JAMA Dermatology | Original Investigation

# Use of Antibiotics for Dermatologic Procedures From 2008 to 2016

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**IMPORTANCE** Although overall antibiotic use among dermatologists is decreasing, there has been an increase in use associated with dermatologic procedures during the past decade. This higher antibiotic use may increase antibiotic-associated adverse events and promote the development of antibiotic resistance.

**OBJECTIVE** To characterize antibiotic use associated with dermatologic procedures, including geographic variation.

**DESIGN, SETTING, AND PARTICIPANTS** Using Optum Clinformatics DataMart deidentified commercial claims data, we performed a repeated cross-sectional analysis of antibiotic prescribing by dermatologists from 2008 to 2016. Dermatology clinicians were identified by their National Uniform Claim Committee taxonomy codes, encounters for surgical procedures were identified by Common Procedure Terminology codes, and courses of oral antibiotics prescribed by these clinicians were identified by their National Drug Codes.

**EXPOSURES** Claims for oral antibiotic prescriptions associated with encounters with dermatologists associated with dermatologic procedures.

**MAIN OUTCOMES AND MEASURES** Frequency of antibiotic prescribing and associated procedures. Poisson regression models were used to assess for changes in the frequency of antibiotic prescribing over time.

**RESULTS** Between 2008 and 2016, among 1 934 633 encounters (1 128 244 unique patients, 854 072 [44.1%] were women and the median [interquartile range] age was 66 [52-76] years) for dermatologic procedures, oral antibiotic prescribing associated with benign excisions increased from 2.9% to 4.4% of visits (52.5% relative change; incidence rate ratio [IRR], 1.04; 95% CI, 1.03-1.04), antibiotic prescribing associated with malignant excisions increased from 4.2% to 6.3% of visits (49.5% relative change; IRR, 1.06; 95% CI, 1.05-1.06), and antibiotic prescribing associated with Mohs surgery increased from 9.9% to 13.8% of visits (39.7% relative change; IRR, 1.04; 95% CI, 1.03-1.04). There was greater than 2-fold variation in antibiotic prescribing rates across geographic census divisions. If higher prescribing divisions were to develop antibiotic prescribing rates similar to lower prescribing divisions, antibiotic use could be decreased by over 50%.

**CONCLUSIONS AND RELEVANCE** Oral antibiotic prescribing by dermatologists associated with benign excisions, malignant excisions, and Mohs surgery is increasing over the past decade and there is substantial geographic variation. These findings highlight that there may be opportunities to optimize antibiotic use associated with dermatologic procedures.

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Supplemental content

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Antibiotic resistance is a growing concern throughout medicine, resulting in at least 23 000 deaths annually in the United States.[1] In addition to the development of antimicrobial resistance, antibiotic use has been associated with other adverse effects, such as emergency department visits and disruption of the microbiome.[2-8]

A 2015 report[9] from the Centers for Disease Control and Prevention found that dermatologists prescribe more oral antibiotics per provider than any other specialty. Although use of oral antibiotics for chronic inflammatory conditions such as acne and rosacea appears to be decreasing, use of oral antibiotics associated with dermatologic procedures has increased substantially over the past decade.[10] In addition, a 2012 survey[11] sent to American College of Mohs Surgery members found that there may be antibiotic overuse associated with dermatologic procedures. However, factors associated with oral antibiotic use, differences in use between procedure types, and geographic variation in prescribing practices have not been well characterized. The purpose of this study was to further characterize the use of oral antibiotics associated with dermatologic procedures.

### Key Points

**Question** How often are antibiotics prescribed for dermatologic procedures and how is this use changing over time?

**Findings** In this repeated cross-sectional analysis of over 1 million unique patients, between 2008 and 2016, antibiotic prescribing increased from 2.9% to 4.4% of visits for benign excisions, from 4.2% to 6.3% of visits for malignant excisions, and from 9.9% to 13.8% of visits for Mohs surgery from 2008 to 2016. There was greater than 2-fold geographic variation in prescribing practices.

**Meaning** Antibiotic use associated with dermatologic procedures is increasing and there is substantial geographic variation, suggesting there may be opportunities to optimize this antibiotic use.

## Methods

### Study Design and Study Population

This study was a repeated cross-sectional analysis using the Optum Clinformatics DataMart database between 2008 and 2016. Antibiotic prescriptions were associated with visits for surgical procedures as previously described.[10] Procedures were classified by their Current Procedural Terminology codes (eTable 1 in the Supplement).[12] History of diabetes, solid organ transplant, and human immunodeficiency virus (HIV) infection, joint replacement, and artificial heart valve placement were determined using *International Classification of Diseases, Ninth Revision (ICD-9)* and *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision (ICD-10)* codes.[13,14]

This study was deemed exempt by the institutional review board of the University of Pennsylvania owing to the retrospective nature of the study and the deidentified data used.

### Statistical Analysis

Multivariable logistic regression models were used to assess for factors associated with antibiotic prescribing and multivariable Poisson regression models were used to assess for changes in antibiotic prescribing over time. In addition, geographic variation was assessed at the level of census division. Similar to prior studies on outpatient antibiotic use, comparisons between current prescribing levels and what could be achieved if high-prescribing regions were to prescribe at a rate similar to low-prescribing regions were used to assess for potential opportunities to reduce antibiotic use.[15] Statistical analyses were performed in Stata statistical software (version 15, StataCorp).

## Results

### Cohort

There were 1 934 633 encounters for surgical procedures during the study period among 1 128 244 unique patients (854 072 [44.1%] encounters involved female patients and the median [IQR] age was 66 [52-76] years) (**Table 1**) (eTable 2 in the Supplement). In 2016, antibiotics were prescribed for 1.2%, 4.4%, 6.3%, and 13.8% of visits for malignant destructions, benign excisions, malignant excisions, and Mohs surgery, respectively. The most commonly prescribed antibiotics were cephalexin (64.6%), doxycycline (14.2%), and trimethoprim-sulfamethoxazole (6.1%). The median course duration was 7 days (IQR, 5-10 days).

### Factors Associated With Antibiotic Prescriptions

Among those undergoing Mohs surgery, use of flaps (OR, 1.79; 95% CI, 1.75-1.82) and use of grafts (OR, 2.23; 95% CI, 2.16-2.30) were associated with increased odds of antibiotic prescribing. In addition, female sex was associated with increased odds of antibiotic prescribing (OR, 1.08; 95% CI, 1.06-1.10). Older age was associated with decreased odds of antibiotic prescribing (**Table 2**). History of diabetes was associated with increased odds of antibiotic prescribing (OR, 1.08; 95% CI, 1.06-1.11).

### Temporal Trends in Antibiotic Use

Between 2008 and 2016, overall antibiotic prescribing associated with malignant excisions increased from 4.2% to 6.3% of visits (49.5% relative change; IRR, 1.06; 95% CI, 1.05-1.06). Overall antibiotic prescribing associated with Mohs surgery increased from 9.9% to 13.8% of visits (39.7% relative change; IRR, 1.04; 95% CI, 1.03-1.04). There was no significant change in antibiotic prescribing associated with malignant destructions during this time period (**Table 3**) (**Figure 1**).

### Geographic Variation

There was substantial geographic variation in antibiotic prescribing (**Figure 2**) (eTable 3 in the Supplement). Over the period from 2014 to 2016, for malignant excisions, antibiotics were prescribed for 3.6% of visits in the lowest-utilizing division (West North Central) compared with 9.9% in the highest-utilizing division (West South Central) (2.76-fold variation). During this period, for Mohs surgery, antibiotics were prescribed for 7.6% of visits in the lowest-utilizing division (West North Central) compared with 16.9% in the highest-utilizing division (West South Central) (2.23-fold variation). These differences persisted after controlling for patient age, sex, comorbidities, and reconstructive factors

(Table 2). If the highest-utilizing regions were to prescribe oral antibiotics at a rate similar to the lowest-utilizing region, that would result in a 57.6%, 53.6%, and 55.8% reduction in antibiotic use associated with benign excisions, malignant excisions, and Mohs surgery, respectively.

## Discussion

In this cross-sectional analysis, antibiotic prescribing by dermatologists associated with dermatologic procedures has increased considerably over the past decade across multiple procedure types. Use of grafts followed by use of flaps were the 2 strongest factors associated with use of antibiotics for Mohs surgery, which is aligned with prior studies[16-18] identifying that grafts and flaps are at increased risk of infection. Patients with a history of diabetes were also more likely to receive postoperative antibiotics, which is consistent with evidence[18,19] suggesting diabetes may be an independent risk factor for surgical site infection for multiple procedure types.

For both Mohs surgery and malignant excisions, women and younger patients had higher odds of receiving a prescription for postoperative antibiotics, although it is important to note the odds ratios are near 1 and the clinical significance of this effect may be small. Because prior studies[20-22] have found that younger patients and female patients have higher concerns related to appearance, surgeons may be more likely to prescribe antibiotics in these populations in an effort to prevent poor cosmetic outcomes owing to infectious complications.

Although antibiotic prophylaxis may be helpful in certain settings, given the low overall risk of surgical site infections associated with dermatologic procedures and the potential complications from antibiotic use, current postoperative antibiotic prescribing practices may not be optimal for patient outcomes.[16-18] In addition, the observed geographic variation between high- and low-utilizing regions, which persists after controlling for other patient risk factors, suggests that it may be possible to decrease oral antibiotic prescribing associated with benign excisions, malignant excisions, and Mohs surgery by more than 50%.[15]

There also may be opportunities to decrease the duration of prophylaxis from the median duration of 7 days observed in this study. Guidelines recommend limited use of single-dose perioperative antibiotics for the prevention of infective endocarditis and joint infections in high-risk patients.[13,14,23] With respect to prevention of surgical site infections, studies of clean-contaminated outpatient procedures, including several randomized clinical trials of surgical procedures on the head and neck, have not identified increased efficacy from longer antibiotic regimens.[24-29] In addition, 1 study[27] found rates of adverse effects, including nausea (10% vs 0%), diarrhea (13% vs 0%), and skin rashes (5% vs 2%) were more common in the postoperative antibiotic group than the perioperative antibiotic-alone group.

The results of these studies are reflected in the 2008 *Journal of the American Academy of Dermatology* Advisory Statement on antibiotic prophylaxis,[23] which recommends single-dose perioperative antibiotics for those at increased risk of surgical site infection. Although it may be challenging to have single-dose perioperative antibiotics readily available in dermatologic clinics not associated with a pharmacy, using perioperative antibiotics alone or short postoperative courses may have similar efficacy and reduced rates of adverse effects compared with longer postoperative courses.[27] Similar to the question of topical antibiotics for postoperative surgical site treatment, well controlled, prospective studies are needed to determine the optimal settings and duration of therapy for perioperative and postoperative oral antibiotics for dermatologic procedures.[30]

Table 1. Patient Demographics

| Characteristic | No. (%) |
|---|---|
| Age, median (IQR) | 66 (52-76) |
| Female sex | 854 072 (44.1) |
| Census division | |
| East North Central | 238 745 (12.3) |
| East South Central | 64 923 (3.4) |
| Mid Atlantic | 120 378 (6.2) |
| Mountain | 232 288 (12.0) |
| New England | 75 111 (3.9) |
| Pacific | 149 783 (7.7) |
| South Atlantic | 691 079 (35.7) |
| West North Central | 172 705 (8.9) |
| West South Central | 189 621 (9.8) |
| Medical History | |
| Diabetes | 385 952 (19.9) |
| HIV | 6110 (0.3) |
| Prosthetic heart valve | 22 687 (1.2) |
| Solid organ transplant | 17 725 (0.9) |
| Joint replacement | 113 209 (5.9) |
| Procedure type | |
| Benign destruction | 41 351 (2.1) |
| Malignant destruction | 453 374 (23.4) |
| Benign excision | 530 643 (27.4) |
| Malignant excision | 389 814 (20.1) |
| Mohs surgery | 500 382 (25.9) |
| Reconstruction characteristics | |
| Use of flap | 131 419 (6.8) |
| Use of graft | 32 564 (1.7) |
| Most commonly prescribed antibiotics | |
| Cephalexin | 76 014 (64.6) |
| Doxycycline | 16 729 (14.2) |
| Trimethoprim-sulfamethoxazole | 7192 (6.1) |
| Azithromycin | 6250 (5.3) |
| Minocycline | 4152 (3.5) |
| Clindamycin | 3479 (3.0) |
| Amoxicillin | 3517 (3.0) |
| Other | 404 (0.3) |
| Course duration, median (IQR), d | 7 (5-10) |

Abbreviations: HIV, human immunodeficiency virus; IQR, interquartile range.

### Limitations

The results of this study should be interpreted in the context of the study design. Because perioperative antibiotics administered in the office may not generate an associated pharmacy claim and because we are unable to link preoperative antibiotics prescribed at the time of consultation prior to the surgical appointment, we may be unable to fully capture in-office use of perioperative antibiotics. As a result, our results may

Table 2. Factors Associated With Antibiotic Prescribing for Benign Excisions, Malignant Excisions, and Mohs Surgery

| Variable | Odds Ratio (95% CI) | | |
|---|---|---|---|
| | Benign Excision | Malignant Excision | Mohs Surgery |
| Location on face | NA | NA | 1.02 (1.00-1.04) |
| Use of flap | NA | NA | 1.79 (1.75-1.82) |
| Use of graft | NA | NA | 2.23 (2.16-2.30) |
| Female sex | 0.88 (0.85-0.90) | 1.05 (1.02-1.08) | 1.08 (1.06-1.10) |
| Age, y | 0.98 (0.97-0.99) | 0.97 (0.96-0.98) | 0.94 (0.93-0.94) |
| <50 | 1 [Reference] | 1 [Reference] | 1 [Reference] |
| 50-59 | 1.00 (0.96-1.04) | 0.92 (0.87-0.97) | 1.02 (0.99-1.06) |
| 60-69 | 0.95 (0.91-0.99) | 0.94 (0.90-0.99) | 0.97 (0.94-1.01) |
| 70-79 | 0.91 (0.87-0.97) | 0.93 (0.88-0.97) | 0.89 (0.86-0.92) |
| >80 | 0.82 (0.75-0.89) | 0.84 (0.80-0.89) | 0.80 (0.77-0.82) |
| Medical history | | | |
| History diabetes | 1.18 (1.13-1.24) | 1.15 (1.12-1.19) | 1.08 (1.06-1.11) |
| History HIV | 1.21 (0.97-1.50) | 0.93 (0.72-1.20) | 1.09 (0.94-1.26) |
| History prosthetic heart valve | 1.43 (1.17-1.75) | 1.09 (0.97-1.22) | 0.98 (0.91-1.05) |
| History solid organ transplant | 1.26 (0.98-1.62) | 1.03 (0.90-1.17) | 0.93 (0.86-1.00) |
| History joint replacement | 1.22 (1.12-1.32) | 1.06 (1.01-1.12) | 0.96 (0.93-0.99) |
| Calendar year of procedure | 1.04 (1.03-1.04) | 1.06 (1.06-1.07) | 1.04 (1.04-1.05) |
| Division | | | |
| East North Central | 1 [Reference] | 1 [Reference] | 1 [Reference] |
| East South Central | 1.61 (1.49-1.75) | 1.32 (1.22-1.44) | 1.25 (1.19-1.31) |
| Mid Atlantic | 1.00 (0.93-1.07) | 0.98 (0.90-1.07) | 0.50 (0.48-0.53) |
| Mountain | 1.53 (1.45-1.62) | 1.21 (1.14-1.28) | 0.86 (0.83-0.89) |
| New England | 0.89 (0.81-0.98) | 1.00 (0.91-1.09) | 0.72 (0.68-0.75) |
| Pacific | 0.99 (0.93-1.05) | 0.87 (0.81-0.93) | 0.87 (0.83-0.90) |
| South Atlantic | 1.24 (1.18-1.30) | 1.19 (1.13-1.24) | 0.92 (0.90-0.95) |
| West North Central | 0.75 (0.70-0.80) | 0.70 (0.65-0.76) | 0.53 (0.51-0.55) |
| West South Central | 1.76 (1.67-1.86) | 2.19 (2.07-2.32) | 1.32 (1.28-1.37) |

Abbreviations: HIV, human immunodeficiency virus; NA, not applicable.

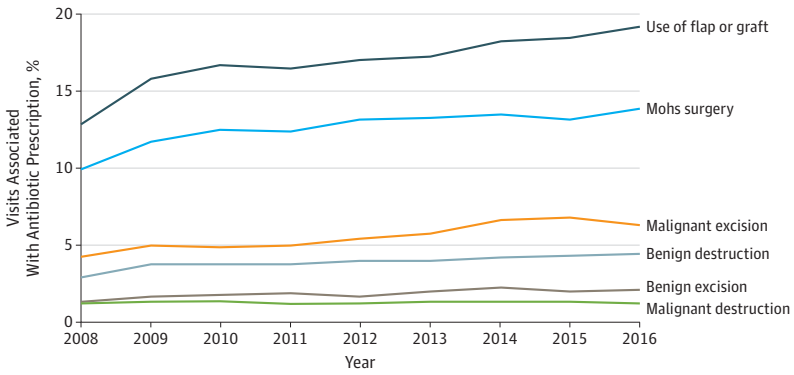
Table 3. Change in Percentage of Visits Associated With Antibiotic Prescribing Over Time

| Variable | Visits Associated With Antibiotic Use, % | | | | |
|---|---|---|---|---|---|
| | 2008 | 2012 | 2016 | Relative Change 2008-2016 | Adjusted IRR (95% CI)[a] |
| Benign destruction | 1.3 | 1.6 | 2.1 | 36.7 | 1.06 (1.04-1.09) |
| Malignant destruction | 1.2 | 1.2 | 1.2 | −0.2 | 1.00 (0.99-1.01) |
| Benign excision | 2.9 | 4.0 | 4.4 | 52.5 | 1.04 (1.03-1.04) |
| Malignant excision | 4.2 | 5.4 | 6.3 | 49.5 | 1.06 (1.051.06) |
| Mohs surgery | 9.9 | 13.1 | 13.8 | 39.7 | 1.04 (1.03-1.04) |
| Use of flap or graft | 12.8 | 17.0 | 19.1 | 49.3 | 1.04 (1.03-1.04) |

Abbreviations: HIV, human immunodeficiency virus; IRR, incidence rate ratio.

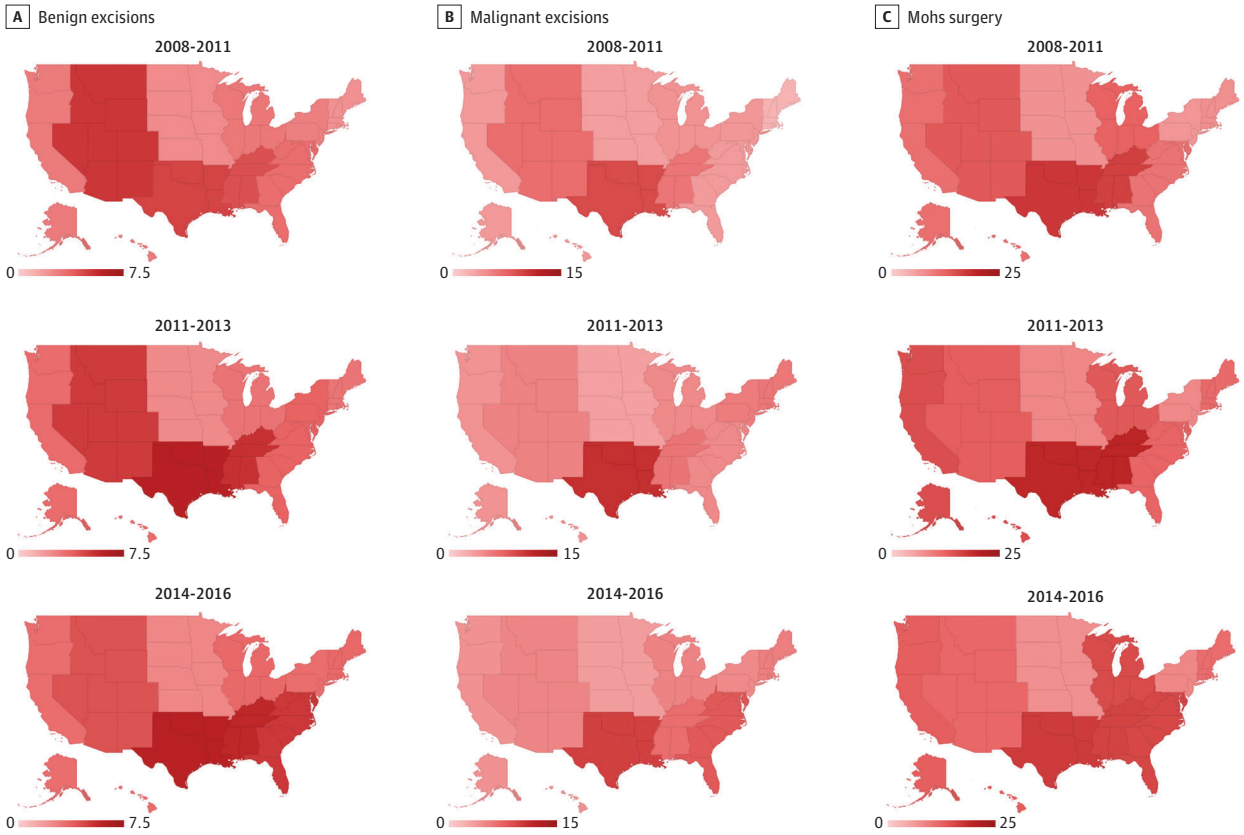
[a] Adjusted for Current Procedural Terminology code location including the face, use of flaps or grafts in the reconstruction, census division and prior history of diabetes, solid organ transplant, HIV, joint replacement, and artificial heart valve.

Figure 1. Antibiotic Prescribing Trends, 2008 to 2016




Percentage of encounters associated with antibiotic prescriptions for benign destructions, malignant destructions, benign excisions, malignant excisions, Mohs surgery, and for repairs involving the use of a flap or graft.

Figure 2. Geographic Variation in Percentage of Visits Associated With an Antibiotic Prescription for Benign Excisions, Malignant Excisions, and Mohs Surgery




Data are aggregate for time periods 2008 to 2010, 2011 to 2013, and 2014 to 2016.

underestimate the true use of oral antibiotics in clinical practice. In addition, the lack of site specificity in the Current Procedural Terminology (CPT) codes for surgical procedures limits our ability to precisely evaluate for differences in antibiotic use between different high-risk surgical sites.

## Conclusions

Although overall oral antibiotic use among dermatologists is declining, antibiotic prescribing by dermatologists associated with benign excisions, malignant excisions, and Mohs surgery has been increasing over the past decade and there is substantial geographic variation in antibiotic use.[10] These prolonged courses of postoperative antibiotics may place patients at unnecessary risk of adverse outcomes without providing additional value with respect to prevention of postoperative complications. Given the substantial geographic variation in practice patterns, there are likely opportunities to optimize antibiotic use associated with dermatologic procedures to improve patient outcomes. Additional clinical studies of the optimal use of perioperative and postoperative antibiotics for dermatologic procedures are needed to better inform clinical practice and guidelines.

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*Study concept and design:* All authors.
*Acquisition, analysis, or interpretation of data:* All authors.
*Drafting of the manuscript:* All authors.
*Critical revision of the manuscript for important intellectual content:* All authors.
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