Appropriateness of outpatient antibiotic prescribing among privately insured US patients: ICD-10-CM based cross sectional study

Kao-Ping Chua, Michael A Fischer, Jeffrey A Linder

ABSTRACT

OBJECTIVE
To assess the appropriateness of outpatient antibiotic prescribing for privately insured children and non-elderly adults in the US using a comprehensive classification scheme of diagnosis codes in ICD-10-CM (international classification of diseases-clinical modification, 10th revision), which replaced ICD-9-CM in the US on 1 October 2015.

DESIGN
Cross sectional study.

SETTING
MarketScan Commercial Claims and Encounters database, 2016.

PARTICIPANTS
19.2 million enrollees aged 0-64 years.

MAIN OUTCOME MEASURES
A classification scheme was developed that determined whether each of the 91 738 ICD-10-CM diagnosis codes “always,” “sometimes,” or “never” justified antibiotics. For each antibiotic prescription fill, this scheme was used to classify all diagnosis codes in claims during a look back period that began three days before antibiotic prescription fills and ended on the day fills occurred. The main outcome was the proportion of fills in each of four mutually exclusive categories: “appropriate” (associated with at least one “always” code during the look back period), “potentially appropriate” (associated with at least one “sometimes” but no “always” codes), “inappropriate” (associated only with “never” codes), and “not associated with a recent diagnosis code” (no codes during the look back period).

RESULTS
The cohort (n=19 203 264) comprised 14 571 944 (75.9%) adult and 9 935 791 (51.7%) female enrollees. Among 15 455 834 outpatient antibiotic prescription fills by the cohort, the most common antibiotics were azithromycin (2 931 242, 19.0%), amoxicillin (2 818 939, 18.2%), and amoxicillin-clavulanate (1 784 921, 11.6%). Among these 15 455 834 fills, 1 973 873 (12.8%) were appropriate, 5 487 003 (35.5%) were potentially appropriate, 3 592 183 (23.2%) were inappropriate, and 4 402 775 (28.5%) were not associated with a recent diagnosis code. Among the 3 592 183 inappropriate fills, 2 541 125 (70.7%) were written in office based settings, 22 804 (6.2%) in urgent care centers, and 168 396 (4.7%) in emergency departments. In 2016, 2 697 918 (14.1%) of the 19 203 264 enrollees filled at least one inappropriate antibiotic prescription, including 4 904 745 out of 4 631 320 children (10.6%) and 2 207 173 out of 14 571 944 adults (15.2%).

CONCLUSIONS
Among all outpatient antibiotic prescription fills by 19 203 264 privately insured US children and non-elderly adults in 2016, 23.2% were inappropriate, 35.5% were potentially appropriate, and 28.5% were not associated with a recent diagnosis code. Approximately 1 in 7 enrollees filled at least one inappropriate antibiotic prescription in 2016. The classification scheme could facilitate future efforts to comprehensively measure outpatient antibiotic appropriateness in the US, and it could be adapted for use in other countries that use ICD-10 codes.

Introduction
Inappropriate antibiotic prescribing to outpatients promotes the development of antibiotic resistance, which is one of the greatest threats to public health worldwide. Over the past three decades, many countries have invested substantial resources in education, quality improvement, and antibiotic stewardship initiatives. Despite these initiatives, studies suggest that a large proportion of outpatient antibiotic prescriptions could still be unnecessary.

Although antibiotics are prescribed for a wide variety of conditions, studies assessing the appropriateness of outpatient antibiotic prescribing have mostly focused on specific conditions, such as acute respiratory tract infections. Furthermore, studies of outpatient antibiotic appropriateness in the US have been limited to pre-2015 data owing to reliance on diagnosis codes in ICD-9-CM (international classification of diseases-clinical modification, ninth revision). ICD-9-CM was replaced by ICD-10-CM in the US on 1 October 2015.
2015; therefore future studies of outpatient antibiotic appropriateness in the US would be greatly facilitated by the development of a comprehensive ICD-10-CM based classification scheme. Such a scheme could be adapted for use in countries outside the US, many of which have been using a modified version of ICD-10 for decades.

We developed a novel classification scheme determining whether each of the 91738 diagnosis codes in the 2016 version of ICD-10-CM justified the use of antibiotics. Using this classification scheme and a 2016 national US claims database, we assessed the appropriateness of all outpatient antibiotic prescriptions among a large cohort of US children and non-elderly adults with private employer sponsored insurance coverage. In 2016, about 152 million of the 320 million Americans had such coverage.11

Methods

Data source and study cohort

We conducted a cross sectional analysis of data from the 2016 Truven MarketScan Commercial Claims and Encounters database, which contains claims for people aged 0-64 years who receive private health insurance from their employers.12 Elderly people aged 65 years and older are not included in this database. Compared with all non-elderly people with employer sponsored insurance in the US, MarketScan enrollees have a similar age and sex distribution but are more likely to live in the South.13 The MarketScan Inpatient Services, Outpatient Services, and Facility Header databases include claims for medical visits from a variety of settings, including primary care offices, specialist offices, hospital outpatient departments, urgent care centers, retail clinics, ambulatory surgery centers, emergency departments, home visits, community hospitals, and academic hospitals. The MarketScan pharmacy database includes claims for outpatient prescription fills at retail and mail order pharmacies, but it does not capture antibiotic utilization in the inpatient setting.

We limited the cohort to children aged 0-17 years and adults aged 18-64 years who had pharmacy benefit coverage and were continuously insured for all 12 months in 2016 (or continuously insured since birth, as applicable).

Definition of antibiotics and identification of antibiotic prescription fills

We defined antibiotics as the 39 oral antibiotics assessed in the 2016 “antibiotic utilization” measure in the Healthcare Effectiveness Data and Information Set (HEDIS), a collection of quality measures reported by more than 90% of US health insurance plans (see appendix 1 for the list of antibiotics).14 These 39 oral antibiotics include agents against bacteria and protozoa but not against fungi, helminths, viruses, or malaria. To identify prescription fills for these antibiotics in the MarketScan pharmacy database, we used a list of 7177 national drug codes published on the website of the National Committee for Quality Assurance, which sponsors the HEDIS measures.14 ICD-10-CM diagnosis code classification scheme

Following the approach used in previous studies, we classified each of the 91738 diagnosis codes in the 2016 version of ICD-10-CM as “always” if the associated condition is almost always an indication for antibiotics (eg, pneumonia or urinary tract infection), “sometimes” if the condition is a potential indication for antibiotics (eg, acute sinusitis or acute otitis media), and “never” if the condition is almost never an indication for antibiotics (eg, acute upper respiratory tract infection, acute bronchitis, or non-infectious conditions). We did not adapt previous ICD-9-CM based classification schemes to ICD-10-CM owing to the differences between these coding systems. Additionally, we aimed to develop a scheme that could be applied to any administrative dataset. Therefore, we created a new scheme in which we classified each ICD-10-CM diagnosis code one by one. The primary author (KC) initially decided on the classifications, which the other authors (JAL and MAF) reviewed; disagreements were resolved by discussion until consensus was achieved. The authors included one general pediatrician and two general internists with expertise in the measurement of antibiotic overuse and medication use in administrative data.3 6 18 19

In developing the scheme, we erred on the side of assuming appropriate antibiotic use. For example, we classified several codes as “always” even though antibiotics might not always be required (eg, pneumonia is often viral). As another example, we classified several diagnosis codes as “sometimes” even when oral antibiotics are rarely necessary (eg, infective otitis externa), or even when the diagnosis code typically implies a viral illness (eg, infectious colitis and gastroenteritis). As a final example, we classified some non-specific diagnosis codes as “sometimes” when they might be used to denote complications requiring antibiotics (eg, superficial thrombophlebitis, a diagnosis code that could be used for thrombophlebitis complicated by cellulitis).

Appendix 2 includes additional details about the classification scheme. For illustrative purposes, box 1 presents the classification scheme for diseases of the respiratory system (ICD-10-CM codes J00-J99), which are among the most common indications for outpatient antibiotic prescriptions.6 Appendix 3 includes a table summarizing the scheme by diagnosis code category. We also developed a similar classification scheme (although not used in the current study) of all 17553 diagnosis codes in the final 2015 version of ICD-9-CM to facilitate analyses using older datasets, as well as a classification scheme of all 94249 codes in the 2017 version of ICD-10-CM. Appendix 4 discusses the comparability of the 2015 ICD-9-CM and 2016 ICD-10-CM scheme. For each version of the scheme, a full list of classification decisions is included online.

Claims based measure of outpatient antibiotic appropriateness

Because prescription drug claims do not report the indication for prescriptions, claims based studies
Fig 1 | Claims based measure of outpatient antibiotic appropriateness. (First column) At least one “always” code is present on a claim on the day of fill or during the three days before the fill; (second column) at least one “sometimes” code and no “always” codes are present during the look back period; (third column) only “never” codes are present during the look back period; (fourth column) no claims and therefore no diagnosis codes are present during this period lacked diagnosis codes). In other words, appropriate antibiotic fills were associated with at least one recent diagnosis code that almost always justifies antibiotics, potentially appropriate fills were associated with at least one recent diagnosis code that sometimes justifies antibiotics but no codes that almost always justify antibiotics, and inappropriate fills were only associated with recent diagnosis codes that almost never justify antibiotics.

Study outcomes
The main outcome was the proportion of antibiotic prescription fills in each mutually exclusive appropriateness category. To generate population level prevalence estimates, we also calculated the proportion of enrollees who filled at least one prescription in each category in 2016. These proportions were not mutually exclusive (eg, an enrollee could fill one appropriate
RESEARCH

N/A = not applicable.

Table 1 | Demographic characteristics of cohort and of antibiotic users, MarketScan 2016. Values are numbers (percentages)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>All enrollees in cohort (n=19,203,264 enrollees)</th>
<th>Enrollees filling ≥1 antibiotic prescription (n=7,625,438 enrollees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-4</td>
<td>1,229,293 (6.4%)</td>
<td>582,252 (7.6%)</td>
</tr>
<tr>
<td>5-12</td>
<td>2,052,971 (10.7%)</td>
<td>760,659 (10.0%)</td>
</tr>
<tr>
<td>13-17</td>
<td>1,349,056 (7.0%)</td>
<td>480,393 (6.3%)</td>
</tr>
<tr>
<td>18-34</td>
<td>4,930,434 (25.7%)</td>
<td>1,809,888 (23.7%)</td>
</tr>
<tr>
<td>35-50</td>
<td>4,704,587 (24.5%)</td>
<td>1,886,258 (24.7%)</td>
</tr>
<tr>
<td>51-64</td>
<td>4,936,923 (25.7%)</td>
<td>2,105,715 (27.6%)</td>
</tr>
<tr>
<td>Region</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northeast</td>
<td>1,300,589 (16.2%)</td>
<td>1,119,269 (15.6%)</td>
</tr>
<tr>
<td>Midwest</td>
<td>3,905,622 (20.3%)</td>
<td>1,483,197 (19.5%)</td>
</tr>
<tr>
<td>South</td>
<td>8,790,740 (45.8%)</td>
<td>3,856,172 (50.6%)</td>
</tr>
<tr>
<td>West</td>
<td>3,326,768 (17.3%)</td>
<td>1,068,687 (14.0%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>79,545 (0.4%)</td>
<td>29,113 (0.4%)</td>
</tr>
<tr>
<td>Urban or rural</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>16,861,099 (87.8%)</td>
<td>6,593,228 (86.5%)</td>
</tr>
<tr>
<td>Rural</td>
<td>2,273,862 (11.8%)</td>
<td>1,007,328 (13.2%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>68,303 (0.4%)</td>
<td>24,882 (0.3%)</td>
</tr>
</tbody>
</table>

N/A = not applicable.

Classifications Software ICD-10-CM diagnosis code grouping algorithm published by the US Agency for Healthcare Research and Quality,11 we identified the three most frequent diagnoses associated with appropriate, potentially appropriate, and inappropriate fills during the look back period (see appendix 5 for details). For these three categories of fills, we also identified the healthcare setting in which prescriptions were most likely written based on the types of claims present during the look back period (see appendix 6 for details).

Statistical analysis

We used SAS 9.4 (Cary, NC) to calculate descriptive statistics for the overall cohort and for each age subgroup (children versus adults). We did not conduct formal significance testing, as many clinically insignificant differences may have been statistically significant given the large size of the study cohort.

Sensitivity analyses

In sensitivity analyses, we examined the degree to which the proportion of fills assigned to each category changed when we examined diagnosis codes occurring which prescriptions were most likely written based on the types of claims present during the look back period (see appendix 5 for details).

Results

Study population

Our database included 27,895,445 enrollees; we excluded 7,409,175 who were not continuously insured in 2016 and 1,283,006 who did not have pharmacy benefit coverage, leaving 19,203,264 enrollees in the study cohort. This cohort included 14,571,944 adults (75.9%) and 4,631,320 children (24.1%) (table 1). Among the 19,203,264 enrollees in the cohort, 9,935,791 (51.7%) were women, 2,273,862 (11.8%) lived in a rural area, and 3,100,589 (16.2%) were from the Northeast region, compared with 3,905,622 (20.3%) from the Midwest, 8,790,740 (45.8%) from the South, 3,326,768 (17.3%) from the West, and 79,545 (0.4%) from an unknown region.

Antibiotic fills and users

In 2016, patients in the cohort filled 15,455,834 outpatient antibiotic prescriptions, a rate of 805 prescriptions per 1000 enrollees. The most commonly filled antibiotics were azithromycin (2,931,242, 19.0%), amoxicillin (2,818,939, 18.2%), and amoxicillin-clavulanate (1,784,921, 11.6%). Among the 15,455,834 antibiotic prescription fills, in which we assigned the setting to an inpatient visit or outpatient surgery (since diagnosis codes alone may not be sufficient to assess outpatient antibiotic appropriateness in these settings).

Patient and public involvement

No patients were involved in setting the research question or the outcome measures, nor were they involved in developing plans for implementation of the study. No patients were asked to advise on interpretation or writing up of results. There are no plans to disseminate the results of the research to study participants or the relevant patient community.

In 2016, patients in the cohort filled 15,455,834 outpatient antibiotic prescriptions, a rate of 805 prescriptions per 1000 enrollees. The most commonly filled antibiotics were azithromycin (2,931,242, 19.0%), amoxicillin (2,818,939, 18.2%), and amoxicillin-clavulanate (1,784,921, 11.6%). Among the 15,455,834 antibiotic prescription fills,
Table 2 | Proportion of antibiotic prescription fills in each appropriateness category, and proportion of cohort filling at least one prescription in each category, MarketScan 2016

<table>
<thead>
<tr>
<th>Categories</th>
<th>Proportion of fills in each category (%)a</th>
<th>Proportion of cohort filling at least one antibiotic prescription in each category (%)b</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overall (n=15 455 834 fills)</td>
<td>Adults (n=11 780 881 fills)</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>------------------------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Appropriate</td>
<td>1 973 387 (12.8)</td>
<td>1 347 569 (11.6)</td>
</tr>
<tr>
<td>Potentially appropriate</td>
<td>5 487 003 (35.5)</td>
<td>3 696 473 (31.4)</td>
</tr>
<tr>
<td>Inappropriate</td>
<td>3 592 183 (23.2)</td>
<td>2 965 194 (25.2)</td>
</tr>
<tr>
<td>Not associated with recent diagnosis code</td>
<td>4 402 777 (28.5)</td>
<td>3 771 645 (32.0)</td>
</tr>
</tbody>
</table>

Proportion of antibiotic prescription fills in each appropriateness category

Among all 15 455 834 fills, 1 973 873 (12.8%) were appropriate, 5 487 003 (35.5%) were potentially appropriate, 3 592 183 (23.2%) were inappropriate, and 4 402 777 (28.5%) were not associated with a recent diagnosis code (table 2). Among the 4 402 777 fills not associated with a recent diagnosis code, 917 140 (5.9%) were refills of previous antibiotic prescriptions.

Antibiotics were filled by 7 625 438 enrollees (39.7% of the cohort); table 1 displays the demographic characteristics. Among these 7 625 438 antibiotic users, 3 995 690 (52.4%) filled one antibiotic prescription in 2016, 1 815 305 (23.8%) filled two, 852 979 (11.2%) filled three, and 961 464 (12.6%) filled four or more. Antibiotic users filled a mean of 2.0 antibiotic prescriptions in 2016.

Proportion of antibiotic prescription fills in each appropriateness category

Among all 15 455 834 fills, 1 973 873 (12.8%) were appropriate, 5 487 003 (35.5%) were potentially appropriate, 3 592 183 (23.2%) were inappropriate, and 4 402 777 (28.5%) were not associated with a recent diagnosis code (table 2). Among the 4 402 777 fills not associated with a recent diagnosis code, 4 392 068 (99.8%) were not associated with any claims during the look back period, whereas 10 707 (0.2%) were associated only with claims that lacked diagnosis codes.

In subgroup analyses by age, 3 696 473 (31.4%) of the 11 780 881 antibiotic prescription fills among adults were potentially appropriate, compared with 1 790 530 (48.7%) of the 3 674 953 fills among children. Additionally, 2 965 194 (25.2%) of the 11 780 881 fills among adults were inappropriate, compared with 626 989 (17.1%) of the 3 674 953 fills among children.

Population level prevalence estimates

In 2016, 1 446 673 (7.5%) of the 19 203 264 enrollees filled at least one appropriate antibiotic prescription, 3 750 225 (19.5%) filled at least one potentially appropriate prescription, 2 697 918 (14.1%) filled at least one inappropriate prescription, and 2 756 082 (14.4%) filled at least one prescription in each category.
(14.4%) filled at least one prescription that was not associated with a recent diagnosis code (table 2).

In subgroup analyses by age, 2,610,416 (17.9%) of the 14,571,944 adults in the cohort filled at least one potentially appropriate prescription during 2016, compared with 1,139,839 (24.6%) of the 463,120 children in the cohort. Additionally, 2,207,173 (15.2%) of the 14,571,944 adults filled at least one inappropriate prescription during 2016, compared with 490,745 (10.6%) of the 463,120 children.

**Characteristics of antibiotic prescription fills in each category**

Among the 19,738,737 appropriate fills, the three most frequently associated diagnoses were urinary tract infections, streptococcal pharyngitis/tonsillitis, and bacterial pneumonia (table 3). Among the 5,487,003 potentially appropriate fills, the three most frequently associated diagnoses were acute sinusitis, acute suppurative otitis media, and acute pharyngitis. Among the 3,592,183 inappropriate fills, the three most frequently associated diagnoses were acute bronchitis, acute upper respiratory tract infection, and respiratory symptoms such as cough.

Among the 11,053,059 antibiotic fills classified as either appropriate, potentially appropriate, or inappropriate, 8,257,536 (74.7%) were prescribed in office-based settings, 866,804 (7.8%) were prescribed in urgent care centers, and 664,639 (6.0%) were prescribed in emergency departments. Among the 3,592,183 inappropriate fills, 2,541,125 (70.7%) were prescribed in office-based settings, 222,804 (6.2%) in urgent care centers, and 168,396 (4.7%) in emergency departments.

Among the 4,402,775 antibiotic prescription fills that were not associated with a recent diagnosis code, 747,342 (16.9%) were refills of previous antibiotic prescriptions (table 3). Among these 747,342 refills, the most common antibiotics were doxycycline (218,668, 29.3%), minocycline (139,524, 18.7%), and sulfamethoxazole–trimethoprim (74,899, 10.0%).

**Sensitivity analyses**

Results did not change substantially when we used a longer look back period, excluded refills, excluded fills occurring between 1 January 2016 and 3 January 2016, or excluded fills in which the setting was assigned to inpatient visits or outpatient surgeries (see appendices 7-10).

**Discussion**

We developed a comprehensive classification scheme determining whether each of the 91,738 ICD-10-CM diagnosis codes justified the use of antibiotics. Using this scheme, we assessed outpatient antibiotic appropriateness for a cohort of 19.2 million US children and non-elderly adults with private employer sponsored insurance coverage in 2016—a cohort that accounted for about one eighth of those with such coverage in the US. Among all outpatient antibiotic prescription fills by the cohort, 12.8% were appropriate, 35.5% were potentially appropriate, 23.2% were inappropriate, and 28.5% were not associated with a recent diagnosis code.

We classified 23.2% of outpatient antibiotic prescription fills as inappropriate because they were only associated with diagnoses that almost never justify antibiotics (eg, acute upper respiratory tract infections and acute bronchitis). Owing to the high rate of antibiotic prescribing at the population level in our study (805 per 1000 enrollees), a large proportion of enrollees in the cohort received inappropriate antibiotic prescriptions during the year. Specifically, 14.1% of enrollees filled at least one inappropriate antibiotic prescription in 2016, including 15.2% of adults and 10.6% of children.

By themselves, these findings would show the widespread nature of inappropriate outpatient antibiotic prescribing at the level of both prescription fill and population. However, two other findings in our study suggest that the true scope of inappropriate prescribing is even greater. First, among the 35.5% of fills classified as potentially appropriate, many could have been inappropriate. For example, 34.3% and 16.6% of fills in this category were associated with diagnoses of sinusitis and pharyngitis, respectively, and previous literature has shown that both these conditions have high rates of non-guideline adherent antibiotic prescribing.

Second, among the 28.5% of fills that were not associated with a recent diagnosis code in claims, many might also have been inappropriate. Some of these fills could represent non-visit based prescribing in which prescriptions were written without patients having been examined (eg, prescriptions sent to a pharmacy after telephone or online consultation). Additionally, some could represent antibiotic prescriptions from healthcare visits that were not observed in our medical claims database (eg, retail clinic and urgent care visits paid out of pocket, or dental visits, settings in which inappropriate antibiotic prescribing often occurs). Finally, among fills that were not associated with a recent diagnosis code, one sixth were refills. Although some of these refills could have been for conditions requiring a prolonged course of antibiotics (eg, many were for doxycycline and minocycline, which are commonly prescribed for the long term treatment of acne), others may represent inappropriate refills of previous prescriptions. Collectively, fills that were potentially appropriate or not associated with a recent diagnosis code represented 64.0% of all fills, highlighting the importance of conducting future studies to assess their appropriateness using data sources with detailed clinical information, such as medical charts.

In our study, inappropriate outpatient antibiotic prescription fills were more prevalent among adults (25.2% of fills) than among children (17.1% of fills). This finding is potentially consistent with previous studies suggesting that antibiotic prescriptions for adults are more likely to be unnecessary compared with antibiotic prescriptions for children.
Importantly, however, the proportion of fills classified as potentially appropriate was higher among children. Robust methods to assess these fills must be developed to examine age based differences in overall appropriateness of antibiotics in outpatients.

**Comparison to past studies**

This study assessed the appropriateness of outpatient antibiotic prescribing for all conditions using a comprehensive, ICD-10-CM based classification scheme. Our finding that 23.2% of outpatient antibiotic prescription fills were inappropriate seems to be lower than estimates from previous studies, but direct comparisons are challenging owing to key differences in methodology, data, and populations. For example, using nationally representative visit level data from US offices and emergency departments and a classification scheme based on ICD-9-CM diagnosis codes, Fleming-Dutra et al estimated that 30% of outpatient antibiotic prescriptions in 2010 and 2011 were inappropriate.6 To obtain this estimate, the authors considered all prescribing for conditions that never justify antibiotics to be inappropriate, and additionally they estimated the rate of inappropriate prescribing for conditions that sometimes justify antibiotics based on rates of bacterial prevalence or the lowest rate of prescribing among US census regions.6 In contrast, we only considered antibiotic prescription fills to be inappropriate if they were prescribed for conditions that never justify antibiotics. Furthermore, our study captured prescribing in a broader variety of healthcare settings than offices and emergency departments, although it did not capture prescribing in populations other than those who are privately insured.

As another example, Olesen et al adapted the ICD-9-CM classification scheme of Fleming-Dutra et al to US Medicare claims and found that 40% of outpatient antibiotic prescriptions filled by elderly Americans between 2011 and 2014 were inappropriate.7 In contrast, we used an ICD-10-CM based classification scheme that was not adapted from that of Fleming-Dutra et al, focused on a younger population, and used more recent data.

**Limitations of this study**

First, similar to previous studies of outpatient antibiotic prescribing, we relied on diagnosis codes assigned by clinicians.5 8 9 10 18 20 26 In some cases, however, clinicians may fail to code the condition for which antibiotics are prescribed,28 whereas in other cases, clinicians may err on the side of up-coding when prescribing antibiotics (eg, coding pneumonia rather than bronchitis for a patient with ambiguous respiratory symptoms). Chart reviews will likely be necessary to ascertain the magnitude and direction of any misclassification bias due to inaccurate or incomplete coding.

Second, similar to previous studies of outpatient antibiotic appropriateness, we used a classification scheme that was developed on the basis of consensus.67 We acknowledge that other authors may have made different classification decisions, and we have provided a full list of our decisions to facilitate efforts to assess and validate our scheme.

Third, our database did not capture antibiotic prescription fills or visits paid entirely out of pocket, and additionally it did not contain information on prescriber specialty. Fourth, we assessed outpatient antibiotic appropriateness solely based on indication and not the choice of agent or duration of therapy, which are also important dimensions of appropriate prescribing.28 Finally, findings may not generalize to publicly insured US patients covered by Medicaid or Medicare or to all privately insured people in the US.

**Conclusion and policy implications**

This study provides the most recent and comprehensive estimates of outpatient antibiotic appropriateness in the US privately insured population to date. Our results show the scale of inappropriate antibiotic prescribing at both the prescription and population levels. Furthermore, our results highlight the importance of conducting future studies to assess the 64.0% of outpatient antibiotic prescription fills that are either only potentially appropriate or not associated with a recent diagnosis code.

This study also provides a methodological framework for assessing outpatient antibiotic appropriateness using ICD-10-CM diagnosis codes. Our classification scheme could be applied to any dataset that uses ICD-10-CM, including claims data, visit level data, and electronic health record data. Furthermore, our scheme could be adapted to the country specific versions of ICD-10 that are currently being utilized across the world. As such, our scheme could be a valuable tool for policymakers and researchers interested in measuring and improving the appropriateness of outpatient antibiotic prescribing.

**Contributors:** KC, MAF, and JAL conceived and designed the study. KC acquired the data. KC, MAF, and JAL analyzed and interpreted the data. KC drafted the manuscript. KC, MAF, and JAL critically revised the manuscript for important intellectual content. KC was responsible for the statistical analysis. JAL supervised the study. KC is the guarantor. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

**Funding:** JAL and MAF are supported by a grant from the Agency for Healthcare Research and Quality (HHSP233201500020I). The funding source played no role in the design of the study; the collection, analysis, and interpretation of the data; and the decision to approve publication of the finished manuscript.

**Competing interests:** All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coiDisclosure.pdf and declare: no support from any organization for the submitted work; no financial relationships with any organizations that might have an interest in the submitted work in the previous three years; and no other relationships or activities that could appear to have influenced the submitted work.

**Ethical approval:** Owing to the use of deidentified data, the institutional review board of the University of Michigan Medical School exempted this study from human subjects review.

**Data sharing:** Programming code is available from the corresponding author at chuak@med.umich.edu. The data used in this study are proprietary and cannot be shared.

**Transparency:** The lead author (KC) affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted;
and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

This is an Open Access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/.


Supplementary material: Appendices 1-10

Supplementary material: Spreadsheet showing ICD-9-CM and ICD-10-CM antibiotic appropriateness classification schemes

No commercial reuse: See rights and reprints http://www.bmj.com/permissions

Subscribe: http://www.bmj.com/subscribe

BMJ: first published as 10.1136/bmj.k5092 on 16 January 2019. Downloaded from www.bmj.com on 17 June 2021 by guest. Protected by copyright.