Open Forum Infectious Diseases

MAJOR ARTICLE

Antibiotic Prescribing Practices for Upper Respiratory Tract Infections Among Primary Care Providers: A Descriptive Study

Liton Chandra Deb,[1,2] Brenda M. McGrath,[1] Levi Schlosser,[3] Austin Hewitt,[4] Connor Schweitzer,[4] Jeff Rotar,[5] Nathan D. Leedahl,[5] Ross Crosby,[5] and Paul Carson[1,4,5]

[1]Department of Public Health, North Dakota State University, Fargo, North Dakota, USA, [2]Department of Population Health and Pathobiology, College of Veterinary Medicine, North Carolina State University, Raleigh, North Carolina, USA, [3]North Dakota Department of Health, Bismarck, North Dakota, USA, [4]School of Medicine and Health Sciences, University of North Dakota, Grand Forks, North Dakota, USA, and [5]Sanford Health, Fargo, North Dakota, USA

Background. Most antibiotics are prescribed in the ambulatory setting with estimates that up to 50% of use is inappropriate. Understanding factors associated with antibiotic misuse is essential to advancing better stewardship in this setting. We sought to assess the frequency of unnecessary antibiotic use for upper respiratory infections (URIs) among primary care providers and identify patient and provider characteristics associated with misuse.

Methods. Unnecessary antibiotic prescribing was assessed in a descriptive study by using adults ≥18 years seen for common URIs in a large, Upper Midwest, integrated health system, electronic medical records from June 2017 through May 2018. Individual provider rates of unnecessary prescribing were compared for primary care providers practicing in the departments of internal medicine, family medicine, or urgent care. Patient and provider characteristics associated with unnecessary prescribing were identified with a logistic regression model.

Results. A total of 49 463 patient encounters were included. Overall, antibiotics were prescribed unnecessarily for 42.2% (95% confidence interval [CI], 41.7–42.6) of the encounters. Patients with acute bronchitis received unnecessary antibiotics most frequently (74.2%; 95% CI, 73.4–75.0). Males and older patients were more likely to have an unnecessary antibiotic prescription. Provider characteristics associated with higher rates of unnecessary prescribing included being in a rural practice, having more years in practice, and being in higher volume practices such as an urgent care setting. Fifteen percent of providers accounted for half of all unnecessary antibiotic prescriptions.

Conclusions. Although higher-volume practices, a rural setting, or longer time in practice were predictors, unnecessary prescribing was common among all providers.

Keywords. antibiotic stewardship; bronchitis; pharyngitis; sinusitis; viral upper respiratory tract infection.

The World Health Organization and the Centers for Disease Control and Prevention (CDC) have identified antibiotic resistance as one of the greatest threats to global health, food security, and development [1, 2]. Antibiotic resistance is driven by antibiotic use, whether that use is appropriate or inappropriate [3]. Professional societies and public health agencies have called for greater stewardship over antibiotic use to decrease resistance and preserve antibiotic usefulness over time [3, 4].

Although most efforts at antibiotic stewardship have focused on the inpatient setting, the majority of antibiotics prescribed in the United States are in the ambulatory setting [5–7]. One recent study has suggested that as much as 85%–95% of all antibiotics consumed are in the community setting for most countries [8]. Several studies suggest that approximately 30%–50% of all outpatient prescriptions may be unnecessary or inappropriate, most often for viral upper respiratory infections (URIs) [5, 9, 10].

In 2015, the President of the United States released the "National Action Plan to Combat Antibiotic-Resistant Bacteria", or CARB, which included a goal to decrease rates of unnecessary outpatient antibiotic prescribing by 50% by the year 2020 [11]. The CDC estimated that the United States needed to reduce overall outpatient antibiotic prescriptions by 15% to approach that goal. However, usage only fell from 835 dispensed prescriptions per 1000 population in 2014, to

Received 22 April 2022; editorial decision 10 June 2022; accepted 14 June 2022; published online 17 June 2022

Correspondence: Liton Chandra Deb, DVM, MSc, MPH, Department of Population Health and Pathobiology, North Carolina State University, 1060 William Moore Drive, College of veterinary Medicine, Raleigh, NC 27695 (lchandr@ncsu.edu).

Open Forum Infectious Diseases®

https://doi.org/10.1093/ofid/ofac302

765 in 2019, an 8% decrease [12]. A much larger drop to 613 dispensed prescriptions per 1000 in 2020 was likely due to markedly reduced outpatient visits during the coronavirus disease 2019 pandemic, and it remains to be seen how outpatient antibiotic use will change after the pandemic [12, 13].

We studied antibiotic use in adults seen in a large Upper Midwest health system for 3 conditions that should almost never warrant an antibiotic; pharyngitis without a positive test for group A *Streptococcus*, uncomplicated acute bronchitis, and nonspecific acute upper respiratory tract infection (AURI). In addition, we assessed the necessity of antibiotic use in uncomplicated acute rhinosinusitis (ARS). We compared patient and provider characteristics among those with and without unnecessary antibiotic prescribing.

METHODS

Setting

The study was conducted in 2 major regions of a large multicenter integrated health system in the Upper Midwest. The included regions encompass over 95 clinics with over 500 primary care providers in 4 states.

Subjects

Patients were included if they were ≥18 years old and were seen by a primary care provider (family medicine, internal medicine, or urgent care) for a URI between June 1, 2017 through May 31, 2018. Eligible subjects were identified by using existing electronic medical record workbench reports for patients with *International Classification of Diseases, Tenth Revision, Clinical Modification* (ICD-10-CM) codes corresponding to acute bronchitis, pharyngitis, nonspecific AURI, or ARS. Patients were excluded if they had chronic lung disease, another infectious disease, a condition or medication that suppresses the immune system, hospitalization or other antibiotics in the prior 5 days, or a similar visit for a URI in the prior 30 days. The ICD-10-CM codes used for inclusion and exclusion were adapted from previous similar studies [14, 15]. Acute rhinosinusitis patients not receiving an antibiotic were excluded from the analysis.

Study Outcomes

Rates of unnecessary antibiotic prescribing were assessed for each of the conditions as well as a composite measure of all 4 of the conditions for the study population as well as by individual providers. Individual provider rates of unnecessary prescribing (using the composite measure) were compared for primary care providers practicing in the departments of internal medicine, family medicine, or urgent care. Unnecessary prescribing was defined as antibiotics given for any nonexcluded patient with any of the following conditions: (1) acute bronchitis, (2) nonspecific AURI, (3) acute pharyngitis without a documented positive laboratory test for group A *Streptococcus*, and (4) ARS (<4 weeks of symptoms) without documentation of a guideline-based indication per the Infectious Disease Society of America (IDSA) [16]. Specifically, for appropriate ARS prescribing, documentation needed to be present for 1 of the following 4 indications: (1) symptom duration ≥10 days, (2) "double-sickening" (ie, worsening symptoms after initial improvement), (3) severe pain for at least 3–4 days, or (4) high fever (≥102°F) for at least 3–4 days. Determination of necessary therapy for ARS was assessed by chart review. Reviews were performed by 5 trained public health graduate students or medical students, and interobserver variation was assessed on a random subsample of 5% of the study patients.

The appropriate antibiotic choice for ARS was considered to be a penicillin class antibiotic, (amoxicillin or amoxicillin-clavulanate), unless there was a documented allergy, as per guidelines from the American Academy of Otolaryngology-Head and Neck Surgery Foundation (AAOHN) and the IDSA [16, 17]. The inappropriate antibiotic choice for ARS was a nonpenicillin class antibiotic without a documented penicillin allergy.

Individual prescribing patterns were characterized for any primary care provider having at least 5 encounters during the study period for each of the respiratory conditions. Based on the total number of included ARS encounters, providers were designated as either low volume (<100 encounters over the study period) or high volume (≥100 encounters over the study period). High-volume providers typically had some portion of their practice in an urgent care or walk-in clinic setting and were grouped separately for comparisons. For low-volume providers, 100% of their ARS cases were manually reviewed, whereas high-volume providers had 25% of their encounters randomly subsampled.

Statistical Analysis

Logistic regression was used to determine the provider characteristics that were associated with an inappropriate antibiotic prescription. The model adjusted for patient characteristics (including URI condition, patient gender, and patient age) and provider characteristics, including provider gender, specialty (family Medicine, high-volume, internal medicine), setting (urban vs rural), years in practice, provider age, and provider type (medical doctor [MD], nurse practitioner [NP], doctor of osteopathic medicine [DO], physician assistant-certified [PA-C]). An urban practice setting was defined as the clinic being in a city with a population greater than 50 000. Clinic locations in cities with populations less than 50 000 were classified as rural. A random intercept for providers was used to account for the nesting of the patients into providers.

Chart Reviews

Interobserver variation in the ARS determination was assessed by raters doing a blinded cross-check of each other's abstraction on every 20th encounter and performing kappa correlation

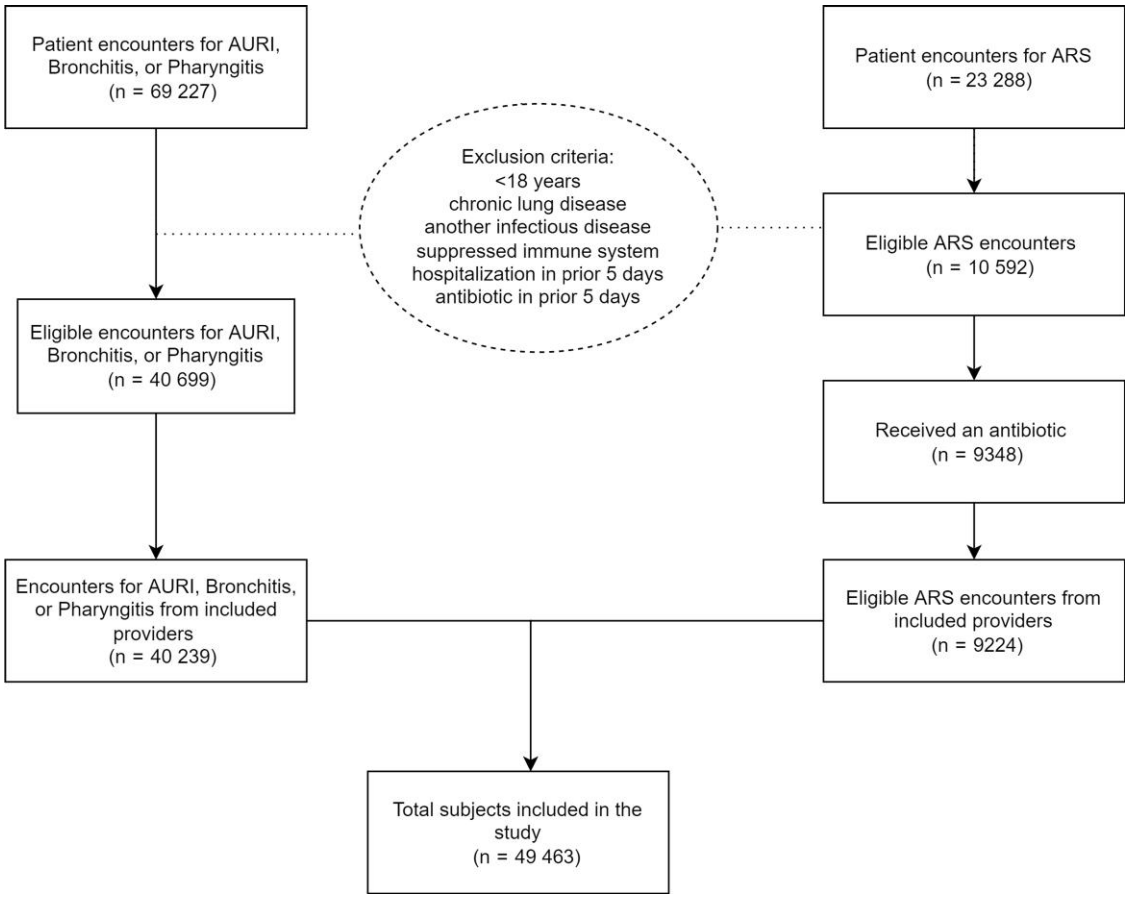

Figure 1. Study subject selection after application of inclusion and exclusion criteria. ARS, acute rhinosinusitis; AURI, acute upper respiratory tract infection.

for all rater pairs. Kappa correlation was acceptable [18] and ranged from 0.445 to 0.929 on all abstracted measures; for the measure that accounted for the vast majority of patients meeting ARS guideline criteria, that is, duration of symptoms ≥10 days, the kappa correlation was 0.929.

RESULTS

During the study period, 92 515 patients were seen for one of the included URI conditions. After applying the exclusion criteria, 41 224 (44.6%) of the subjects were excluded (Figure 1). Of the 10 592 patients with ARS, 9348 (88.2%) subjects received an antibiotic. A total of 1244 patient did not receive an antibiotic and were excluded from the analysis. In addition, patients who were seen by providers with fewer than 5 encounters or missing information were excluded. This left a total of 49 463 subjects ultimately eligible for analysis, with a total of 429 providers.

Overall, antibiotics were unnecessarily prescribed for the 4 indicated conditions in 42.2% (95% CI, 41.7%–42.6%) of the encounters. Acute bronchitis had the highest rate of unnecessary prescribing, followed by ARS, then AURI, then pharyngitis (see Table 1). For 25.9% of patients with pharyngitis without a documented positive test for group A *Streptococcus*, the vast majority (96.9%) had no test ordered, and the remaining 3.1% had a negative test documented. Patient characteristics are noted in Table 2. Although more females were seen than males for URIs, males were more likely to be prescribed an unnecessary antibiotic. In addition, patients who were older or lived in a rural setting were more likely to receive antibiotics unnecessarily.

The composite rates of unnecessary antibiotic prescribing for all 4 respiratory conditions by provider type/characteristic are summarized in Table 3. Results from the logistic regression predicting unnecessary antibiotic prescription by patient and provider characteristics are summarized in Table 4. Practitioners in a rural setting (odds ratio [OR], 1.49; 95% CI, 1.20–1.84) and with more years in practice (OR = 1.09, 95% CI = 1.01–1.16 for every 5 years) had higher odds of unnecessary prescribing. Compared to providers in the family medicine specialty, providers in a high-volume specialty such as urgent care had higher odds of unnecessary prescribing

Table 1. Unnecessary Antibiotic Prescriptions by Condition

Respiratory Condition	Received Unnecessary Antibiotics (N)	Total With Condition (N)	Prescription Rate (95% CI)
Bronchitis	8107	10 923	74.2% (73.4–75.0)
ARS without indication	4223	9224	45.8% (44.8–46.8)
Nonspecific AURI	4882	15 283	31.9% (31.2–32.7)
Pharyngitis without a positive test	3635	14 033	25.9% (25.2–26.6)
Overall	20 847	49 463	42.2% (41.7–42.6)

Abbreviations: ARS, acute rhinosinusitis; AURI, acute upper respiratory tract infection; CI, confidence interval.

(OR, 1.43; 95% CI, 1.08–1.89), but the odds were not significantly different for internal medicine. Provider sex and provider designation were not associated with unnecessary prescribing. As a supplementary analysis, we considered the interaction between provider characteristics. We found that none of the interaction terms were statistically significant.

The breakdown of antibiotics given to ARS patients is shown in Figure 1. A total of 4223 (45.8%) ARS patients received an antibiotic without a guideline-based indication. In addition, of the 5001 (54.2%) who warranted an antibiotic, 1212 (24.2%) received an inappropriate antibiotic class, for a total of 5435 (58.9%) ARS patients receiving an unnecessary and/or inappropriate antibiotic. After the penicillin class of antibiotics, macrolides were the next most common class of antibiotics used. There is a specific recommendation against the use of macrolide antibiotics by both the IDSA and the AAOHN guidelines.

DISCUSSION

Most of the research in the area of ambulatory antibiotic stewardship focuses on either antibiotic inappropriate conditions (such as bronchitis or AURI) or on the appropriateness of antibiotic therapy (appropriate class and duration of treatment) for URIs that may warrant an antibiotic, such as otitis media,

Table 2. Patient Characteristics Compared for Those Who Did or Did Not Receive an Unnecessary Prescription for Antibiotics

Characteristic	Received Unnecessary Antibiotics N (%)	Did Not Receive Unnecessary Antibiotics N (%)	Significance (*P* Value)
Male	8395 (45.2)	10 194 (54.8)	<.001*
Female	12 452 (40.3)	18 422 (59.7)	
Age (mean ± S.D.)	46.2 (18.0)	41.0 (17.5)	<.001
Setting			
Urban	9773 (39.5)	24 954 (60.5)	<.001*
Rural	11 074 (44.8)	13 662 (55.1)	

Abbreviations: S.D., standard deviation.

**P* value is for patients who received an antibiotic; male vs female and urban vs rural.

Table 3. Provider Characteristics and Composite Rate of Unnecessary Prescribing

Characteristic	Number (%)	Composite Rate of Unnecessary Antibiotic Prescription (%)
Gender		
Male	156 (36.4%)	44.1%
Female	273 (63.6%)	40.7%
Specialty		
Family Medicine	307 (71.6%)	41.0%
Internal Medicine	59 (13.8%)	45.0%
High volume	63 (14.7%)	43.2%
Setting		
Urban	154 (36.0%)	39.6%
Rural	275 (64.1%)	44.5%
Provider Type		
MD	201 (46.9%)	43.6%
DO	14 (3.3%)	40.8%
NP	117 (27.3%)	41.3%
PA-C	97 (22.6%)	40.7%
Provider Volume		
High	176 (41.0%)	42.8%
Low	253 (59.0%)	40.2%

Abbreviations: DO, doctor of osteopathic medicine; MD, medical doctor; NP, nurse practitioner; PA-C, physician assistant-certified.

Table 4. Results From Logistic Regression of Patient and Provider Characteristics Predicting Higher Composite Rate of Unnecessary Prescribing

Characteristic	Odds Ratio	95% Confidence Interval		Significance (*P* Value)
Patient Characteristics				
Respiratory Condition (ref = Pharyngitis)				
AURI	1.03	0.97	1.10	.31
Bronchitis	8.80	8.22	9.41	<.001
ARS	2.35	2.20	2.50	<.001
Patient male (ref = female)	1.13	1.08	1.18	<.001
Patient age (5 years)	1.03	1.02	1.04	<.001
Provider Characteristics				
Provider Designation (ref = MD)				
DO	1.24	0.70	2.18	.46
NP/PA-C	1.19	0.94	1.51	.15
Provider Specialty (ref = Family Medicine)				
High volume	1.43	1.08	1.89	.01
Internal medicine	1.01	0.75	1.40	.94
Provider male (ref = female)	1.19	0.94	1.52	.15
Provider setting rural (ref = Urban)	1.49	1.20	1.84	<.001
Provider years in practice (5 years)	1.09	1.02	1.16	<.001

Abbreviations: ARS, acute rhinosinusitis; AURI, acute upper respiratory tract infection; DO, doctor of osteopathic medicine; MD, medical doctor; NP, nurse practitioner; PA-C, physician assistant-certified; ref, reference.

sinusitis, and pharyngitis [19–21]. Our study focused on the necessity of antibiotics for both antibiotic-inappropriate conditions (bronchitis and AURI) and conditions that sometimes warrant an antibiotic (ARS and pharyngitis). Our findings of overall unnecessary prescribing in 42.2% of patients, with very high rates for bronchitis (74.2%) and rates of 31.9% and 25.9% for nonspecific AURI and pharyngitis, respectively, are comparable with previous reports in the literature [7, 22, 23]. Not giving an antibiotic for a nonspecific AURI should seem obvious because the provider is documenting an overt diagnostic code for a presumed viral infection, yet prescribing for this condition is common. The particularly high rates of antibiotics use in cases of acute bronchitis may stem from greater perceived demand from patients with this condition [24, 25]. Notwithstanding, in the absence of chronic lung disease, numerous studies, meta-analyses, and a recent Cochrane review show little to no benefit when patients are given an antibiotic for this condition [26].

In the case of pharyngitis, particularly in adults, viruses account for almost 90% of cases, yet physicians prescribe antibiotics approximately 60% of the time [27]. As such, guidelines recommend only treating acute pharyngitis when there is a positive test for group A *Streptococcus* [28]. We looked at prescribing rates in adult pharyngitis where no positive test was documented for group A streptococci. Antibiotics were given in 25.9% of these encounters and accounted for 23.4% of the unnecessary antibiotic prescribing overall. In the vast majority of these cases, no streptococcus test was ever ordered.

Management of ARS may warrant an antibiotic, but the majority of cases are due to a virus and will resolve on its own with enough time. It is estimated that only 0.5%–2.0% of ARS will transition to a secondary bacterial infection [29]. Nevertheless, up to 80% of patients with this diagnosis will receive an antibiotic [30, 31]. Our study similarly found that 88.3% of patients with ARS received an antibiotic. Few studies have directly assessed the necessity of antibiotics for this condition because it requires manual data abstraction to look for documentation of a guideline-based indication. The few studies that have attempted this were somewhat limited in size, but they found similar rates of guideline nonadherence as our study [32, 33]. The largest study that abstracted data found 38% of 1200 patients received an antibiotic within 3 or fewer days of symptoms [22]. We abstracted over 9000 medical records in patients who received an antibiotic and used the most recent guidelines outlined by the IDSA and AAOHN to search for documentation of a guideline-based indication [16, 17]. In almost 46% of cases, no appropriate indication for an antibiotic was documented. Most of the time, this was due to prescribing an antibiotic before waiting at least 10 days for symptoms to subside, even though a delay in prescribing has been shown to be safe and effective management for most patients, even in higher risk subgroups [34].

Previous studies have assessed what provider characteristics predict unnecessary or inappropriate prescribing. Similar to several prior studies [35, 36], we found that providers who had spent more years in practice were more likely to give unnecessary prescriptions. In addition, providers in rural settings compared with urban settings were more likely to provide unnecessary antibiotic prescriptions, as seen in studies conducted in different geographic regions [37, 38]. Similar to several other studies showing higher rates of inappropriate prescribing in an urgent-care setting, we found that higher volume providers inappropriately prescribed more often than their lower volume colleagues [23, 30, 36, 39, 40]. Unlike other researchers, we did not find higher rates of inappropriate prescribing associated with any particular medical specialty (internal medicine vs family medicine) nor by provider type (MD, DO, NP, PA) [23, 36]. Most of the differences between our study and others are likely explained by regional differences, different practice settings, different conditions being assessed, and slight differences in how "necessity" and "appropriateness" were defined.

The misuse of antibiotics is ubiquitous. As such, broad stewardship initiatives are needed to address this issue. Notwithstanding, efforts targeting providers more likely to misuse antibiotics (eg, those practicing in high patient volume settings) may be beneficial [41, 42], because approximately 15% of our clinicians were responsible for over 50% of the unnecessary antibiotic usage in our study population.

CONCLUSIONS

Despite multiple public health initiatives and professional society guidelines aimed at producing more judicious use of antibiotics for URIs in the outpatient setting, overuse remains quite common. Efforts using electronic medical record prompts such as "best practice alerts" or suggested non-antibiotic alternatives have had mixed results [14, 15]. However, retrospective audits paired with feedback and peer comparison, public commitment posters, accountable justification, and viral prescription pads have all been shown to lead to significant reductions in both unnecessary and inappropriate antibiotic use [15, 43]. Targeting higher volume clinicians may be particularly impactful. Health systems should be encouraged to engage these, as well as novel strategies, to promote necessary and appropriate antibiotic usage as an urgent priority for their quality improvement initiatives.

Acknowledgments

We thank Luke Unger, Haimanot Berhane, and Sargam Ghimire for their assistance in data collection.

Financial support. This work was funded by the Centers for Disease Control and Prevention and the North Dakota Department of Health (NU50CK000514).

Potential conflicts of interest. All authors: No reported conflicts of interest.

All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest.

References

1. Centers for Disease Control and Prevention. Antibiotic resistance and patient safety portal - antibiotic use. Available at: https://arpsp.cdc.gov/profile/antibiotic-use/217. Accessed 6 February 2022.
2. World Health Organization. Antibiotic resistance. 2018. Available at: https://www.who.int/news-room/fact-sheets/detail/antibiotic-resistance. Accessed 6 February 2022.
3. Spellberg B. Antibiotic resistance and antibiotic development. Lancet Infect Dis **2008**; 8:211–2. doi:10.1016/S1473-3099(08)70048-3.
4. Barlam TF, Soria-Saucedo R, Cabral HJ, et al. Unnecessary antibiotics for acute respiratory tract infections: association with care setting and patient demographics. Open Forum Infect Dis **2016**; 3:1–7. doi:10.1093/ofid/ofw045.
5. Fleming-Dutra KE, Hersh AL, Shapiro DJ, et al. Prevalence of inappropriate antibiotic prescriptions among US ambulatory care visits, 2010-2011. JAMA **2016**; 315:1864–73. doi=10.1001/jama.2016.4151.
6. Suda KJ, Hicks LA, Roberts RM, et al. A national evaluation of antibiotic expenditures by healthcare setting in the United States, 2009. J Antimicrob Chemother **2013**; 68:715–8. doi:10.1093/jac/dks445.
7. Silverman M, Povitz M, Sontrop JM, et al. Antibiotic prescribing for nonbacterial acute upper respiratory infections in elderly persons. Ann Intern Med **2017**; 166: 765–74. doi:10.7326/M16-1131.
8. Duffy E, Ritchie S, Metcalfe S, et al. Antibacterials dispensed in the community comprise 85%-95% of total human antibacterial consumption. J Clin Pharm Ther **2018**; 43:59–64. doi:10.1111/jcpt.12610.
9. Hersh AL, Fleming-Dutra KE, Shapiro DJ, et al. Frequency of first-line antibiotic selection among US ambulatory care visits for otitis media, sinusitis, and pharyngitis. JAMA Intern Med **2016**; 176:1870. doi:10.1001/jamainternmed.2016.6625.
10. Sanchez GV, Fleming-Dutra KE, Roberts RM, et al. Core elements of outpatient antibiotic stewardship. MMWR Recomm Reports **2016**; 65:1–12. doi:10.15585/mmwr.rr6506a1.
11. The White House. National Action Plan For Combating Antibiotic-Resistant Bacteria. 2015. Available at: https://obamawhitehouse.archives.gov/sites/default/files/docs/national_action_plan_for_combating_antibotic-resistant_bacteria.pdf. Accessed 6 February 2022.
12. Centers for Disease Control and Prevention. Measuring outpatient antibiotic prescriptions. Available at: https://www.cdc.gov/antibiotic-use/data/outpatient-prescribing/index.html. Accessed 6 February 2022.
13. King LM, Lovegrove MC, Shehab N, et al. Trends in US outpatient antibiotic prescriptions during the coronavirus disease 2019 pandemic. Clin Infect Dis **2021**; 73:e652–60. doi:10.1093/cid/ciaa1896.
14. Hansen MJ, Carson PJ, Leedahl DD, et al. Failure of a best practice alert to reduce antibiotic prescribing rates for acute sinusitis across an integrated health system in the Midwest. J Manag Care Spec Pharm **2018**; 24:154–9. doi:10.18553/jmcp.2018.24.2.154.
15. Meeker D, Linder JA, Fox CR, et al. Effect of behavioral interventions on inappropriate antibiotic prescribing among primary care practices. JAMA **2016**; 315: 562–70. doi:10.1001/jama.2016.0275.
16. Chow AW, Benninger MS, Brook I, et al. IDSA clinical practice guideline for acute bacterial rhinosinusitis in children and adults. Clin Infect Dis **2012**; 54:e72–112. doi:10.1093/cid/cir1043.
17. Rosenfeld RM, Piccirillo JF, Chandrasekhar SS, et al. Clinical practice guideline (update): adult sinusitis. Otolaryngol Head Neck Surg **2015**; 152:S1–39. doi:10.1177/0194599815572097.
18. Cohen J. A coefficient of agreement for nominal scales. Educ Psychol Meas **1960**; 20:37–46. doi:10.1177/001316446002000104.
19. King LM, Sanchez GV, Bartoces M, et al. Antibiotic therapy duration in US adults with sinusitis. JAMA Intern Med **2018**; 178:992–4. doi:10.1001/jamainternmed.2018.0407.
20. Smith SS, Kern RC, Chandra RK, et al. Variations in antibiotic prescribing of acute rhinosinusitis in United States ambulatory settings. Otolaryngol Head Neck Surg **2013**; 148:852–9. doi:10.1177/0194599813479768.
21. Barlam TF, Morgan JR, Wetzler LM, et al. Antibiotics for respiratory tract infections: a comparison of prescribing in an outpatient setting. Infect Control Hosp Epidemiol **2015**; 36:153–9. doi:10.1017/ice.2014.21.
22. Havers FP, Hicks LA, Chung JR, et al. Outpatient antibiotic prescribing for acute respiratory infections during influenza seasons. JAMA Netw Open **2018**; 1: e180243. doi:10.1001/jamanetworkopen.2018.0243.
23. Sanchez GV, Hersh AL, Shapiro DJ, et al. Outpatient antibiotic prescribing among United States nurse practitioners and physician assistants. Open Forum Infect Dis **2016**; 3:1–4. doi:10.1093/ofid/ofw168.
24. Dempsey PP, Businger AC, Whaley LE, et al. Primary care clinicians perceptions about antibiotic prescribing for acute bronchitis: a qualitative study. BMC Fam Pract **2014**; 15:1–10. doi:10.1186/s12875-014-0194-5.
25. Coenen S, Michiels B, Renard D, Denekens J, Van Royen P. Antibiotic prescribing for acute cough: the effect of perceived patient demand. Br J Gen Pract **2006**; 56: 183–90.
26. Little P, Stuart B, Smith S, et al. Antibiotic prescription strategies and adverse outcome for uncomplicated lower respiratory tract infections: prospective cough complication cohort (3C) study. BMJ **2017**; 357. doi:10.1136/bmj.j2148.
27. Barnett ML, Linder JA. Antibiotic prescribing to adults with sore throat in the United States, 1997-2010. JAMA Intern Med **2014**; 174:138–40. doi:10.1001/jamainternmed.2013.11673.
28. Harris AM, Hicks LA, Qaseem A. Appropriate antibiotic use for acute respiratory tract infection in adults: advice for high-value care from the American College of Physicians and the Centers for Disease Control and Prevention. Ann Intern Med **2016**; 164:425–34. doi:10.7326/M15-1840.
29. Gwaltney JM. Acute community-acquired sinusitis. Clin Infect Dis **1996**; 23: 1209–23. quiz 1224–5.doi:10.1093/clinids/23.6.1209.
30. Jones BE, Sauer B, Jones MM, et al. Variation in outpatient antibiotic prescribing for acute respiratory infections in the Veteran population: a cross-sectional study. Ann Intern Med **2015**; 163:73–80. doi:10.7326/M14-1933.
31. Fairlie T, Shapiro DJ, Hersh AL, et al. National trends in visit rates and antibiotic prescribing for adults with acute sinusitis. Arch Intern Med **2012**; 172:1513–4. doi:10.1001/archinternmed.2012.4089.
32. Alweis R, Greco M, Wasser T, et al. An initiative to improve adherence to evidence-based guidelines in the treatment of URIs, sinusitis, and pharyngitis. J Community Hosp Intern Med Perspect **2014**; 4:22958. doi:10.3402/jchimp.v4.22958.
33. Crocker A, Alweis R, Scheirer J, et al. Factors affecting adherence to evidence-based guidelines in the treatment of URI, sinusitis, and pharyngitis. J Community Hosp Intern Med Perspect **2013**; 3:20744. doi:10.3402/jchimp.v3i2.20744.
34. Stuart B, Hounkpatin H, Becque T, et al. Delayed antibiotic prescribing for respiratory tract infections: individual patient data meta-analysis. BMJ **2021**; 373:n808. doi:10.1136/bmj.n808.
35. Li D, Conson M, Kim N, et al. Patient and provider characteristics and outcomes associated with outpatient antibiotic overuse in acute adult bronchitis. Proc (Bayl Univ Med Cent) **2020**; 33:183–7. doi:10.1080/08998280.2019.1708667.
36. Schmidt ML, Spencer MD, Davidson LE. Patient, provider, and practice characteristics associated with inappropriate antimicrobial prescribing in ambulatory practices. Infect Control Hosp Epidemiol **2018**; 39:307–15. doi:10.1017/ice.2017.263.
37. Dantuluri KL, Bruce J, Edwards KM, et al. Rurality of residence and inappropriate antibiotic use for acute respiratory infections among young Tennessee children. Open Forum Infect Dis **2021**; 8:ofaa587. doi:10.1093/ofid/ofaa587.
38. Sulis G, Daniels B, Kwan A, et al. Antibiotic overuse in the primary health care setting: a secondary data analysis of standardised patient studies from India, China and Kenya. BMJ Glob Health **2020**; 5:e003393. doi:10.1136/bmjgh-2020-003393.
39. Fleming-Dutra KE, Bartoces M, Roberts RM, et al. Characteristics of primary care physicians associated with high outpatient antibiotic prescribing volume. Open Forum Infect Dis **2018**; 5 (1). doi:10.1093/ofid/ofx279.
40. Aabenhus R, Siersma V, Sandholdt H, et al. Identifying practice-related factors for high-volume prescribers of antibiotics in Danish general practice. J Antimicrob Chemother **2017**; 72:2385–91. doi:10.1093/jac/dkx115.
41. Schwartz KL, Ivers N, Langford BJ, et al. Effect of antibiotic-prescribing feedback to high-volume primary care physicians on number of antibiotic prescriptions: a randomized clinical trial. JAMA Intern Med **2021**; 181:1165–73. doi:10.1001/jamainternmed.2021.2790.
42. Gouin KA, Fleming-Dutra KE, Tsay S, et al. Identifying higher-volume antibiotic outpatient prescribers using publicly available Medicare part D data—United States, 2019. MMWR Morb Mortal Wkly Rep **2022**; 71:202–5. doi:10.15585/mmwr.mm7106a3.
43. King LM, Fleming-Dutra KE, Hicks LA. Advances in optimizing the prescription of antibiotics in outpatient settings. BMJ **2018**; 176:k3047. doi:10.1136/bmj.k3047.