CLINICAL RESEARCH STUDY

THE AMERICAN JOURNAL of MEDICINE®

Avoidable Antibiotic Exposure for Uncomplicated Skin and Soft Tissue Infections in the Ambulatory Care Setting

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ABSTRACT

BACKGROUND: Uncomplicated skin and soft tissue infections are among the most frequent indications for outpatient antibiotics. A detailed understanding of current prescribing practices is necessary to optimize antibiotic use for these conditions.

METHODS: This was a retrospective cohort study of children and adults treated in the ambulatory care setting for uncomplicated cellulitis, wound infection, or cutaneous abscess between March 1, 2010 and February 28, 2011. We assessed the frequency of avoidable antibiotic exposure, defined as the use of antibiotics with broad gram-negative activity, combination antibiotic therapy, or treatment for 10 or more days. Total antibiotic-days prescribed for the cohort were compared with antibiotic-days in 4 hypothetical short-course (5-7 days), single-antibiotic treatment models consistent with national guidelines.

RESULTS: A total of 364 cases were included for analysis (155 cellulitis, 41 wound infection, and 168 abscess). Antibiotics active against methicillin-resistant *Staphylococcus aureus* were prescribed in 61% of cases of cellulitis. Of 139 cases of abscess where drainage was performed, antibiotics were prescribed in 80% for a median of 10 (interquartile range, 7-10) days. Of 292 total cases where complete prescribing data were available, avoidable antibiotic exposure occurred in 46%. This included use of antibiotics with broad gram-negative activity in 4%, combination therapy in 12%, and treatment for 10 or more days in 42%. Use of the short-course, single-antibiotic treatment strategies would have reduced prescribed antibiotic-days by 19% to 55%.

CONCLUSIONS: Approximately half of uncomplicated skin infections involved avoidable antibiotic exposure. Antibiotic use could be reduced through treatment approaches using short courses of a single antibiotic.

 • The American Journal of Medicine (2013) 126, 1099-1106

KEYWORDS: Abscess; Antimicrobial stewardship; Cellulitis; Skin and soft tissue infection; Uncomplicated skin and soft tissue infection

Antibiotic prescribing in the community is associated with antimicrobial resistance[1-3] and adverse events.[4,5] Prevention of unnecessary antibiotic use for common outpatient infections is therefore an essential component of efforts to prevent further antimicrobial resistance and improve patient safety. Uncomplicated skin and soft tissue infections, such as cellulitis and cutaneous abscess, are among the most frequent indications for outpatient antibiotic use. With the widespread emergence of community-associated methicillin-resistant *Staphylococcus aureus* over the past decade, ambulatory care visits for skin infections have rapidly increased and now exceed 14 million visits per year.[6,7]

Despite the burden of skin infections on the health care system and their contribution to overall antibiotic use, knowledge of current antibiotic prescribing practices is incomplete. Additional details of antibiotic selection and

Funding: This work was supported by the Departments of Medicine and Patient Safety and Quality, Denver Health Medical Center. TCJ was supported by the National Institute of Allergy and Infectious Diseases at the National Institutes of Health (K23 AI099082).

Conflict of Interest: None.

Authorship: All authors had access to the data and played a role in writing this manuscript.

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0002-9343/$ -see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.amjmed.2013.08.016

duration of therapy for the various types of uncomplicated skin infection are necessary to develop interventions to optimize prescribing. Previously, we demonstrated that use of overly broad-spectrum antibiotic regimens and prolonged treatment durations were common in patients hospitalized with cellulitis and cutaneous abscess.[8,9] However, the majority of skin infections are managed in the ambulatory setting. Our hypothesis was that, similar to hospitalized patients, a substantial amount of antibiotic exposure for outpatient skin infections is avoidable. The objectives of this study were to describe antibiotic prescribing practices in cases of uncomplicated skin and soft tissue infection in a large ambulatory care system and assess for opportunities to reduce antibiotic use.

CLINICAL SIGNIFICANCE

- Approximately half of uncomplicated skin infections were associated with avoidable antibiotic exposure, defined as the use of antibiotics with broad gram-negative activity, combination antibiotic therapy, or treatment for 10 or more days.
- Use of a short-course, single-antibiotic treatment strategy would reduce total antibiotic exposure by up to 55%.
- Uncomplicated skin infections are an important target for future antimicrobial stewardship interventions.

MATERIALS AND METHODS

Study Setting and Population

Denver Health is a vertically integrated public safety net institution. Adults and children can access care at multiple sites, including a 500-bed teaching hospital, emergency department, urgent care center, 8 federally qualified community health clinics, 16 school-based clinics, specialty clinics, and the public health department.[10] The entire Denver Health system is served by a single laboratory and a unified electronic health record that contains both inpatient and outpatient records.

Study Design

We performed a retrospective cohort study of adults and children presenting to the emergency department, urgent care center, or any outpatient clinic in the Denver Health system with a primary diagnosis of skin and soft tissue infection between March 1, 2010, and February 28, 2011. *International Classification of Diseases, 9th Revision, Clinical Modification* codes (680, 681, 682, 683, 686, 035) were used to identify eligible cases. For patients with multiple infections during the study period, only the initial episode was included. Manual chart review was performed on a random sample of cases for diagnostic, treatment, and outcomes data using a standardized data-collection instrument.

Patients aged less than 31 days or more than 89 years were excluded. Cases involving the following complicating factors were excluded: hospitalization at the time of the initial visit or within 30 days prior, deep tissue involvement, periorbital or perineal infection, presence of another infection requiring antibiotic therapy, infected ulcer, peripheral arterial disease, bacteremia, human or animal bite, recurrence of a skin infection treated within 90 days, postsurgical wound infection, and pregnancy. Cases also were excluded that involved superficial infection such as folliculitis or impetigo, odontogenic infection, miscoding, lack of sufficient medical record documentation to classify the case, and leaving against medical advice. All clinical encounters within a 30-day period after the initial visit were reviewed to assess outcomes. The study was approved by the Colorado Multiple Institutional Review Board.

Outcome Measures and Study Definitions

By using clinical documentation at the initial visit, cases were categorized into 3 groups: cellulitis, defined as a diffuse skin infection characterized by spreading areas of redness, edema, or induration without a draining wound; wound infection, defined as drainage from a wound with surrounding redness, edema, or induration; and cutaneous abscess, defined as a collection of pus within the dermis or deeper accompanied by redness, edema, or induration.[11] A subset of cases of abscess were considered candidates for drainage without antibiotic therapy based on Infectious Diseases Society of America (IDSA) guidance,[12] including those where adequate drainage was achieved and the absence of hand or face involvement, multiple foci of infection, diabetes mellitus, human immunodeficiency virus infection, use of immunosuppressing medications, temperature $>38.0^{\circ}C$, and age <3 or >75 years.

Details of antibiotic treatment were obtained from provider documentation, medication lists, or pharmacy prescription fill data. Prescribing data were recorded on the basis of the provider's intent at the initial visit, irrespective of patient adherence to the treatment. The primary end point was the frequency of avoidable antibiotic exposure, defined as use of antibiotics with a broad spectrum of gram-negative activity; combination antibiotic therapy; and treatment for 10 or more days. The primary end point analysis was limited to cases with complete documentation of antibiotics prescribed (when applicable) and duration of therapy. Antibiotics with a broad spectrum of gram-negative activity were defined as β-lactam/β-lactamase inhibitor combinations and second-, third-, or fourth-generation cephalosporins, fluoroquinolones, carbapenems, or aminoglycosides. Combination therapy was defined as prescription of 2 or more concurrent antibiotics. Prespecified secondary end points included the proportion of cases of cellulitis where an antibiotic with activity against methicillin-resistant *S. aureus* was prescribed, the proportion of drained abscesses where an antibiotic was prescribed, and factors

associated with avoidable antibiotic exposure by multivariate analysis.

Clinical failure was a composite end point of treatment failure, recurrent infection, or change in therapy because of an adverse drug event within 30 days of the initial visit. Treatment failure was defined as any unplanned drainage procedure, change in antibiotic regimen, hospitalization for treatment, or extension of planned duration of therapy because of inadequate clinical response. Recurrent infection was defined as signs or symptoms of skin infection that required reinitiation of antibiotics.

Data Analysis

Descriptive statistics were calculated for each variable as appropriate. Stepwise multivariate logistic regression was conducted to determine factors associated with avoidable antibiotic exposure. Entry into the multivariate model was limited to factors with a *P* value for univariate association of less than .25 or those deemed to be of clinical significance.

To estimate total antibiotic use for the entire study cohort, antibiotic-days for each case were first calculated as follows: when antibiotics were prescribed for a known duration, the calendar days of each individual antibiotic prescribed were summed; when antibiotics were prescribed but the duration of therapy was unknown, the median value of antibiotic-days in cases with a known duration of therapy was imputed; when antibiotic therapy was not prescribed (eg, drained abscesses), antibiotic-days were recorded as zero. Total antibiotic-days for the study cohort were then estimated by summing the antibiotic-days for all cases. To illustrate the opportunity to reduce antibiotic use, we compared total antibiotic-days in the study cohort with total antibiotic-days that would have been prescribed if each of 4 short-course, single-antibiotic treatment strategies consistent with IDSA guidance[12] were applied to the cohort: 7-day course of a single antibiotic for all cases; no antibiotic therapy for abscesses meeting criteria for drainage alone and a 7-day course of a single antibiotic for all other cases; 5-day course of a single antibiotic for all cases; and no antibiotic therapy for abscesses meeting criteria for drainage alone and a 5-day course of a single antibiotic for all other cases. All analyses were conducted using SAS v.9.3 (SAS Institute, Cary, NC).

RESULTS

A total of 2713 discrete patients had a visit with a primary diagnosis of skin infection by International Classification of Diseases, 9th Revision, Clinical Modification codes (**Figure 1**). Of a random sample of 670 cases reviewed, 306 were excluded for reasons detailed in **Figure 1**. The remaining 364 cases of uncomplicated skin infection were included in the study: 155 were classified as cellulitis, 41 were classified as wound infection, and 168 were classified as cutaneous abscess.

The median age of the cohort was 38 years (**Table 1**); 61 (17%) were aged ≤18 years. Diabetes mellitus (48, 13%) and a prior skin infection (75, 21%) were common risk factors. The majority of infections involved upper (114, 31%) or lower (121, 33%) extremities.

Specimens for microbiological culture were obtained in 108 cases (30%), of which 85 (79%) were abscess cultures (**Table 2**). Of the 68 cases with a positive culture, *S. aureus* or streptococci were present in 65 (96%). Methicillin-susceptible *S. aureus* was identified more frequently than methicillin-resistant *S. aureus* (50% vs 35%), including in cases of abscess (47% vs 40%). Gram-negative and anaerobic organisms were identified infrequently.

Antibiotic regimens with activity against methicillin-resistant *S. aureus* were prescribed in the majority of cases of cellulitis, wound infection, and abscess (61%, 58%, and 93%, respectively) (**Table 3**). For cases of abscess, incision and drainage were performed in 139 (83%). Of

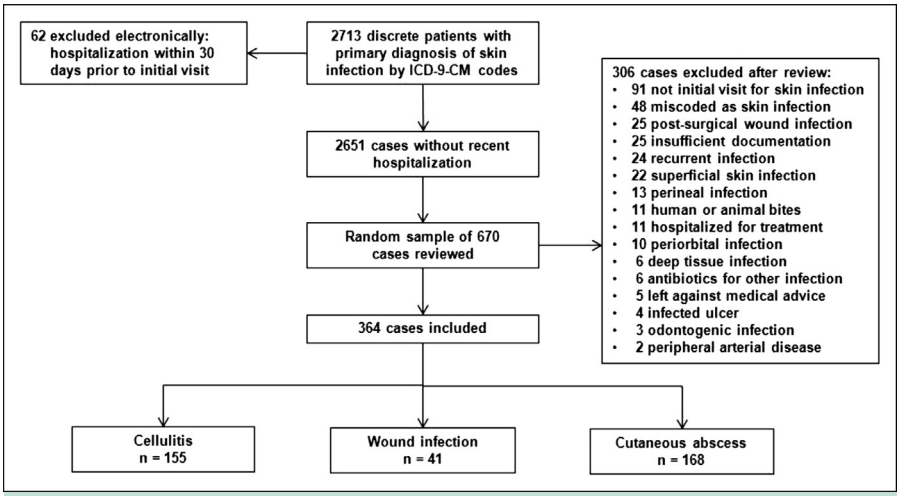

Figure 1 Study schematic. ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification.

Table 1 Demographic and Clinical Characteristics

	Cellulitis n = 155	Wound Infection n = 41	Abscess n = 168	Total n = 364
Age, median (IQR)	37 (21-53)	38 (26-53)	38 (26-53)	38 (24-53)
Male	76 (49)	22 (54)	87 (52)	185 (51)
Comorbid condition/risk factor*	66 (43)	17 (41)	93 (55)	176 (48)
Diabetes mellitus	21 (14)	5 (12)	22 (13)	48 (13)
Injection drug use	1 (1)	3 (7)	19 (11)	23 (6)
Alcohol abuse or dependence	19 (12)	9 (22)	33 (20)	61 (17)
Lymphedema	15 (10)	1 (2)	0	16 (4)
Chronic venous stasis	4 (3)	0	0	4 (1)
Immunosuppressing medications	2 (1)	0	4 (2)	6 (2)
HIV infection	2 (1)	0	3 (2)	5 (1)
Cirrhosis	1 (1)	1 (2)	0	2 (1)
Dialysis dependence	1 (1)	0	0	1 (0.3)
Prior skin infection	23 (15)	3 (7)	49 (29)	75 (21)
Prior MRSA infection or colonization	5 (3)	0	12 (7)	17 (5)
Anatomic location				
Head and neck	23 (15)	3 (7)	22 (13)	48 (13)
Upper extremity	46 (30)	15 (37)	53 (32)	114 (31)
Lower extremity	66 (43)	21 (51)	34 (20)	121 (33)
Trunk	16 (10)	2 (5)	41 (24)	59 (16)
Buttock	5 (3)	0	20 (12)	25 (7)
Multiple distinct areas of infection	9 (6)	0	17 (10)	26 (7)
Duration of symptoms before presentation, median days (IQR)	3 (2-7)	4 (2-7)	6 (3-7)	4 (2-7)
Temperature $\geq$38°C	2 (1)	0	3 (2)	5 (1)
White blood cell count >10,000 cells/mm^3	13/37 (35)	1/3 (33)	11/28 (39)	25/68 (37)
Site of initial visit				
Emergency department	33 (21)	7 (17)	50 (30)	90 (25)
Urgent care	72 (46)	20 (49)	76 (45)	168 (46)
Outpatient clinic	50 (32)	14 (34)	42 (25)	106 (29)

Data presented as n (%) unless noted otherwise.
HIV = human immunodeficiency virus; IQR = interquartile range; MRSA = methicillin-resistant *Staphylococcus aureus*.
*No cases involved active malignancy, connective tissue disease or vasculitis, or leg vein harvest.

those 139 cases, antibiotic therapy was prescribed in 111 (80%) for a median of 10 (interquartile range, 7-10) days. Eighty cases (48%) of abscess were candidates for drainage alone by IDSA guidance; of those, 59 (74%) were treated with antibiotics for a median of 10 (interquartile range, 7-10) days. For the entire cohort, combination therapy with a β-lactam plus a methicillin-resistant *S. aureus*–active antibiotic was prescribed in 55 cases (15%), including 25 cases (16%) of cellulitis, 11 cases (27%) of wound infections, and 19 cases (11%) of abscesses.

For the 292 cases with complete prescribing documentation, avoidable antibiotic exposure occurred in 135 (46%) and was common for all 3 types of uncomplicated skin infection (Table 4). Avoidable antibiotic exposure was most frequently due to the use of combination therapy (35, 12%) or treatment for 10 or more days (122, 42%). Only 5 cases (2%) were treated for more than 10 days. By multivariate logistic regression, the only factor independently associated with avoidable antibiotic exposure was the type of infection (cellulitis or wound infection vs abscess: odds ratio, 1.7; 95% confidence interval, 1.1-2.8).

For the entire study cohort, an estimated 3159 antibiotic-days were prescribed (Figure 2). Use of the 4 short-course, single-antibiotic treatment strategies would have resulted in 1420 to 2548 antibiotic-days, representing 19% to 55% reductions in antibiotic use compared with the study cohort. In total, clinical failure occurred in 52 cases (14%) (Table 5). The rate of clinical failure was 14% in cases involving avoidable antibiotic exposure and 11% in all others (P = .34).

DISCUSSION

Skin and soft tissue infections are one of the most frequent indications for antibiotic use in the ambulatory care setting. In this cohort of patients with uncomplicated skin infection, avoidable antibiotic exposure occurred in approximately half of cases, most often related to use of combination therapy or treatment for $\geq$10 days. More than 60% of cases of cellulitis were prescribed a regimen with activity against methicillin-resistant *S. aureus*. Antibiotics were prescribed in approximately three quarters of cases of abscess that were candidates for drainage alone according to IDSA guidance.

Table 2 Diagnostic Tests and Microbiology

	Cellulitis n = 155	Wound Infection n = 41	Abscess n = 168	Total n = 364
Laboratory study performed	37 (24)	3 (7)	28 (17)	68 (19)
White blood cell count	37 (24)	3 (7)	28 (17)	68 (19)
Erythrocyte sedimentation rate	16 (10)	1 (2)	12 (7)	29 (8)
C-reactive protein	18 (12)	2 (5)	15 (9)	35 (10)
Imaging study performed	39 (25)	7 (17)	26 (15)	72 (20)
Plain film radiograph	27 (17)	6 (15)	15 (9)	48 (13)
Ultrasound	14 (9)	2 (5)	11 (7)	27 (7)
Computed tomography scan	0	0	1 (1)	1 (0.3)
Microbiological specimen obtained	19 (12)	4 (10)	85 (51)	108 (30)
Surface culture	13 (8)	3 (7)	2 (1)	18 (5)
Abscess culture	1 (1)*	0	81 (48)	82 (23)
Blood culture	5 (3)	0	4 (2)	9 (2)
Other culture†	1 (1)	1 (2)	1 (1)	3 (1)
Microorganisms identified‡	7 (5)	4 (10)	57 (34)	68 (19)
Methicillin-susceptible *Staphylococcus aureus*	4 (57)	3 (75)	27 (47)	34 (50)
MRSA	0	1 (25)	23 (40)	24 (35)
Streptococci	2 (29)	0	5 (9)	7 (10)
S. aureus or streptococci	6 (86)	4 (100)	55 (96)	65 (96)
S. aureus or streptococci only	6 (86)	3 (75)	51 (89)	59 (88)
Anaerobe(s)	0	0	1 (2)	1 (1)
Gram-negative organisms§	1 (14)	1 (25)	4 (7)	6 (9)
Enterococci	0	0	1 (2)	1 (1)

MRSA = methicillin-resistant *Staphylococcus aureus*.
*Case classified as cellulitis at initial visit; abscess had formed by follow-up visit.
†Includes aspirate (2) and operative tissue culture (1).
‡Denominator for proportion of each individual microorganism is cases with a microorganism identified.
§Includes *Proteus mirabilis* (2), *Eikenella corrodens* (2), *Klebsiella pneumoniae* (1), and *Pseudomonas aeruginosa* (1).

A treatment approach using short courses of a single antibiotic (or drainage alone for low-risk abscesses) would have reduced antibiotic exposure by 19% to 55%.

Previous population-based studies of outpatient skin infections demonstrated an increase in use of antibiotics with methicillin-resistant *S. aureus* activity and a decrease in use of β-lactam agents during the emergence of community-associated methicillin-resistant *S. aureus* from 2000 to 2005.[6,7] The present study is a comprehensive evaluation that provides both an update on antibiotic prescribing practices as the community-associated methicillin-resistant *S. aureus* epidemic has evolved and additional details regarding antibiotic selection and duration of therapy. Such information may inform the prioritization and development of outpatient antimicrobial stewardship interventions.

A number of aspects of the treatment of uncomplicated skin infections are controversial. The 3 elements of our composite primary end point of avoidable antibiotic exposure therefore warrant further discussion. First, the use of antibiotics with a broad spectrum of gram-negative activity is perhaps the most straightforward of the 3 because the majority of uncomplicated skin infections are caused by gram-positive pathogens,[13,14] and national guidelines recommend antibiotics targeting these organisms.[12,15] Thus, prevention of the use of agents with a broad spectrum of gram-negative activity is one approach to reducing unnecessary antibiotic exposure. Fortunately, in contrast to the treatment of inpatient skin infections,[8,9] we found use of agents with broad gram-negative activity in the ambulatory care setting to be relatively uncommon.

Second, combination antibiotic therapy such as a β-lactam plus a methicillin-resistant *S. aureus*—active agent is avoidable in most cases of uncomplicated skin infection. Although current IDSA guidance presents combination therapy as an option "if coverage for both β-hemolytic streptococci and community-associated methicillin-resistant *S. aureus* is desired,"[12] it is noted that the need for such coverage is controversial. Since publication of the guideline, the only randomized trial to date evaluating combination therapy for uncomplicated cellulitis demonstrated that cephalexin plus trimethoprim-sulfamethoxazole did not improve clinical response compared with cephalexin alone.[16] A larger randomized trial evaluating the same antibiotic regimens for uncomplicated cellulitis is nearing completion.[17] In the case of cutaneous abscess, adjunctive antibiotic therapy provides little, if any, incremental benefit over drainage alone,[18,19] and *S. aureus* is the overwhelmingly predominant pathogen. Consequently, there is no reason to expect that adding a β-lactam to a methicillin-resistant *S. aureus*—active agent would substantially improve outcomes. On the other hand, it certainly has the potential to increase adverse events. Despite the lack of

Table 3 Drainage Procedures and Antibiotic Therapy

	Cellulitis n = 155	Wound Infection n = 41	Abscess n = 168	Total n = 364
Drainage or debridement performed	0	4 (10)	139 (83)	143 (39)
Intravenous antibiotic administered at initial visit	12 (8)	4 (10)	9 (5)	25 (7)
Antibiotic regimen prescribed at discharge	153 (99)	38 (93)	134 (80)	325 (89)
TMP-SMX	40 (26)	7 (17)	71 (42)	118 (32)
Cephalexin	49 (32)	13 (32)	7 (4)	69 (19)
Doxycycline	26 (17)	2 (5)	25 (15)	53 (15)
β-lactam plus MRSA-active agent*	25 (16)	11 (27)	19 (11)	55 (15)
Clindamycin	3 (2)	1 (2)	8 (5)	12 (3)
Amoxicillin-clavulanate	4 (3)	0	2 (1)	6 (2)
Dicloxacillin	4 (3)	2 (5)	0	6 (2)
Fluoroquinolone	1 (1)	2 (5)	0	3 (1)
Other combination	1 (1)	1 (2)	1 (1)	3 (1)
MRSA-active therapy†,‡	94/153 (61)	22/38 (58)	125/134 (93)	241/325 (74)
Duration of therapy prescribed, median days (IQR)§	7 (7-10)	7 (7-10)	7 (5-10)‖	7 (7-10)
5 d	8 (7)	0	6 (4)	14 (5)
7 d	51 (44)	17 (52)	44 (31)	112 (38)
10 d	53 (46)	12 (36)	52 (36)	117 (40)
≥14 d	1 (1)	0	4 (3)	5 (2)
Other duration¶	1 (1)	1 (3)	3 (2)	5 (2)

IQR = interquartile range; MRSA = methicillin-resistant *Staphylococcus aureus*; TMP-SMX = trimethoprim-sulfamethoxazole.

*Includes cephalexin/TMP-SMX (48), cephalexin/doxycycline (1), cephalexin/clindamycin (1), amoxicillin-clavulanate/TMP-SMX (3), penicillin/TMP-SMX (1), and dicloxacillin/TMP-SMX (1).

†Denominator includes only patients who were treated with antibiotics.

‡Treatment regimen included vancomycin, TMP-SMX, doxycycline, or clindamycin.

§Analysis limited to 292 cases with known duration of therapy.

‖Includes cases where no antibiotic was given; when limited to the 134 cases where an antibiotic was prescribed, the median increased to 10 (IQR, 7-10) days.

¶Includes 1 day (1), 6 days (1), and 9 days (3).

evidence supporting a role for combination therapy in any type of uncomplicated skin infection, we found that use of a β-lactam plus a methicillin-resistant *S. aureus*—active agent was relatively common across all 3 types. Pending the results of additional studies, on the basis of currently available evidence, the use of combination therapy in uncomplicated skin infections should be discouraged.

Last, although the optimal duration of therapy for uncomplicated skin infection has not been definitively established, treatment durations of 10 or more days represent an opportunity to reduce antibiotic use. We acknowledge that a 10-day treatment course is within IDSA guideline recommendations for 5 to 10 days of therapy for outpatient cellulitis.[12] However, treatment durations of 5 or 6 days seem to be as effective as 10 days.[20,21] Our data demonstrate that providers uncommonly treat cellulitis for only 5 days (7% of cases) but treat for 10 days in approximately half of cases. Regardless of whether one considers a 10-day course of therapy to be appropriate, shifting prescribing practices to shorter durations (ie, 5-7 days) has the potential to reduce antibiotic exposure substantially while adhering to national guidelines.

With respect to the optimal duration of therapy in cases of cutaneous abscess, whether adjunctive antibiotics are needed after abscess drainage remains controversial.[22,23] IDSA guidance recommends drainage alone for simple abscesses without complicating factors.[12] In the present study, antibiotics were prescribed in approximately three quarters of such cases, highlighting the discordance between current guidelines and clinical practice. It also is notable that

Table 4 Avoidable Antibiotic Exposure in 292 Cases with Complete Prescribing Data*

	Cellulitis n = 116	Wound Infection n = 33	Abscess n = 143	Total n = 292
Total cases with avoidable antibiotic exposure	60 (52)	17 (52)	58 (41)	135 (46)
Antibiotics with a broad spectrum of gram-negative activity	5 (4)	3 (9)	3 (2)	11 (4)
Combination antibiotic therapy	15 (13)	8 (24)	12 (8)	35 (12)
Treatment for ≥10 d	54 (47)	12 (36)	56 (39)	122 (42)

*Analysis excludes 72 cases where an antibiotic was prescribed but the duration of therapy could not be determined.

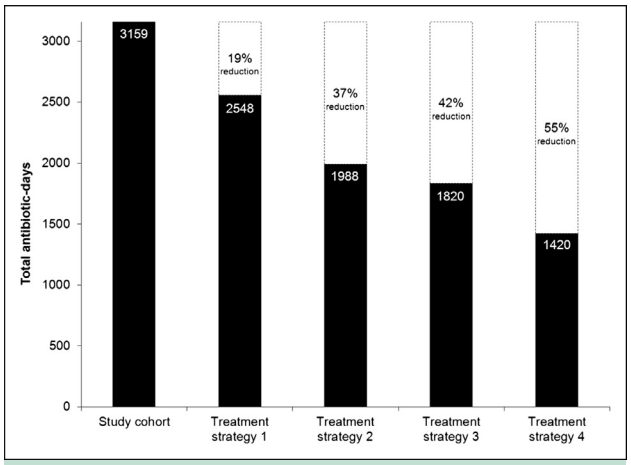

Figure 2 Estimated total antibiotic-days prescribed for uncomplicated skin and soft tissue infections in the study cohort and in 4 hypothetical short course, single-antibiotic treatment models. Treatment strategy 1: 7-day course of a single antibiotic for all cases. Treatment strategy 2: no antibiotic therapy for cases of abscesses meeting IDSA criteria for drainage alone, 7-day course of a single antibiotic for all other cases. Treatment strategy 3: 5-day course of a single antibiotic for all cases. Treatment strategy 4: no antibiotic therapy for cases of abscesses meeting IDSA criteria for drainage alone, 5-day course of a single antibiotic for all other cases. *Dashed boxes* indicate the relative reduction in total antibiotic-days that would be achieved using each respective treatment model strategy compared with the study cohort.

when antibiotics were prescribed after abscess drainage, the duration of therapy was 10 or more days in approximately half of cases. Because drainage alone is sufficient to cure most abscesses,[18,19] use of shorter courses of therapy (when antibiotics are prescribed) seems rational. The results of an ongoing large, randomized trial should help to clarify the role of adjunctive antibiotic therapy in the management of cutaneous abscess.[17] In the meantime, our findings suggest that much of current antibiotic exposure is avoidable through drainage alone or use of shorter treatment courses when antibiotics are prescribed.

Despite the community-associated methicillin-resistant *S. aureus* epidemic, treatment targeted toward β-hemolytic streptococci (ie, β-lactams) continues to be effective for cellulitis[13,24-26] and may result in fewer adverse events than antibiotics with methicillin-resistant *S. aureus* activity.[25] We found that methicillin-resistant *S. aureus*—active agents—most commonly trimethoprim-sulfamethoxazole—were prescribed in approximately 60% of uncomplicated cellulitis cases. This suggests a lack of understanding of the microbiology of cellulitis or may simply reflect discomfort in not covering for methicillin-resistant *S. aureus*. Unfortunately, this practice may put patients at risk for poor outcomes; Elliott et al[24] demonstrated an increased risk of treatment failure with trimethoprim-sulfamethoxazole compared with β-lactams in nonpurulent skin infections. Future interventions to optimize prescribing for uncomplicated skin infections therefore should include efforts to educate providers regarding the appropriate spectrum of antibiotic therapy for cellulitis.

By extrapolating data from our cohort to the entire Denver Health ambulatory care system, using one of the proposed short-course, single-antibiotic treatment strategies would have avoided between 2419 and 6881 antibiotic-days (6.6-18.9 antibiotic-years!) during the 1-year period. Foregoing antibiotic therapy for low-risk abscesses and treating the remainder of uncomplicated skin infections with 5 days of a single antibiotic, a treatment approach concordant with IDSA guidance,[12] would have cut antibiotic use by more than half. This degree of potentially avoidable antibiotic exposure and the frequency of uncomplicated skin infections highlight the importance of focusing antimicrobial stewardship resources to these infections.

Study Limitations

First, the study was performed at a single institution; however, the inclusion of children and adults and diverse sites within a large ambulatory care system increases the generalizability. Second, because of the retrospective nature of the study, we could not determine the duration of therapy in 20% of cases where an antibiotic was prescribed, and therefore we

Table 5 Clinical Outcomes

	Cellulitis n = 155	Wound Infection n = 41	Abscess n = 168	Total n = 364
Follow-up visit within 30 d	72 (46)	22 (54)	100 (60)	194 (53)
Clinical failure	24 (15)	4 (10)	24 (14)	52 (14)
Treatment failure	19 (12)	3 (7)	24 (14)	46 (13)
Unplanned drainage procedure	5 (3)	1 (2)	18 (11)	24 (7)
Change in antibiotic	14 (9)	3 (7)	17 (10)	34 (9)
Hospitalization for treatment	6 (4)	0	5 (3)	11 (3)
Extension of planned duration of therapy	5 (3)	0	1 (1)	6 (2)
Recurrence	7 (5)	0	1 (1)	8 (2)
Change in antibiotic because of adverse drug event	2 (1)	1 (2)	0	3 (1)

excluded such cases from the primary end point analysis. It also is possible that antibiotics were prescribed, but not documented, in some cases. This could explain the apparent nontreatment of several cases of cellulitis and wound infections. Overall, this study underestimates the true burden of skin infections and resultant antibiotic use in our ambulatory care system because we excluded presentations for a non-first episode or secondary diagnosis of skin infection and those with limited documentation. Finally, the most recent IDSA guideline addressing the management of uncomplicated skin infections was not published until the last month of the study period.[12] Therefore, it is important to point out that this study was not an evaluation of adherence to guideline recommendations. Rather, the recommendations are discussed to provide context to the observed prescribing practices and highlight the opportunity to decrease antibiotic use.

CONCLUSIONS

Uncomplicated skin infections are frequently associated with avoidable antibiotic exposure. Total antibiotic use could be substantially reduced through the use of a short-course, single-antibiotic treatment approach. Skin infections are therefore a high-yield target for antimicrobial stewardship interventions aimed at preventing unnecessary antibiotic exposure. On the basis of our findings, we are planning an initiative involving an institutional treatment guideline, provider education, and peer-champion advocacy to improve prescribing.

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