Talk to patients and families about when antibiotics are and are not needed, and discuss possible harms such as allergic reactions, *C. difficile*, and antibiotic-resistant infections.
  - ▶ Ask patients if they have ever had a *C. difficile* infection, and tailor antibiotic treatment accordingly.
- ❑ For patients with conditions that usually resolve without antibiotic treatment:
  - ▶ Talk to patients about ways to relieve their symptoms without antibiotics.
  - ▶ Discuss a clear plan for follow-up if symptoms worsen or do not improve.
- ❑ Be aware of antibiotic resistance patterns in your community; use the data to inform prescribing decisions.
- ❑ Follow hand hygiene and other infection prevention measures with every patient.

What can patients and families do to support appropriate antibiotic use and prevent infections in outpatient settings?

- ❑ Talk to your healthcare provider about when antibiotics will and won't help, and ask about antibiotic resistance.
- ❑ Talk to your healthcare provider about how to relieve symptoms.
- ❑ Take antibiotics only when prescribed and exactly as prescribed.
- ❑ Don't save an antibiotic for later or share the drugs with someone else.
- ❑ Insist that everyone cleans their hands before touching you.
- ❑ Stay healthy and keep others healthy by cleaning hands, covering coughs, staying home when sick, and getting recommended vaccines.

WHAT DO WE KNOW ABOUT ANTIBIOTIC USE IN NURSING HOMES?

Current data on antibiotic use in nursing homes is limited so the information here is based on a few small studies. Over the course of a year, approximately 4 million individuals receive care and services in a nursing home. Antibiotics are some of the most commonly prescribed medications in nursing homes with 50 to 70 percent of residents receiving an antibiotic over the course of a year.[12,13] Up to 75 percent of antibiotics prescribed in nursing homes are prescribed incorrectly.[12,13] The most common prescribing problems in nursing homes are using an antibiotic when not needed, choosing the wrong antibiotic, and using the correct antibiotic but for the wrong dose or duration. Prescribing problems can lead to harm including side effects, allergic reactions, *C. difficile* infection, and antibiotic-resistant infections. This is especially concerning because nursing home residents are already at high risk for getting a *C. difficile* infection.

From December 2013 to May 2014, CDC examined the medical records of nine U.S. nursing homes in four different states to assess how many antibiotics residents received in a single day and the documentation for those prescriptions. Researchers found that 11 percent of nursing home residents were on antibiotics on any single day. One in three of these antibiotic prescriptions was for the treatment of urinary tract infections; yet at least half of these prescriptions were for either the wrong drug, dose, or duration. Finally, 38 percent of orders for antibiotics lacked documentation of one or more important prescribing elements.[14] CDC is launching a study with a larger number of nursing homes and pursuing partnerships with nursing home networks, pharmacies, and other companies to identify where action is needed most.

Improving Antibiotic Use in Nursing Homes

To protect nursing home residents, in 2015 CDC released **The Core Elements of Antibiotic Stewardship for Nursing Homes**. By adapting hospital recommendations to the nursing home setting, the Core Elements guide provides practical ways for nursing homes to initiate or expand antibiotic stewardship activities. The guide provides examples of how antibiotic use can be monitored and improved by nursing home leadership and staff. The companion checklist can be used to assess policies and practices already in place and to review progress in expanding stewardship activities. CDC works to provide support and technical assistance to health departments and nursing home partners to help implement the Core Elements in nursing homes.

CORE ELEMENTS OF ANTIBIOTIC STEWARDSHIP FOR NURSING HOMES

LEADERSHIP COMMITMENT
Demonstrate support and commitment to safe and appropriate antibiotic use in your facility.

ACCOUNTABILITY
Identify physician, nursing and pharmacy leads responsible for promoting and overseeing antibiotic stewardship activities in your facility.

DRUG EXPERTISE
Establish access to consultant pharmacists or other individuals with experience or training in antibiotic stewardship for your facility.

ACTION
Implement at least one policy or practice to improve antibiotic use.

TRACKING
Monitor at least one process measure of antibiotic use and at least one outcome from antibiotic use in your facility.

REPORTING
Provide regular feedback on antibiotic use and resistance to prescribing clinicians, nursing staff and other relevant staff.

EDUCATION
Provide resources to clinicians, nursing staff, residents and families about antibiotic resistance and opportunities for improving antibiotic use.

CDC collaborates with partners to implement appropriate antibiotic use efforts at a local level. CDC funds and supports many state and local health departments and other partners across the country to implement targeted antibiotic stewardship improvements in nursing homes.

Massachusetts Department of Public Health: Reducing *C. difficile* through Educational Interventions in Nursing Homes

The Massachusetts Department of Public Health extended *C. difficile* prevention activities from acute care hospitals into nursing homes. Sixteen nursing homes implemented multi-faceted educational interventions to reduce unnecessary antibiotic use for asymptomatic bacteriuria (when bacteria are found in urine without causing symptoms of a urinary tract infection). They conducted in-person trainings on antibiotic use for urinary tract infections and engaged patients and families. After one year, nursing homes experienced:

- Improved urinary tract infection diagnostic practices with a 28 percent decrease in unnecessary urine cultures for patients who did not have symptoms of urinary tract infection.
- Decreased antibiotic use with a 37 percent reduction in antibiotics given to patients experiencing asymptomatic bacteriuria.
- Improved patient outcomes with a 47 percent reduction in healthcare-acquired *C. difficile* infections.

Presbyterian Senior Care Network: Implementing the Core Elements of Antibiotic Stewardship for Nursing Homes

Presbyterian Senior Care Network is a network of senior care and independent living facilities in Erie, Pennsylvania. The first Antibiotic Stewardship Program team was initiated by two nurses focused on quality care and infection prevention and control. They anticipate all Presbyterian Senior Care Network communities will adopt the program over time. Their activities are based on **CDC's Core Elements of Antibiotic Stewardship for Nursing Homes**.

State Policies to Improve Antibiotic Use in Nursing Homes

- **State of California: Requiring Antibiotic Stewardship in Nursing Homes**
  California Senate Bill 361 required skilled nursing facilities to adopt and implement an antibiotic stewardship policy by January 1, 2017. According to the bill, the antibiotic stewardship policy should be consistent with **CDC's Core Elements of Antibiotic Stewardship for Nursing Homes**. California was the first state to enact legislation to improve antibiotic use in nursing homes.

HEALTHCARE PROVIDERS, RESIDENTS, AND FAMILIES PLAY A CRITICAL ROLE IN SUPPORTING OPTIMAL ANTIBIOTIC USE AND PREVENTING INFECTIONS IN NURSING HOMES.

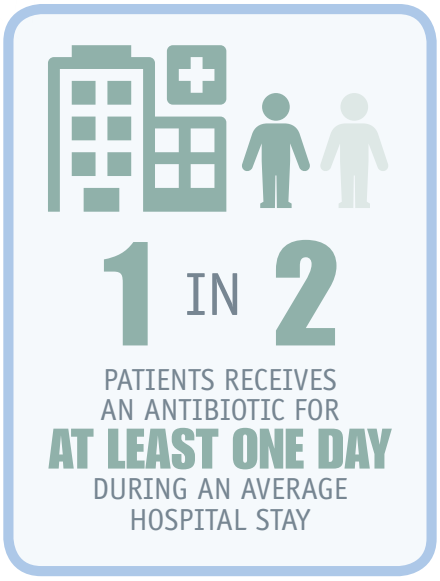
What can healthcare providers do to support appropriate antibiotic use and prevent infections in nursing homes?

- ❑ Follow clinical guidelines when prescribing antibiotics.
  - ▶ Use the right antibiotic, at the right dose, for the right duration, and at the right time.
- ❑ Review antibiotic therapy 2-3 days after it is started based on the resident's clinical condition and microbiology culture results.
- ❑ Talk to residents and their families about when antibiotics are and are not needed, and discuss possible harms such as allergic reactions, *C. difficile* and antibiotic-resistant infections.
  - ▶ Ask residents if they have ever had a *C. difficile* infection, and tailor antibiotic treatment accordingly.
- ❑ Be aware of antibiotic resistance patterns in your facility and community; use the data to inform prescribing decisions.
- ❑ Follow hand hygiene and other infection prevention measures with every resident.

What can residents and families do to support appropriate antibiotic use and prevent infections in nursing homes?

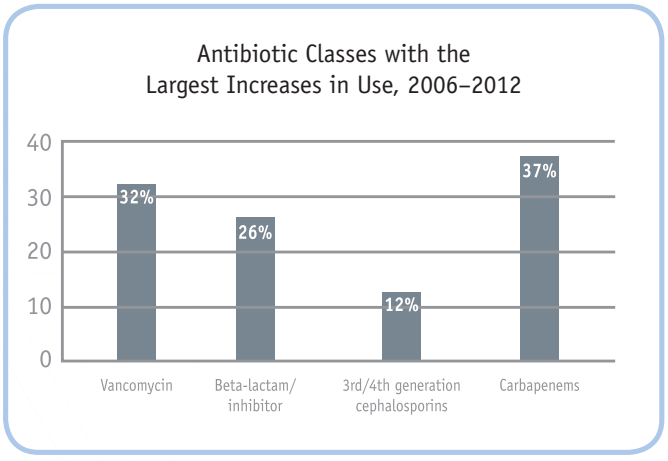
- ❑ Talk to your healthcare provider about when antibiotics will and won't help, and ask about antibiotic resistance.
- ❑ Ask what infection an antibiotic is treating, how long antibiotics are needed, and what side effects might happen.
- ❑ Ask what your nursing home is doing to protect you from antibiotic-resistant and *C. difficile* infections.
- ❑ Insist that everyone cleans their hands before touching you.
- ❑ Ask visitors and family not to visit when they feel ill.
- ❑ Get vaccinated for flu and pneumonia, and encourage others to stay up-to-date on vaccines.

WHAT DO WE KNOW ABOUT ANTIBIOTIC USE IN HOSPITALS?



In a 2016 study, CDC experts found that overall rates of antibiotic use in U.S. hospitals did not change from 2006-2012. More than half of patients received at least one antibiotic during their hospital stay.[15] However, there were significant changes in the types of antibiotics prescribed with the most powerful antibiotics being used more often than others. There was a 37 percent rise in the use of carbapenems. Infections caused by bacteria that develop resistance to carbapenems can be especially hard to treat, and even deadly. There was also a 32 percent rise in the use of vancomycin, an important antibiotic used to treat common antibiotic-resistant infections caused by methicillin-resistant *Staphyloccus aureus,* or MRSA. Data from **CDC's National Healthcare Safety Network** Antimicrobial Use Option show healthcare providers in some hospitals prescribe up to three times as many antibiotics as providers in similar areas of other hospitals. This variation suggests there are opportunities to improve prescribing practices.

One-third of antibiotic prescriptions in hospitals involve potential prescribing problems such as giving an antibiotic without proper testing or evaluation, prescribing an antibiotic when it is not needed, or giving an antibiotic for too long.[16] **The National Action Plan for Combating Antibiotic-Resistant Bacteria** sets a goal that all hospitals have antibiotic stewardship programs to help reduce inappropriate antibiotic prescriptions by 20 percent by 2020.



A national survey of antibiotic use done by **CDC's Emerging Infections Programs** identified key opportunities to reduce inappropriate use. This study found that two out of three antibiotics in hospitals are given for three conditions: pneumonia, urinary tract infections (including bladder and kidney infections), and skin infections.[17] There are **data** showing a variety of ways to improve antibiotic use in treating these conditions, so targeting them could have a large impact on improving appropriate antibiotic use. Likewise, studies have shown that there are many opportunities to improve the use of vancomycin and fluoroquinolones, two of the most commonly prescribed antibiotics in hospitals.

Improving Antibiotic Use in Hospitals

Evidence demonstrates that hospital-based antibiotic stewardship programs improve the treatment of infections and reduce side effects associated with antibiotic use. They also significantly reduce hospital rates of *C. difficile* infection and antibiotic resistance. Moreover, these programs often achieve these benefits while saving hospitals money.

In 2014 CDC recommended that all acute care hospitals implement antibiotic stewardship programs. **CDC's Core Elements of Hospital Antibiotic Stewardship Programs** provides a framework for establishing and improving antibiotic stewardship in hospitals. Since their adoption, the Core Elements have been used as an implementation framework by large health systems and have become part of The Joint Commission's accreditation standard for antibiotic stewardship.

CORE ELEMENTS OF ANTIBIOTIC STEWARDSHIP FOR HOSPITALS

LEADERSHIP COMMITMENT Dedicating necessary human, financial and information technology resources.

ACCOUNTABILITY Appointing a single leader responsible for program outcomes. Experience with successful programs show that a physician leader is effective.

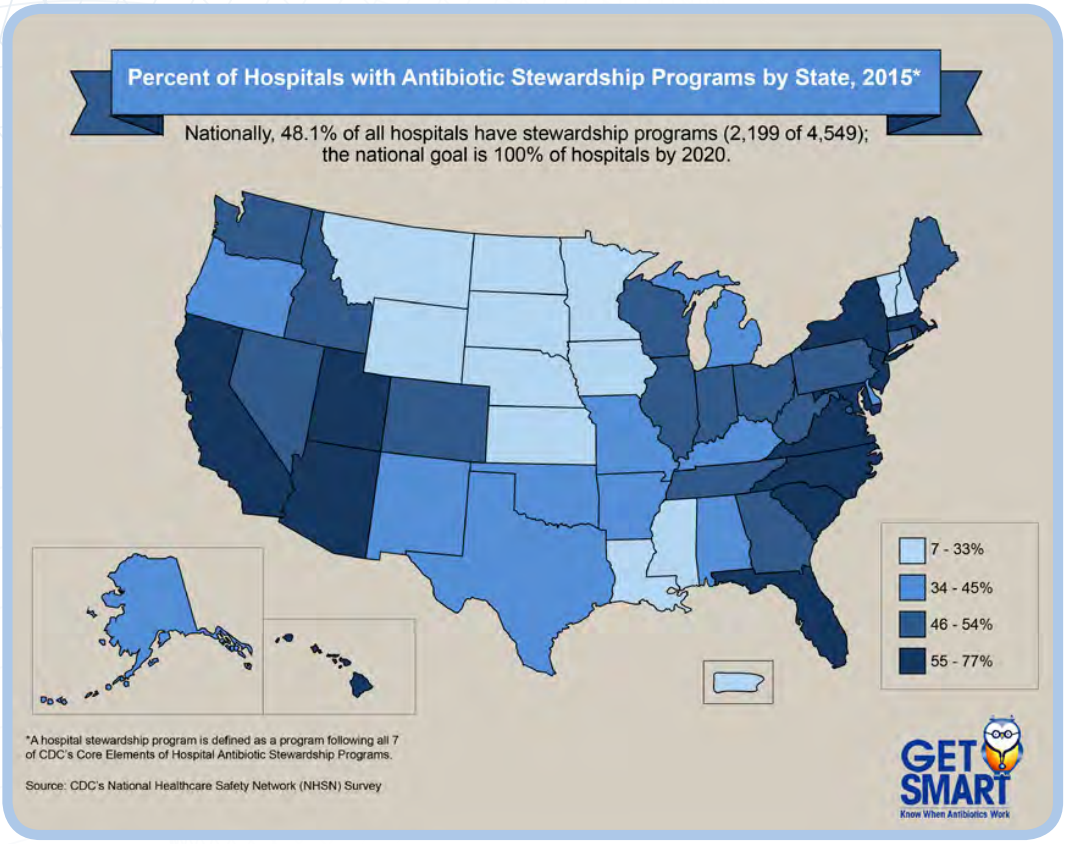
DRUG EXPERTISE Appointing a single pharmacist leader responsible for working to improve antibiotic use.

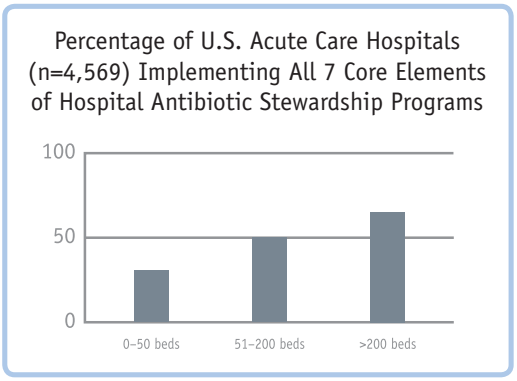
ACTION Implementing at least one recommended action, such as systemic evaluation of ongoing treatment need after a set period of initial treatment (i.e. "antibiotic time out" after 48 hours).

TRACKING Monitoring antibiotic prescribing and resistance patterns.

REPORTING Regular reporting information on antibiotic use and resistance to doctors, nurses and relevant staff.

EDUCATION Educating clinicians about resistance and optimal prescribing.





The Core Elements were designed to be flexible enough to be adopted in hospitals of any size. In 2016, CDC partnered with the National Quality Partnership of the National Quality Forum, a not-for-profit, nonpartisan, membership-based organization that works to catalyze improvements in health care, to lead a team of experts in creating a practical guide to help hospitals implement the Core Elements. **The Antibiotic Stewardship in Acute Care: A Practical Playbook** provides real-world strategies to help hospitals and health systems of all sizes implement and improve antibiotic stewardship programs.

CDC has been assessing the implementation of the Core Elements through the NHSN Annual Survey. In 2014, 41 percent of hospitals reported implementing all seven elements. By 2015, that had increased to 48 percent. However, there were important differences in implementation, with larger hospitals showing much more uptake: 66.1 percent of hospitals with over 200 beds reported all seven Core Elements, compared to 49.6 percent of hospitals with 51–200 beds and 31.1 percent of hospitals with 1–50 beds. Data from this survey indicate that there is much more to do, especially in smaller hospitals which face special challenges in implementing the Core Elements. CDC partnered with The Pew Charitable Trusts, the American Hospital Association and the Federal Office of Rural Health Policy to develop **Implementation of Antimicrobial Stewardship Core Elements at Small and Critical Access Hospitals** to support the implementation of stewardship programs in these hospitals.

CDC's Standardized Antimicrobial Administration Ratio (SAAR): Assessment Tool Offers Step for Improvement

The NHSN Antimicrobial Use Option is available to hospitals currently using NHSN and allows hospitals to monitor antibiotic use. The centerpiece of the Antimicrobial Use Option is a risk-adjusted benchmarking measure of antibiotic use, the Standardized Antimicrobial Administration Ratio, or SAAR, which was endorsed by the National Quality Forum in 2016. The SAAR calculates the ratio of observed antibiotic use to predicted antibiotic use, based on modeled data from all reporting hospitals and allows hospitals to compare their antibiotic use with similar facilities. The SAAR offers a way to collect data for action by allowing facilities to not only compare their antibiotic use to others, but to monitor use over time. CDC is working with a variety of experts to further improve the SAAR. For example, experts suggested that a variety of different benchmarks would be most useful, so CDC has developed SAARs for five different antibiotic categories and several different hospital locations.

While the SAAR cannot be used to measure the appropriateness of antibiotic use in a hospital, it can be used to direct hospital antibiotic stewardship programs to areas where antibiotic use deviates from what is expected. A high SAAR signals a need for further review to see if there are opportunities to improve use. CDC collaborated with The Pew Charitable Trusts and a number of experts to develop an assessment tool to help hospitals find opportunities to improve use in locations with high SAARs. Though the tool is designed to be used in conjunction with the SAAR, it could be used to look for improvement opportunities in any location where stewardship programs believe use is higher than expected. For more information on the SAAR and strategies to assess antibiotic use in hospitals, visit **Strategies to Assess Antibiotic Use to Drive Improvements In Hospitals**.

CDC collaborates with partners to implement appropriate antibiotic use efforts at a local level. CDC funds and supports many state and local health departments and other partners across the country to implement targeted antibiotic stewardship improvements in hospitals.

Ascension: Building the Infrastructure for Antibiotic Stewardship in a Large Health System

Ascension is the largest non-profit health system in the United States, with facilities in 25 states and the District of Columbia, including 141 hospitals and more than 21,000 acute care beds. Ascension has made swift progress in its antibiotic stewardship efforts by implementing four strategies in support of full implementation of **CDC's Core Elements** in all Ascension hospitals:

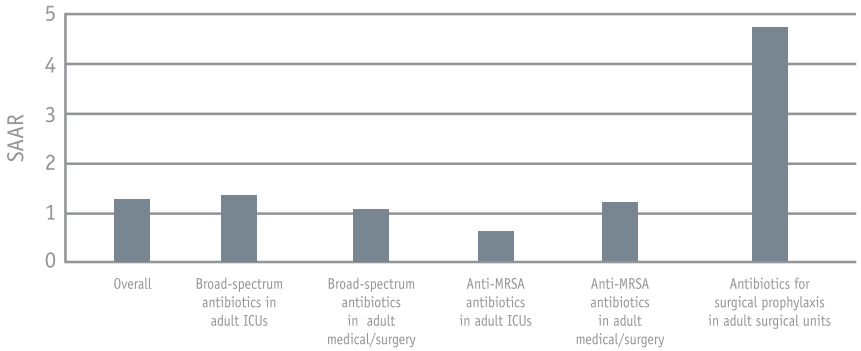
- Making antibiotic stewardship a system priority with full leadership support.
- Creating an infrastructure to promote and share best practices.
- Promoting the careful use of narrow-spectrum antibiotics (antibiotics that are specifically effective against a limited number of bacteria).
- Helping hospitals achieve their goals by investing in clinical decision support systems, strengthening local expertise, and tracking and evaluating antibiotic use data.

As a result of these efforts, Ascension has seen reductions in antibiotic use and 15.9 percent reduction in *C. difficile* infections. One 376-bed teaching hospital drove a 70 percent drop in the use of selected antibiotics over a six-month period.

Intermountain Healthcare: Using Data to Identify Opportunities for Improvement

Intermountain Healthcare is a not-for-profit health system based in Salt Lake City, Utah, with 22 hospitals, about 1,400 primary care and secondary care physicians at more than 185 clinics in the Intermountain Medical Group, and health insurance plans from SelectHealth. Intermountain Healthcare has been an early adopter of the NHSN Antimicrobial Use Option and has been using the data for action. For example, they identified one facility that had an overall antibiotic SAAR measure indicating use was as expected, but found one very high SAAR – for antibiotics used for surgical prophylaxis on adult surgical units—indicating higher use of these antibiotics than would be expected. This highlighted a specific area for further exploration and improvement.

Ratio of observed to expected antibiotic use (SAAR*) by category and unit type in one Intermountain Healthcare facility, Quarter 1, 2016.



*Standardized Antimicrobial Administration Ratio. A SAAR value of less than 1 indicates less than expected antibiotic use, and a value greater than 1 indicates higher than expected antibiotic use.

Southwest Health System: Pharmacist-led Antibiotic Stewardship in a Small Health System

Southwest Health System (SHS) serves about 50,000 people in rural southwest Colorado, and in parts of Utah, Arizona, and New Mexico, and the Ute Mountain and Navajo reservations. SHS has 25 inpatient beds and 8 clinics. SHS has made antibiotic stewardship a priority through a variety of strategies while implementing CDC's Core Elements:

- Creating a stewardship team of hospital leaders, including laboratory professionals, physicians, pharmacists, infection preventionists, nurse educators, and a wound care specialist.
- Using pharmacists to lead the antibiotic stewardship program. Pharmacists also work to decrease risk of *C. difficile* by adjusting medications.
- Educating hospital staff and providing feedback through active daily rounding where staff discuss medications, antibiotic choice, duration of therapy, and discharge medications.
- Collaborating with partners in a state-wide antibiotic stewardship collaborative (including implementation of a urinary tract infection (UTI)/upper respiratory infection (URI) stewardship program in SHS' eight clinics) and seeking efforts to expand stewardship to local long-term care organizations and dentists.

The Richard L. Roudebush Indianapolis Veterans Affairs Medical Center: Using NHSN Data to Evaluate a Stewardship Activity

The Richard L. Roudebush VA Medical Center located in Indianapolis, Indiana, is a general medical and surgical hospital and teaching hospital with 150 beds. The organization used CDC's NHSN Antimicrobial Use Option to evaluate their hospital stewardship program. Infectious disease physicians and clinical pharmacists tracked and reviewed antibiotic usage in their hospital and gave feedback to providers. They used NHSN data to track antibiotic use before and after the intervention and identified a hospital-wide decrease in antibiotic use, as reflected in lower SAAR values, especially in anti-MRSA agents and antibiotics used for hospital onset infections, which were targets of their reviews.

State Policies to Improve Antibiotic Use in Hospitals

- California: California Senate Bills 739 and 1311 require hospitals to develop a process for monitoring antibiotic use and implementing antibiotic stewardship. California was the first state to enact legislation to improve antibiotic use.
- Missouri: In addition to requiring all Missouri hospitals to create antibiotic stewardship programs, Missouri Senate Bill 579 (passed in 2016), requires that all non-psychiatric hospitals must begin reporting antibiotic use to CDC's NHSN by August 2017.

HEALTHCARE PROVIDERS, PATIENTS, AND FAMILIES PLAY A CRITICAL ROLE IN SUPPORTING OPTIMAL ANTIBIOTIC USE AND PREVENTING INFECTIONS IN HOSPITALS.

What can healthcare providers do to support appropriate antibiotic use and prevent infections in hospitals?

- ❑ Follow clinical guidelines when prescribing antibiotics.
  - ▶ Use the right antibiotic, at the right dose, for the right duration, and at the right time.
- ❑ Review antibiotic therapy 2–3 days after it is started based on the patient's clinical condition and microbiology culture results.
- ❑ Talk to patients and families about when antibiotics are and are not needed, and discuss possible harms such as allergic reactions, *C. difficile* and antibiotic-resistant infections.
  - ▶ Ask patients if they have ever had a *C. difficile* infection, and tailor antibiotic treatment accordingly.
- ❑ Be aware of antibiotic resistance patterns in your facility and community; use the data to inform prescribing decisions.
- ❑ Follow hand hygiene and other infection prevention measures with every patient.

What can patients and families do to support appropriate antibiotic use and prevent infections in hospitals?

- ❑ Talk to your healthcare provider about when antibiotics will and won't help, and ask about antibiotic resistance.
- ❑ Ask what infection an antibiotic is treating, how long antibiotics are needed, and what side effects might happen.
- ❑ Tell your healthcare provider if you have been hospitalized in another facility or have recently taken antibiotics.
- ❑ If you have a urinary catheter, ask daily if it's necessary.
- ❑ Ask what your hospital is doing to protect you and your family from antibiotic-resistant and *C. difficile* infections.
- ❑ Insist that everyone cleans their hands before touching you.
- ❑ Get vaccinated for flu and pneumonia, and encourage others to stay up-to-date on vaccines.

CONCLUSION

Antibiotics have saved millions of lives and transformed modern medicine, but they are becoming less effective and therefore are an increasingly limited resource. Too often antibiotics are used inappropriately, putting patients at risk for developing antibiotic-resistant infections, *C. difficile* infections, or a number of other problems. With the implementation of antibiotic stewardship programs and resources, patients should expect to receive the right antibiotic, at the right time, with the right dose and duration.

Across the United States, the number of antibiotic prescriptions given to children and adults remains high. Numerous studies have found that antibiotics are being prescribed for illnesses which do not require antibiotics, and the incorrect type of antibiotic, dose, or duration are often prescribed across all healthcare settings. In outpatient settings, acute respiratory infections are the leading cause of inappropriate prescribing, while in nursing homes and hospitals, urinary tract infections and pneumonia are the leading conditions for which antibiotic prescribing needs to be improved. Additionally, antibiotic overuse may cost the lives of thousands due to deadly *C. difficile* infection.

CDC has helped combat inappropriate antibiotic use and antibiotic resistance with the **Antibiotic Resistance Solutions Initiative**, by collaborating with healthcare partners to promote the importance of appropriate antibiotic use, and by educating healthcare providers and patients. The Core Elements of Antibiotic Stewardship provide a framework for antibiotic stewardship and outline how healthcare providers, health systems, hospitals, clinics, and nursing homes can participate as active forces in helping to improve antibiotic use. Many hospitals have already improved their antibiotic prescribing by following the Core Elements, paving the way for more action and better patient outcomes. When antibiotic stewardship programs and practices are adopted, patients receive the best antibiotic treatment.

Engaging patients is critical to the effort to improve antibiotic use. Helping patients know what they can do to keep themselves and their loved ones safe is part of the discussion of improving antibiotic use. This means raising awareness about the side effects of antibiotics, as well as the unintended consequences of antibiotic use. CDC's new and existing educational efforts will work to ensure that antibiotics are used properly and that patients who might have sepsis are recognized and started on the right antibiotic quickly, and reassessed within 48 hours when the patient's culture results are back.

Efforts to improve antibiotic use will succeed only if everyone plays a role. Success will depend upon coordinated efforts to promote and adopt principles of responsible antibiotic prescribing and use across the globe, from government agencies, foundations, professional organizations, companies, health systems, hospitals, clinics, nursing homes, patients, and healthcare providers. CDC is committed to using data for action, supporting implementation of programs and practices to optimize antibiotic use, working with partners, driving innovation, and educating patients and healthcare providers about the benefits and risks of antibiotics.

When everyone plays their part to improve antibiotic use, patient safety is preserved and life-saving antibiotics will be available for generations to come.

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The Core Elements of Outpatient Antibiotic Stewardship

Appendix

National Center for Emerging and Zoonotic Infectious Diseases
Division of Healthcare Quality Promotion

CS268900-A

Appendix A. Supplemental Evidence Supporting Outpatient Stewardship

Systematic Reviews

REFERENCE	INTERVENTIONS AND OUTCOMES	METHODS, PARTICIPANTS, AND SETTINGS	RESULTS	CONCLUSIONS
Arnold SR, et al. **Interventions to improve antibiotic prescribing practices in ambulatory care.** *Cochrane Database Syst Rev* 2005. 4:CD003539.	**Interventions** • Physician educational materials • Audit and feedback • Educational meetings • Educational outreach visits • Financial and healthcare system changes • Physician reminders • Patient-based interventions • Multi-faceted interventions **Outcomes** • Improve selection, dose and duration of antibiotics prescribed • Reduce incidence of pathogens with antimicrobial resistance	**Methods** • Systematic review **Participants** • Healthcare consumers or primary care providers **Setting** • Primary care clinics and ambulatory care clinics	• 39 studies • Only small changes observed for single interventions using printed educational materials or audit and feedback. • Active educational interventions are more effective than nonactive interventions. • Delayed prescriptions effectively reduced antibiotic use by patients without negatively affecting patient outcomes. • Multifaceted interventions were more successful in decreasing inappropriate antibiotic prescribing.	• Multifaceted interventions are most effective. • No single intervention is recommended for all settings.
Drekonja DM et al. **Antimicrobial stewardship in outpatient settings: a systematic review.** *Infect Control Hosp Epidemiol* 2015. Feb;36(2):142-52.	**Interventions** • Provider and or patient education • Provider feedback • Delayed prescribing • Communication skills training • Guidelines • Restriction Policies • Computerized clinical decision support • Financial incentives • Rapid diagnostics • Costs reporting **Outcomes** • Prescribing outcomes • Patient outcomes • Microbial outcomes • Costs	**Methods** • Systematic review **Participants** • Primarily healthcare consumers and primary care providers **Setting** • Primary care clinics and ambulatory care clinics	• 50 studies • Stewardship programs using communication skills training and laboratory testing can lower antibiotic use. • Several stewardship interventions can effectively improve antibiotic prescribing. • Patient outcomes were not often reported, but did not appear to worsen due to intervention.	• Outpatient antibiotic stewardship programs can improve antibiotic prescribing without negatively affecting patient outcomes. • Sustainability and scalability of specific interventions is less clear.

REFERENCE	INTERVENTIONS AND OUTCOMES	METHODS, PARTICIPANTS, AND SETTINGS	RESULTS	CONCLUSIONS
McDonagh M, et al. **Improving Antibiotic Prescribing for Uncomplicated Acute Respiratory Tract Infections.** *AHRQ Comparative Effectiveness Reviews* 2016. No. 163.	**Interventions** • Education • Communication • Clinical • System-level • Multifaceted interventions **Outcomes** • Improvement of appropriate antibiotic prescribing • Reduction in antibiotic resistance • Reduction in overall antibiotic prescribing for acute respiratory tract infections (RTIs) • Increases in adverse drug events • Increases in patient dissatisfaction	**Methods** • Systematic review **Participants** • Healthcare consumers (both adults and children) with acute RTIs • Primary care providers **Setting** • Primary care clinics and ambulatory care clinics	• 133 studies • Four interventions showed evidence of improving antibiotic prescribing with without worsening patient outcomes due to reductions in antibiotic prescribing: • Clinic-based parent education (21% reduction). • Public patient education campaigns combined with clinician education (7% prescribing reduction). • Procalcitonin for adults (12% to 72% prescribing reduction). • Electronic decision support systems (improved antibiotic selection and 5% to 9% reduction in prescribing). • Public parent education campaigns reduce overall prescribing without increasing followup visits.	• Several interventions safely reduced antibiotic prescribing or improved appropriate antibiotic prescribing without adversely affecting patient outcomes. • These include education for patients, parents, and clinicians, procalcitonin testing in adults, and electronic clinician decision support.
Ranji SR, et al. **Closing the quality gap: A critical analysis of quality improvement strategies.** (Vol. 4: Antibiotic Prescribing Behavior). Agency for Healthcare Research and Quality (US). 2006. Rockville, MD.	**Interventions** • Clinician education • Patient education • Delayed prescriptions • Audit and feedback • Clinician reminders • Financial or regulatory incentives **Outcomes** • Reductions in inappropriate antibiotic prescribing • Prescribing antibiotics for non-bacterial illnesses • Prescribing broad-spectrum antibiotics when narrow-spectrum agents are indicated	**Methods** • Systematic review **Participants** • Healthcare consumers (both adults and children) with acute respiratory infections • Primary care providers **Setting** • Primary care clinics and ambulatory care clinics	• 54 studies • Interventions demonstrated a median absolute effect of -8.9% reduction in prescribing antibiotic for non-bacterial illnesses. • Antibiotic resistance was measured in two studies, neither of which showed a reduction in resistance. • No individual intervention was most effective at reducing prescribing. • Active educational strategies target clinicians appeared more effective than passive strategies.	• Selected interventions appear effective at reducing both antibiotic overprescribing and inappropriate antibiotic selection. • No single intervention was clearly more effective than others. • Active clinician education interventions appear more effective than passive education.

REFERENCE	INTERVENTIONS AND OUTCOMES	METHODS, PARTICIPANTS, AND SETTINGS	RESULTS	CONCLUSIONS
Ranji SR, et al. **Interventions to reduce unnecessary antibiotic prescribing: A systematic review and quantitative analysis.** *Med Care* 2008. 46(8):847-62.	**Interventions** • Clinician education • Patient education • Audit and feedback • Clinician reminders **Outcomes** • Reduction in proportion of patients receiving antibiotics	**Methods** • Systematic review and quantitative analysis **Participants** • Healthcare consumers (both adults and children) with acute outpatient infections • Primary care providers **Setting** • Primary care clinics and ambulatory care clinics	• 43 studies • Most studies examined antibiotic prescribing for acute respiratory infections. • The quantitative analysis (n=30 studies) found a median reduction of 9.7% in the percent of patients receiving antibiotics • No single intervention was clearly superior. • Active clinician education strategies had a nonsignificant trend toward better efficacy compared to passive education strategies.	• Some interventions are effective at reducing antibiotic use in outpatient settings. • Active clinician education strategies appear to work better than passive education strategies. • Targeting antibiotic prescribing for all ARIs, versus single diagnoses, may lead to larger reductions in antibiotic use.
van der Velden AW, et al. **Effectiveness of physician-targeted interventions to improve antibiotic use for respiratory tract infections.** *Br J of Gen Pract* 2012. 62(605):e801-7.	**Interventions** • Educational materials (patients, clinicians, and the general public) • Educational meetings • Consensus procedure • Local opinion leaders • Near-patient testing • Audit and feedback • Financial incentives • Communications skills training **Outcomes** • Difference of differences for interventions with a before and after measurement with a control group • Differences for interventions with a before and after measurement without a control group • Difference in after measurement for interventions with a control group but without a before measurement	**Methods** • Systematic review **Participants** • Healthcare consumers (both adults and children) with acute outpatient infections • Primary care providers **Setting** • Primary care clinics in high income countries	• 58 studies • About 60% of studies contained interventions that led to significant improvements in antibiotic prescribing. • Interventions targeting decreases in overall antibiotic prescription were more often effective than interventions targeting improvements in antibiotic selection. • Antibiotic prescriptions were reduced on average by 11.6%. First-line antibiotic prescription increased on average by 9.6%. • Combination interventions targeting clinicians were more often effective compared to single interventions. • Interventions containing patient-directed materials demonstrated no added value. • Interventions with the largest effect sizes included communication skills training and point-of-care testing.	• Clinician education, including communication skills training, is important to optimize antibiotic use. • Combination interventions appear to be more effective than individual interventions.

Commitment

REFERENCE	INTERVENTIONS AND OUTCOMES	METHODS, PARTICIPANTS, AND SETTINGS	RESULTS	CONCLUSIONS
Meeker D, et al. **Nudging guideline-concordant antibiotic prescribing: A randomized clinical trial.** *JAMA Intern Med* 2014. 174(3):425-31.	**Interventions** • Poster containing a public commitment to use antibiotics judiciously with clinician picture and signature displayed in examination rooms at point of clinician-patient encounter **Outcomes** • Antibiotic prescribing rates for acute respiratory infections (ARIs) for which antibiotics are inappropriate	**Method** • Randomized clinical trial **Participants** • 15 primary care providers **Setting** • 5 primary care clinics in the United States	• 954 adults with ARI • Poster group had a 19.7 % decrease in inappropriate prescribing for acute respiratory infections compared to controls, p=0.02, controlled for baseline rates of antibiotic prescribing.	• Public commitments in a poster are a low-cost intervention that can result in reduced inappropriate prescribing.
Pollack LA, et al. **Antibiotic stewardship programs in U.S. acute care hospitals: findings from the 2014 National Healthcare Safety Network (NHSN) Annual Hospital Survey.** *Clinical Infectious Diseases* 2016. [Epub ahead of print].	**Interventions** • No intervention; observational study **Outcomes** • Level of variability in antibiotic stewardship programs (ASPs) by hospital characteristic and location	**Method** • Observational study **Participants** • Hospitals enrolled in the National Healthcare Safety Network **Setting** • 2014 National Healthcare Safety Network Annual Hospital Survey	• 4184 US hospitals • On self-report, 39% of hospitals have an ASP meeting all 7 CDC defined core elements of inpatient antibiotic stewardship. • 59% of hospitals with more than 200 beds (59%) had an ASP meeting all Core Elements • 25% of hospitals with less than 50 beds had an ASP meeting all Core Elements • States reporting a percentage of hospitals with all 7 core elements ranged from 7% to 58%. • Written support and salary support for ASP were significantly associated with having an ASP meeting all Core Elements.	• There is wide variability with ASP implementation. • Hospital leadership support appears crucial for comprehensive ASPs • ASPs can be established in hospitals of all sizes.

REFERENCE	INTERVENTIONS AND OUTCOMES	METHODS, PARTICIPANTS, AND SETTINGS	RESULTS	CONCLUSIONS
Pollack LA, et al. **Antibiotic stewardship programs in U.S. acute care hospitals: findings from the 2014 National Healthcare Safety Network (NHSN) Annual Hospital Survey.** *Clinical Infectious Diseases* 2016. [Epub ahead of print].	**Interventions** • No intervention; observational study **Outcomes** • Level of variability in antibiotic stewardship programs (ASPs) by hospital characteristic and location	**Method** • Observational study **Participants** • Hospitals enrolled in the National Healthcare Safety Network **Setting** • 2014 National Healthcare Safety Network Annual Hospital Survey	• 4184 US hospitals • On self-report, 39% of hospitals have an ASP meeting all 7 CDC defined core elements of inpatient antibiotic stewardship. • 59% of hospitals with more than 200 beds (59%) had an ASP meeting all Core Elements • 25% of hospitals with less than 50 beds had an ASP meeting all Core Elements • States reporting a percentage of hospitals with all 7 core elements ranged from 7% to 58%. • Written support and salary support for ASP were significantly associated with having an ASP meeting all Core Elements.	• There is wide variability with ASP implementation. • Hospital leadership support appears crucial for comprehensive ASPs • ASPs can be established in hospitals of all sizes.

DELAYED PRESCRIBING PRACTICES OR WATCHFUL WAITING				
REFERENCE	**INTERVENTIONS AND OUTCOMES**	**METHODS, PARTICIPANTS, AND SETTINGS**	**RESULTS**	**CONCLUSIONS**
Chao JH, et al. **Comparison of two approaches to observation therapy for acute otitis media in the emergency department.** *Pediatrics.* 2008. 121(5):e1352-6.	**Intervention** • Watchful waiting/observation therapy with no prescription or with a delayed antibiotic prescription **Outcomes** • Antibiotic use for AOM at 3 days (primary) and 7-10 days (secondary) • Parental visit satisfaction	**Methods** • Prospective randomized trial **Participants** • Children aged 2 to 12 years diagnosed with AOM and who met criteria for observation **Setting** • Pediatric emergency room of an urban public hospital in the United States (New York)	• 232 patients enrolled, 206 patients completed follow-up • At 3 days: 87% parents of children in the observation group with no antibiotic prescription reported no antibiotic use versus 62% parents of children in the of children in the observation group with a delayed antibiotic prescription. • At 7-10 days, 81% of the observation group with no antibiotic prescription reported no use of antibiotics compared to 53% in the group with a delayed antibiotic prescription. • No differences in satisfaction were observed between the groups.	• Observation therapy was well accepted by parents of children with AOM. • Observation without an antibiotic prescription led to lower antibiotic use for AOM than observation with a delayed antibiotic prescription without affecting visit satisfaction.

DELAYED PRESCRIBING PRACTICES OR WATCHFUL WAITING				
REFERENCE	**INTERVENTIONS AND OUTCOMES**	**METHODS, PARTICIPANTS, AND SETTINGS**	**RESULTS**	**CONCLUSIONS**
de la Poza A, et al. **Prescription strategies in acute uncomplicated respiratory infections: A randomized clinical trial.** *JAMA Intern Med* 2016. 176(1):21-9.	**Interventions** • 4 antibiotic prescriptions strategies for acute uncomplicated respiratory tract infections. • Delayed antibiotic prescription given to patients at the visit with instructions to wait to fill it unless not improving • Delayed antibiotic prescription awaiting patient at clinic, patient to return and collect prescriptions if not improving • Immediate antibiotic prescription issued at visit • No antibiotic prescription issued at visit **Outcomes** • Primary: symptom duration and severity • Secondary: antibiotic use, patient satisfaction, and belief about antibiotic effectiveness among patients complicated respiratory infections.	**Methods** • Open-label, randomized clinical trial **Participants** • Adults with acute, uncomplicated respiratory infections **Setting** • 23 primary care clinics in Spain	• 405 adult patients with acute, uncomplicated respiratory infections • Delayed prescription strategies led to lower antibiotic use: • 91% of patients used antibiotics in the immediate prescription group; • 33% of patients used antibiotics in the group with delayed prescription; • 23% of patients used antibiotics in the group who had to collect the delayed prescription; • 12% of patients used antibiotics in the no prescription group. • Delayed and no prescription strategies led to “slightly greater” symptom burden. • Similar satisfaction was observed among groups.	• Delayed prescription strategies for acute uncomplicated respiratory tract infections are effective in decreasing antibiotic use.

DELAYED PRESCRIBING PRACTICES OR WATCHFUL WAITING				
REFERENCE	**INTERVENTIONS AND OUTCOMES**	**METHODS, PARTICIPANTS, AND SETTINGS**	**RESULTS**	**CONCLUSIONS**
Francis NA, et al. **Delayed antibiotic prescribing and associated antibiotic consumption in adults with acute cough.** *Br J Gen Pract* 2012. 62(602):e639-46.	**Intervention** • No intervention; observational study **Outcomes** • Rates of delayed antibiotic prescribing in adults presenting with acute cough to primary care. • Duration of advised delay • Consumption of delayed antibiotic or another antibiotic at 28 days • Factors associated with antibiotic consumption	**Methods** • Prospective observational cohort study **Participants** • General practitioners • Adult patients with acute cough **Setting** • 14 primary care networks in 13 European countries	• 3368 patients with acute cough • About 6% (n=210) were prescribed delayed antibiotics (median recommended delay 3 days). • 44% (n=75/169) with consumption data used the delayed prescription antibiotic course by 28 days • 30% (n=50/169) started on the day the prescription was written. • 10% took another antibiotic by 28 days. • 45% took no antibiotic by 28 days. Upper respiratory tract/ viral infections diagnoses were associated with lower use of delayed prescription. • Patients who wanted antibiotics were more likely to consume the antibiotics.	• Delayed antibiotic prescribing was not used often for adults presenting to primary care. • Expanding delayed antibiotic prescribing and standardizing prescribing practices may improve antibiotic prescribing.
Little P, et al. **Information leaflet and antibiotic prescribing strategies for acute lower respiratory tract infection: a randomized controlled trial.** *JAMA* 2005. 22;293(24):3029-35.	**Interventions** • One of 3 prescribing strategies was used • Immediate antibiotics • No antibiotics • Delayed antibiotics available by request after 14 days • Information leaflet for acute lower respiratory tract infection **Outcomes** • Clinical signs and symptoms • Reported antibiotic use • Daily diary and satisfaction questionnaire	**Methods** • Randomized controlled trial • Factorial design involving 6 groups: leaflet or no leaflet and 1 of 3 prescribing strategies **Participants** • 37 English general practitioners • Patients aged ≥3 years with acute uncomplicated lower respiratory infections **Setting** • Primary care clinics in England	• 807 patients recruited • No implemented intervention altered cough duration or other clinical outcome. • Cough lasted on average 11.7 days. • The information leaflet did not have any impact on main outcome. • Fewer patients in the delayed and control groups, compared to immediate antibiotic group, used antibiotics, were “very satisfied” with visit, and believed in the antibiotic effectiveness.	• Not prescribing antibiotics, or offering a delayed antibiotic prescribing is associated with minimal differences in symptom burden and may reduce antibiotic use.

DELAYED PRESCRIBING PRACTICES OR WATCHFUL WAITING				
REFERENCE	**INTERVENTIONS AND OUTCOMES**	**METHODS, PARTICIPANTS, AND SETTINGS**	**RESULTS**	**CONCLUSIONS**
Little P, et al. **Delayed antibiotic prescribing strategies for respiratory tract infections in primary care: pragmatic, factorial, randomised controlled trial.** *Brit Med J* 2014. 348:g1606.	**Intervention** • Delayed antibiotic prescribing strategies • Re-contact for a prescription (i.e., patient calls for the prescription) • Post-dated prescription • Post-visit collection of a prescription • No antibiotic prescription **Outcome** • Primary: Symptom severity at days 2-4 • Secondary: antibiotic use by 14 days and patient belief about antibiotic effectiveness	**Methods** • Open, pragmatic, randomized controlled trial **Participants** • Patients aged ≥3 years with acute respiratory tract infections **Setting** • 25 primary care clinics in the United Kingdom	• 889 patients recruited • No significant differences in symptom severity were observed between those who received no prescription and those receiving delayed prescription via any strategy. • Symptom duration did not differ between groups, and no significant difference was observed for patient satisfaction. • Those receiving antibiotics did not appear to benefit from them based on symptom severity scores.	• Interventions involving delayed antibiotic prescriptions or no prescription strategies resulted in fewer than 40% of prescribed antibiotics being used among patients. • Interventions involving delayed prescriptions or no prescriptions were associated with less belief in antibiotic efficacy and similar symptom outcomes compared to immediate antibiotic prescriptions.
McCormick DP, et al. **Nonsevere acute otitis media: a clinical trial comparing outcomes of watchful waiting versus immediate antibiotic treatment**. *Pediatrics* 2005.115(6):1455-65.	**Intervention** • Watchful waiting (WW) versus immediate antibiotic prescription • Educational intervention **Outcome** • Patient satisfaction with care • Resolution of symptoms • Acute otitis media (AOM) failure/recurrence • Nasopharyngeal colonization with antibiotic-resistant Streptococcus pneumoniae	**Methods** • Single-blind, randomized controlled trial (investigators were blinded) **Participants** • Children aged 6 months to 12 years with nonsevere AOM **Setting** • Pediatric clinics in in the United States (Texas)	• 223 children recruited • Parent satisfaction with care did not differ between treatment groups. • Children treated with immediate antibiotics had faster symptom resolution. • In the WW group, 66% of children did not take antibiotics by day 30. • The WW group were reduced by 73% compared to the immediate antibiotic group. • Immediate antibiotic treatment group had more antibiotic adverse drug events than WW group. • Children in the immediate antibiotic group were more likely to have multi-drug resistant *S. pneumoniae* nasopharyngeal colonization at day 12.	• Immediate antibiotic treatment was associated with decreased treatment failures and improved symptom resolution compared to WW, but also higher adverse drug events and higher likelihood of carriage of multi-drug resistant *S. pneumoniae*. • Classification of AOM severity, parent education, symptom management, followup care, and access to effective antibiotics when needed are all important in implementing watchful waiting for children with AOM.

DELAYED PRESCRIBING PRACTICES OR WATCHFUL WAITING				
REFERENCE	**INTERVENTIONS AND OUTCOMES**	**METHODS, PARTICIPANTS, AND SETTINGS**	**RESULTS**	**CONCLUSIONS**
Siegel R, et al. **Treatment of otitis media with observation and a safety-net antibiotic prescription.** *Pediatrics* 2003. 112(3):527-31.	**Intervention** • Delayed antibiotic prescription ("safety-net prescription") **Outcomes** • Primary: parental willingness to treat AOM without antibiotics and with pain medicine alone • Secondary: filling of antibiotic prescription, parents' future plans to use antibiotics for AOM	**Methods** • Cohort study **Participants** • Children aged 1 to 12 years with nonsevere AOM **Setting** • 11 pediatric clinics in the United States	• 194 children enrolled, 175 with complete follow-up • At follow-up, 31% of parents had filled the antibiotic prescription. • 63% of parents reported willingness in future to use pain medicine only without antibiotics for AOM.	• Safety-net prescriptions can decrease antibiotic use for non-severe AOM, and some parents find it an acceptable treatment strategy.
Spiro DM, et al. **Wait-and-see prescription for the treatment of acute otitis media: a randomized controlled trial.** *JAMA.* 2006. 296(10):1235-41.	**Intervention** • "Wait and see" (i.e. delayed) antibiotic prescription versus standard prescription for children with acute otitis media (AOM) **Outcomes** Filling of the antibiotic prescription Clinical symptoms and symptoms resolution	Methods Randomized controlled trial Participants Children aged 6 months to 12 years with AOM Setting Emergency department in Northeastern United States	283 children More parents in the wait and see group did not fill the antibiotic prescription (62%) compared to the standard prescription group (13% did not fill antibiotic prescription, $p<0.001$). No differences between groups were observed for the frequency of fever, ear pain, or unscheduled medical visits. In the wait and see group, fever and ear pain were associated with filling the antibiotic prescription.	Wait and see antibiotic prescriptions reduced antibiotic use in children with AOM.

COMMUNICATION SKILLS TRAINING				
REFERENCE	**INTERVENTIONS AND OUTCOMES**	**METHODS, PARTICIPANTS, AND SETTINGS**	**RESULTS**	**CONCLUSIONS**
Little P, et al. **Effects of internet-based training on antibiotic prescribing rates for acute respiratory-tract infections: a multinational, cluster, randomised, factorial, controlled trial.** *Lancet.* 2013. 382(9899):1175-82.	**Intervention** • Internet based training on communication skills, C-reactive protein (CRP) testing, or both versus standard care **Outcome** • Changes in antibiotic prescribing for respiratory tract infections (RTIs)	**Methods** • Cluster randomized controlled trial **Participants** • Primary care providers **Settings** • 246 primary care clinics in 6 European countries	• 4264 patients • Training in CRP testing and communication skills independently led to reductions in antibiotic prescribing for RTIs, and combination of both trainings led to largest reduction.	• Internet training for CRP testing and communications skills led to reductions in antibiotic prescribing for RTIs.
Cals JW, et al. **Enhanced communication skills and C-reactive protein point-of-care testing for respiratory tract infection: 3.5-year follow-up of a cluster randomized trial.** *Annals of Family Medicine.* 2013. 11(2):157-64.	**Intervention** • Physician enhanced communication skills training • Point-of-care C-reactive protein (CRP) **Outcome** • Patient visits for respiratory tract infections (RTIs) • Percent of RTI episodes treated with antibiotics	**Methods** • Pragmatic, cluster-randomized controlled trial • 3.5 years of follow-up **Participants** • Patients with family physician visits for RTIs **Setting** • 20 family practices in the Netherlands	• 379 patients • No difference in number of patient visits for RTIs among groups. • RTI episodes treated by physicians who received communications training were less likely to receive antibiotics in follow-up period (26% with communications training v. 39% control, p=0.02). • No difference in antibiotic treatment during follow-up for RTI episodes in CRP group.	• Communications training led to sustained reductions in the percent of RTIs leading to antibiotic prescriptions, while CRP testing did not.

REQUIRE EXPLICIT WRITTEN JUSTIFICATION FOR NON-RECOMMENDED ANTIBIOTIC PRESCRIBING				
REFERENCE	**INTERVENTIONS AND OUTCOMES**	**METHODS, PARTICIPANTS, AND SETTINGS**	**RESULTS**	**CONCLUSIONS**
Meeker et al. **Effect of behavioral interventions on inappropriate antibiotic prescribing among primary care practices: A randomized clinical trial.** *JAMA* 2016. 315(6):562-70.	**Interventions:** **3 behavioral interventions** • Suggested alternatives to antibiotics placed within electronic health records for these diagnoses • Accountable justification required in medical record for non-recommended antibiotic prescribing • Peer comparison to top-performing peers **Outcomes** • Rate of antibiotic prescribing for acute respiratory tract infections for which antibiotics are not indicated	**Methods** • Cluster randomized clinical trial **Participants** • 248 primary care clinicians **Settings** • 47 primary care practices in the United States	• 31,712 visits for acute respiratory tract infections for which antibiotics are not indicated • 14,753 during baseline • 16,959 during intervention • Antibiotic prescribing decreased from: • Controls: 24.1% to 13.1% • Suggested alternatives: 22.1% to 6.1% ($P = .66$ for differences compared to control group) • Accountable justification: 23.2% to 5.2% ($P < .001$) • Peer comparison: 9.9% to 3.7 (**P** < .001). • Compared to the control group, no intervention showed significant diagnosis shifting.	• Accountable justification and peer comparison interventions reduced antibiotic prescribing for acute respiratory tract infections for which antibiotics are not indicated

CLINICAL DECISION SUPPORT				
REFERENCE	**INTERVENTIONS AND OUTCOMES**	**METHODS, PARTICIPANTS, AND SETTINGS**	**RESULTS**	**CONCLUSIONS**
McGinn TG, et al. **Efficacy of an evidence-based clinical decision support in primary care practices: A randomized clinical trial.** *JAMA Intern Med* 2013. 173(17):1584-11.	**Intervention** • Clinical decision support involving integration of Walsh rule for streptococcal sore throat and Heckerling rule for pneumonia **Outcomes** • Frequency of antibiotic prescriptions and streptococcal tests in experimental versus control group • Use of clinical prediction rule in EHR	**Methods** • Randomized clinical trial **Participants** • Attending physicians, fellows, residents and nurse practitioners • Patients with complaints consistent with pharyngitis or pneumonia **Setting** • Two large urban ambulatory care practices in the United States (New York)	• 168 primary care providers with 984 visits with clinical decision rule triggered • Clinicians in the intervention group used the clinical prediction rules in 58% of visits. • Intervention clinicians were less likely to prescribe antibiotics than control clinicians (RR = 0.75; 95% CI, 0.60-0.92). • Number needed to treat in order to prevent one antibiotic prescription was 10.8. • Intervention clinicians ordered rapid streptococcal tests for patients with pharyngitis less often than control clinicians (RR 0.75; 95% CI, 0.58-0.97).	• Clinical prediction rules integrated into EHRs can reduce inappropriate antibiotic prescribing.
Jenkins TC, et al. **Effects of clinical pathways for common outpatient infections on antibiotic prescribing.** *Am J Med.* 2013;126(4):327-35 e312.	**Intervention** • Clinical decision support targeting antibiotic prescribing for common conditions • Patient education materials **Outcomes** • Change in antibiotic prescribing over time for non-pneumonia acute respiratory infections (ARIs) • Change over time in broad-spectrum antibiotic prescriptions for ARIs	**Methods** • Quasi-experimental study **Participants** • Clinicians working in primary care clinics **Setting** • Primary care clinics in the United States (Colorado), including adult and pediatric clinics; urban, suburban and rural clinics; academic and private providers	• 8 primary care clinics • Antibiotic prescriptions for visits for non-pneumonia ARIs decreased from 42.7% to 37.9% (11.2% relative reduction) in the intervention group compared to 39.8% to 38.7% in the control group (2.8% relative reduction) during the intervention period. • Use of broad-spectrum antibiotics decreased from 26.4% to 22.6% in the intervention group (14.4% relative reduction) compared to a 20.0% to 19.4% reduction in the control group (3.0% relative reduction).	• Clinical decision support was associated with reduced antibiotic prescriptions for non-pneumonia ARIs and reduced use of broad-spectrum antibiotics during one year of implementation.

CLINICAL DECISION SUPPORT REFERENCE	INTERVENTIONS AND OUTCOMES	METHODS, PARTICIPANTS, AND SETTINGS	RESULTS	CONCLUSIONS
Gonzales R, et al. **A cluster randomized trial of decision support strategies for reducing antibiotic use in acute bronchitis.** *JAMA Intern Med* 2013. 173(4):267-73.	**Interventions** • Clinical decision support, through the electronic medical record, or printed tools targeting antibiotic prescribing for acute bronchitis • Clinician and patient education • Audit and feedback • Controls without interventions **Outcomes** • Reductions in antibiotic prescribing for acute uncomplicated bronchitis.	**Methods** • Cluster randomized controlled trial **Participants** • Primary care clinicians **Setting** • 33 primary care practices in the United States (Pennsylvania)	• 12,776 visits for acute bronchitis • Prescribing for acute bronchitis reduced by 11.7% in the print-based strategy and 13.7% in the EMR-based strategy. • Prescribing at control sites increased slightly.	• Clinical decision support strategies for acute bronchitis can help reduce overuse of antibiotics in primary care. • The observed effect in print-based versus computer-based interventions showed no significant differences.
Rattinger GB, et al. **A sustainable strategy to prevent misuse of antibiotics for acute respiratory infections.** *PLoS One* 2012. 7(12):e51147.	**Intervention** • Clinical decision support promoting adherence to clinical practice guidelines for acute respiratory infections (ARIs) **Outcomes** • Guideline concordance and proportion of inappropriate antibiotic prescribing • Reductions in fluoroquinolone and azithromycin use	**Methods** • Non-randomized retrospective controlled study **Participants** • Primary care providers for an outpatient veteran population **Setting** • Outpatient clinics in a veteran's healthcare system in the United States	• 3831 patients • Clinical decision support was associated with greater clinical practice guideline adherence (RR=2.57 95% CI, 1.87 to 3.54). • Inappropriate prescriptions for fluoroquinolones and azithromycin decreased from 22% to 3% (P<0.0001).	• A clinical decision support system decreased unwarranted use of fluoroquinolones and azithromycin for ARI and improved antibiotic use for ARI in an outpatient veterans' healthcare system.
Linder JA, et al. **Documentation-based clinical decision support to improve antibiotic prescribing for acute respiratory infections in primary care: A cluster randomised controlled trial.** *Inform Prim Care* 2009. 17(4):231-40.	**Intervention** • Electronic health record-based clinical decision support for acute respiratory infection (ARI) — "ARI Smart Form" versus standard care **Outcome** • Antibiotic prescribing for acute respiratory tract infections	**Methods** • Randomized controlled trial **Participants** • Primary care providers **Setting** • 27 primary care clinics in the United States (Massachusetts)	• 21,961 visits for ARIs • ARI Smart Form only used in 6% of eligible visits. • Antibiotic prescribing for intervention clinics was not different compared to controls: odds ratio (OR) 0.8; 95% CI 0.6-1.2. • When ARI Smart Form was used (per protocol analysis), ARI prescribing was modestly improved.	• A clinical decision support tool for ARIs, the ARI Smart Form, was rarely used by clinicians and thus did not improve antibiotic prescribing for ARIs.

CLINICAL DECISION SUPPORT				
REFERENCE	**INTERVENTIONS AND OUTCOMES**	**METHODS, PARTICIPANTS, AND SETTINGS**	**RESULTS**	**CONCLUSIONS**
Forrest, C. B., et al. **Improving adherence to otitis media guidelines with clinical decision support and physician feedback.** *Pediatrics* 2013. 131(4): e1071-1081.	**Intervention** • Clinical decision support (CDS) in an electronic health record system • Audit and feedback to clinicians with peer comparison **Outcome** • Physician guideline adherence for management of acute otitis media (AOM) and otitis media with effusion (OME)	**Methods** • Factorial-design cluster randomized trial **Participants** • Primary care providers **Setting** • Primary care network in the United States (Pennsylvania, New Jersey, and Delaware)	• 24 practices with 139,305 visits for AOM and OME • Guidelines were adhered to in 15% and 5% of AOM and OME cases, respectively during the baseline period. • Improvements in guideline adherence was larger in visits with CDS and audit and feedback • Audit and feedback combined with CDS did not improve guideline adherence beyond levels observed for audit and feedback alone.	• Both CDS and audit and feedback effectively increased adherence to guidelines for treatment of AOM and OME • The effect of the individual interventions did not appear to be additive.

CALL CENTERS, NURSE HOTLINES, OR PHARMACIST CONSULTATIONS				
REFERENCE	**INTERVENTIONS AND OUTCOMES**	**METHODS, PARTICIPANTS, AND SETTINGS**	**RESULTS**	**CONCLUSIONS**
Harper R, et al. **Optimizing the use of telephone nursing advice for upper respiratory infection symptoms.** *Am J Manag Care* 2015. 21(4): 264-270.	**Intervention** • Use of a nursing advice hotline to optimize self-care for upper respiratory infections **Outcomes** • Clinical outcomes associated with related cases • Sufficiency of advice as evidence by no return calls within 7 days leading to a "higher" level of care, such as an in-person appointment.	**Methods** • Retrospective observational study **Participants** • Adult patients 18 years and older who called into a self-care advice line for URI symptoms **Setting** • Large healthcare system in the United States (California)	• 279,625 calls • For 88% of initial advice calls, self-care advice over the phone alone was sufficient. • Most follow-up calls made by the patient were for additional advice or other information.	• URI symptoms can be effectively managed by nurses via a telephone advice line.

AUDIT AND FEEDBACK REFERENCE	INTERVENTIONS AND OUTCOMES	METHODS, PARTICIPANTS, AND SETTINGS	RESULTS	CONCLUSIONS
Gerber JS, et al. **Effect of an outpatient antimicrobial stewardship intervention on broad-spectrum antibiotic prescribing by primary care pediatricians: A randomized trial.** *JAMA* 2013. 309(22): 2345-52. Gerber JS, et al. **Durability of benefits of an outpatient antimicrobial stewardship intervention after discontinuation of audit and feedback.** *JAMA* 2014; 312(23): 2569-2570.	**Intervention** • Quarterly audit and feedback on antibiotic prescribing practices for sinusitis, pharyngitis, and pneumonia with peer comparisons • One hour of clinician education **Outcomes** • Broad-spectrum antibiotic prescribing rates for sinusitis, pharyngitis, and pneumonia • Antibiotic prescribing for viral infections	**Methods** • Cluster randomized controlled trial **Participants** • Pediatric primary care providers **Setting** • 18 pediatric primary care practices in the United States (New Jersey)	• Intervention group showed a reduction in broad-spectrum antibiotic prescribing compared to controls with6.7% difference in differences. • No change in group A *Streptococcus* pharyngitis prescribing or for viral infections, which were both relatively appropriate at baseline. • Broad-spectrum prescribing returned to baseline rates once audit-and feedback stopped.	• Audit and feedback with peer comparisons and with clinician education led to decreases in non-recommended broad-spectrum antibiotic prescribing. • Benefits were not sustained once the audit-and-feedback ended.
Meeker et al. **Effect of behavioral interventions on inappropriate antibiotic prescribing among primary care practices: A randomized clinical trial.** *JAMA* 2016;315(6):562-70.	**Interventions** **3 behavioral interventions** • Suggested alternatives to antibiotics placed within electronic health records for these diagnoses • Accountable justification required in medical record for non-recommended antibiotic prescribing • Peer comparison to top-performing peers **Outcomes** • Rate of antibiotic prescribing for acute respiratory tract infections for which antibiotics are not indicated	**Methods** • Cluster randomized clinical trial **Participants** • 248 primary care clinicians **Settings** • 47 primary care practices in the United States	• 31,712 visits for acute respiratory tract infections for which antibiotics are not indicated: • 14753 during baseline • 16959 during intervention period. • Antibiotic prescribing decreased from: • Controls: 24.1% to 13.1% • Suggested alternatives: 22.1% to 6.1% ($P = .66$ for differences compared to control group) • Accountable justification: 23.2% to 5.2% ($P < .001$) • Peer comparison: 9.9% to 3.7 ($P < .001$). • Compared to the control group, no intervention showed significant diagnosis shifting.	• Accountable justification and peer comparison interventions reduced antibiotic prescribing for acute respiratory tract infections for which antibiotics are not indicated

AUDIT AND FEEDBACK				
REFERENCE	**INTERVENTIONS AND OUTCOMES**	**METHODS, PARTICIPANTS, AND SETTINGS**	**RESULTS**	**CONCLUSIONS**
Butler CC, et al. **Effectiveness of multifaceted educational programme to reduce antibiotic dispensing in primary care: Practice based randomised controlled trial.** *BMJ* 2012. 344:d8173.	**Intervention** • Multifaceted clinician education, including communication skills, targeting antibiotic prescribing versus standard care • Audit and feedback of practice antibiotic dispensing data **Outcomes** • Primary: total number of antibiotics dispensed per 1000 patients by practice • Secondary: return visits and hospital admissions for respiratory tract infections, and cost	**Methods** • Randomized controlled trial **Participants** • General practitioners **Setting** • General practices in United Kingdom (Wales)	• 68 practices serving 480,000 patients • A 4.2% reduction in total antibiotic prescribing was observed in the intervention group compared to controls in one year (p=0.02). • No differences in hospital admissions or return visits for respiratory tract infections were observed between the intervention and control groups. • 5.5% non-significant decreased in antibiotic dispensing cost in intervention group compared to controls.	• A clinician educational intervention led to reductions in antibiotic dispensing with no changes in hospital admissions, return visits, or costs.
Finkelstein JA, et al. **Impact of a 16-community trial to promote judicious antibiotic use in Massachusetts.** *Pediatrics* 2008. 121(1):e15-23.	**Intervention** • Multi-faceted intervention with clinician education, parent education, and audit and feedback on antibiotic prescribing **Outcomes** • Overall oral antibiotic dispensing per person-year of observation for children 3 to <72 months of age	**Methods** • Community-level cluster-randomized controlled trial **Participants** • Clinicians, parents, and pediatric patients aged 6 years or younger **Setting** • Non-overlapping communities in the United States (Massachusetts)	• 16 communities with 223,135 person-years observed • Decreasing antibiotic prescribing was seen in all groups, including controls, during study period. • Intervention led to 4.2% decrease in overall antibiotic prescribing among children 24 to <48 months old and 6.7% among children 48 to < 72 months old compared to control communities. • No difference in antibiotic prescribing for intervention or control communities for children aged 3 to <24 months.	• A multifaceted, sustained, community level intervention modestly decreased antibiotic use.

AUDIT AND FEEDBACK REFERENCE	INTERVENTIONS AND OUTCOMES	METHODS, PARTICIPANTS, AND SETTINGS	RESULTS	CONCLUSIONS
Metlay JP, et al. **Cluster-randomized trial to improve antibiotic use for adults with acute respiratory infections treated in emergency departments.** *Ann Emerg Med* 2007. 50(3):221-30.	**Intervention** • Clinician and patient education • Audit and feedback on prescribing practices for upper respiratory infections (URIs) and acute bronchitis **Outcomes** • Primary: Proportion of patients URIs and acute bronchitis with antibiotic prescribed • Secondary: antibiotic prescribing for antibiotic-appropriate respiratory infections, return ED visits within 2 weeks, and hospital admission within 2 weeks	**Methods** • Cluster-randomized controlled trial **Participants** • Emergency department (ED) clinicians and patients **Setting** • Hospital EDs, including veterans and non-veterans hospitals in the United States	• 16 EDs with 5,665 visits by adults for acute respiratory infections • Intervention sites had a significant decrease in antibiotic prescribing for URIs and acute bronchitis (-10%; 95% CI -18 to -2%), compared to no change in control sites (0.5% 95% CI -3 to 5%). • No significant increases in emergency department return visits or patient satisfaction was observed among control or intervention sites.	• Multifaceted education interventions combined with audit and feedback can decrease antibiotic prescribing for ED patients with URIs and acute bronchitis.
Hallsworth M, et al. **Provision of social norm feedback to high prescribers of antibiotics in general practice: a pragmatic national randomised controlled trial.** *The Lancet* 2016. 387:1743-52	**Interventions** • Audit and feedback as a letter from England's Chief Medical Officer sent to the high-prescribing practices defined as the top 20% for their National Health Service (NHS) Local Area Team versus no communication • Patient education materials versus no materials **Outcomes** • Rate of antibiotics dispensed per 1000 weighted population, controlling for past prescribing	**Methods** • Pragmatic factorial randomized controlled trial • Analysis by intention-to-treat **Participants** • General practitioners (GP) **Setting** • GP practices NHS clinics across England	• 1581 practices • Letters sent to 3227 GPs • Intervention group had 126.98 antibiotics dispensed per 1000 population versus and 131.25 antibiotics dispensed per 1000 population in the control group (difference of 3.3%, $p<0.001$). • Estimated 73,406 fewer antibiotics dispensed in intervention group. • No difference in antibiotic prescribing for patient educational materials.	• Audit and feedback from an important figure (e.g. England's Chief Medical Officer) reduced antibiotic prescribing at the national level.

Education

EVIDENCE SUPPORTING EDUCATIONAL EFFORTS TARGETING PARENTS AND PATIENTS TO IMPROVE ANTIBIOTIC USE				
REFERENCE	**INTERVENTIONS AND OUTCOMES**	**METHODS, PARTICIPANTS, AND SETTINGS**	**RESULTS**	**CONCLUSIONS**
Mangione-Smith R, et al. **Communication Practices and Antibiotic Use for Acute Respiratory Tract Infections in Children.** *Ann Fam Med* 2015. 13(3): 221-227.	**Intervention** • No intervention; observational study. **Outcome:** • Communication techniques used by providers that were associated with prescribing antibiotics for acute respiratory tract infections (ARTIs) and with parent visit satisfaction	**Methods** • Cross-sectional study with parent and provider post-visit surveys **Participants** • Pediatric providers • Parents of children (6 months to 10 years old) presenting with complaints consistent with ARTIs **Setting** • 10 pediatric practices in the United States (Washington)	• 28 pediatric providers • 1,284 parents • Communication techniques using recommendations for treating symptoms were associated with lower risk of antibiotic prescribing for ARTIs. • Communication techniques that combined explanations of why antibiotics are not needed with recommendations for treating symptoms were associated with lower risk of antibiotic prescribing and higher parental visit satisfaction.	• Communication strategies combining explanations of why antibiotics are not needed with recommendations for treating symptoms may help providers decrease inappropriate antibiotic prescribing while helping maintain parental visit satisfaction.
Mangione-Smith R, et al. **Parent expectations for antibiotics, physician-parent communication, and satisfaction.** *Arch Pediatr Adolesc Med* 2001;155(7): 800-806.	**Intervention** • No intervention; observational study. **Outcome** • Physician perception of parental pressure for antibiotics • Physician-perceived pressure to prescribe antibiotics • Parental visit-specific satisfaction	**Methods** • Qualitative study involving pre- and post-visit survey **Participants** • Physicians and eligible parents who attended acute care visits for their child **Setting** • 2 private practice pediatric clinics in the United States (California)	• 10 physicians and 295 parents • Half of parents expected antibiotics prior to the visit, but only 1% of visits verbally requested them. • Physicians perceived parental expectation for antibiotics 34% of the time without a direct request by parents for antibiotics. • Offering a contingency plan of possibly receiving future antibiotics if their child did not improve was associated with higher satisfaction among parents who expected but did not receive antibiotics.	• A contingency plan should be considered for parents expecting antibiotics for their children who do not need antibiotics.

EVIDENCE SUPPORTING EDUCATIONAL EFFORTS TARGETING PARENTS AND PATIENTS TO IMPROVE ANTIBIOTIC USE

REFERENCE	INTERVENTIONS AND OUTCOMES	METHODS, PARTICIPANTS, AND SETTINGS	RESULTS	CONCLUSIONS
Roberts, RM, et al. **Can Improving Knowledge of Antibiotic-Associated Adverse Drug Events Reduce Parent and Patient Demand for Antibiotics?** *Health Serv Res and Man Epi* 2015. 1-5.	**Intervention** • No intervention; observational study. **Outcomes** • Patient and parent knowledge and attitudes about antibiotics and adverse drug events (ADEs) from antibiotics	**Methods** • Computer assisted telephone focus groups Participants • Adult patients and mothers of young children **Setting** • United States	• Familiarity with side effects of antibiotics were common. • Few mothers were familiar with severe antibiotic-associated ADEs. • Most mothers felt strongly that information about severe ADEs should be shared with parents at the time an antibiotic is prescribed. • Adult patients did not believe that antibiotic-associated ADEs was a significant issue.	• Parents of pediatric patients are interested in information about antibiotic-associated ADEs. • Adult patients may be less receptive about receiving information about antibiotic-associated ADEs.

EVIDENCE SUPPORTING EDUCATIONAL EFFORTS TARGETING CLINICIANS TO IMPROVE ANTIBIOTIC USE

REFERENCE	INTERVENTIONS AND OUTCOMES	METHODS, PARTICIPANTS, AND SETTINGS	RESULTS	CONCLUSIONS
Butler CC, et al. **Effectiveness of multifaceted educational programme to reduce antibiotic dispensing in primary care: Practice based randomised controlled trial.** *BMJ* 2012;344:d8173.	**Intervention** • Multifaceted clinician education, including communication skills, targeting antibiotic prescribing versus standard care • Audit and feedback of practice antibiotic dispensing data **Outcomes** • Primary: total number of antibiotics dispensed per 1000 patients by practice • Secondary: Return visits and hospital admissions for respiratory tract infections, and cost	**Methods** • Randomized controlled trial **Participants** • General practitioners **Setting** • General practices in the United Kingdom (Wales)	• 68 practices serving 480,000 patients • A 4.2% reduction in total antibiotic prescribing was observed in the intervention group compared to controls in one year (p=0.02). • No differences in hospital admissions or return visits for respiratory tract infections were observed between the intervention and control groups. • 5.5% non-significant decreased in antibiotic dispensing cost in intervention group compared to controls	• A clinician educational intervention led to reductions in antibiotic dispensing with no changes in hospital admissions, return visits, or costs.

EVIDENCE SUPPORTING EDUCATIONAL EFFORTS TARGETING CLINICIANS TO IMPROVE ANTIBIOTIC USE				
REFERENCE	**INTERVENTIONS AND OUTCOMES**	**METHODS, PARTICIPANTS, AND SETTINGS**	**RESULTS**	**CONCLUSIONS**
Harris RH, et al. **Optimizing antibiotic prescribing for acute respiratory tract infections in an urban urgent care clinic.** *J Gen Internal Med* 2003.18(5):326-34.	**Intervention** • Clinician education targeting antibiotic prescribing for acute respiratory tract infections (ARTIs) • Posters directed at providers placed in exam rooms • Patient education through an interactive computerized education (ICE) module. • Patients who chose not to participate in the ICE were considered to have been exposed to the "limited" intervention **Outcomes** • Proportion of patients with ARTIs who received antibiotics	**Methods** • Prospective, nonrandomized controlled trial **Participants** • Adults with ARTIs **Setting** • Urban urgent care clinic serving the major public hospital in the United States (Colorado)	• 554 adults with ARTIs • Antibiotic prescribing for patients diagnosed with acute bronchitis decreased from 58% to 30% in those exposed to the limited intervention, and to 24% among those exposed to full intervention ($p<0.001$ compared to baseline). • Antibiotic prescribing for nonspecific upper respiratory tract infections decreased from 14% to 3% in those exposed to the limited intervention, and to 1% among those exposed to the full intervention ($p<0.001$ compared to baseline).	• A combination of patient and provider educational materials can reduce antibiotic prescribing for adults with ARTIs.
Juzych NS, et al. **Improvements in antimicrobial prescribing for treatment of upper respiratory tract infections through provider education.** *J Gen Internal Med* 2005. 20(10):901-5.	**Intervention** • Clinician education using interactive and case-based learning targeting antibiotic prescribing for upper respiratory tract infections (URIs) **Outcomes** • Improvements in antibiotic prescribing for URIs	**Methods** • Prospective nonrandomized controlled trial **Participants** • Primary care physicians **Setting** • Four primary care clinics within a staff model health maintenance organization in the United States (Michigan)	• 30 primary care physicians • Antibiotic prescribing in the intervention group decreased 24.6% for both pediatric and adult medicine clinicians. • In the control group, no significant decline in antibiotic prescribing was observed.	• An educational program involving interaction and case-based learning improved antibiotic prescribing for URIs by primary care providers.

ACADEMIC DETAILING				
REFERENCE	**INTERVENTIONS AND OUTCOMES**	**METHODS, PARTICIPANTS, AND SETTINGS**	**RESULTS**	**CONCLUSIONS**
Gjelstad, S., et al. **Improving antibiotic prescribing in acute respiratory tract infections: cluster randomised trial from Norwegian general practice** (prescription peer academic detailing (Rx-PAD) study). *BMJ* 2013. 347: f4403.	**Intervention** • Academic detailing on antibiotic prescribing for respiratory tract infections • Clinician education • Audit and feedback **Outcomes** • Improvements in antibiotic prescribing for respiratory tract infections • Improvements in broad-spectrum antibiotic prescribing	**Methods** • Cluster randomized controlled trial **Participants** • General practitioners **Setting** • General practice clinics in Norway	• 382 general practitioners • Reductions in antibiotic prescribing were observed in the intervention group compared to the control groups (odds ratio 0.72, 95% confidence interval 0.61 to 0.84). • Prescribing of non-penicillin V drugs also decreased in the intervention arm (0.64, 0.49 to 0.82).	• Education interventions improved antibiotic prescribing among general practitioners in Norway.