Racial/ethnic disparities in antibiotic use and healthcare utilization, United States, 2016/2018: a cross-sectional study
Scott W. Olesen, PhD*, Sanjat Kanjilal, MD MPH, Stephen M. Kissler, PhD, Daphne S. Sun, BS, Yonatan H. Grad, MD PhD*

1 Department of Immunology and Infectious Diseases, Harvard Chan School of Public Health, Boston, MA
2 Department of Population Medicine, Harvard Medical School & Harvard Pilgrim Healthcare Institute, Boston, MA
* Correspondence: olesen@hsph.harvard.edu

ABSTRACT
Antibiotic prescribing rates vary by patient race/ethnicity, with whites more likely to receive antibiotics and broader-spectrum antibiotics. However, the drivers of this disparity, and to what extent it represents antibiotic overuse or underprescribing of appropriate antibiotic treatment, remains unclear. Here, we investigate how antibiotic prescribing appropriateness varies by race/ethnicity and to what extent disparities in antibiotic use can be explained by differing rates of healthcare utilization. In data from two nationally representative healthcare utilization surveys, we found that racial/ethnic disparities in numbers of healthcare visits, not prescribers’ behavior, better explained disparities in antibiotic prescribing rates. We also found that the proportion of antibiotic prescriptions that were appropriate, potentially appropriate, or inappropriate did not vary significantly by race/ethnicity. These results suggest that whites’ higher antibiotic use is due primarily to increased healthcare utilization and that whites’ higher antibiotic use represents a mix of greater appropriate and inappropriate use. Thus, antibiotic stewardship goals should be informed by research into differing rates of antibiotic-treatable disease and healthcare seeking and access across different populations, to ensure that efforts to reduce inappropriate antibiotic overuse do not also reduce appropriate use in underserved populations.

MAIN TEXT
Antibiotic prescribing rates vary by patient race/ethnicity in the United States, with whites more likely to receive antibiotics and broader-spectrum antibiotics.\textsuperscript{1–3} The drivers of this disparity remain unclear. While antibiotics are critical for treating infectious disease, their use carries risk of adverse events and antibiotic resistance, so inappropriate antibiotic use should be reduced.\textsuperscript{4} However, underuse of antibiotics when they are medically indicated is also problematic,\textsuperscript{2} and so addressing disparities in antibiotic use may in fact require increased appropriate antibiotic use for certain populations, rather than only decreasing inappropriate use.

Here, we investigate (1) how rates of appropriate and inappropriate antibiotic use vary by race/ethnicity and (2) to what extent disparities in antibiotic use can be explained by differing rates of visits to physicians’ offices and hospitals. Most studies on racial/ethnic disparities in antibiotic prescribing have focused on the role of the prescriber’s behavior, but recent work\textsuperscript{5} examining antibiotic use rates for childhood respiratory diseases in Massachusetts found that
geographical disparities in antibiotic use are more likely due to differing numbers of healthcare visits rather than to differences in prescriber behavior. Earlier work measured rates of healthcare visits and antibiotic prescribing by race but did not address antibiotic appropriateness or the role of numbers of visits as a mediator of disparities in antibiotic use rates.

We analyzed data from the National Ambulatory Medical Care Survey and National Hospital Ambulatory Medical Care Survey, two nationally representative samples used to characterize antibiotic prescribing practice. Each survey is a sample of outpatient healthcare visits with associated patient demographics, diagnosis codes, and prescriptions. We used the two most recent years with data from both surveys, 2016 and 2018. Visits with oral antibiotics were identified and antibiotic use was classified as appropriate, potentially appropriate, or inappropriate (Supplemental Methods).

During 2016 and 2018, rates of physician office and hospital emergency room visits varied by race/ethnicity, with non-Hispanic whites making the most visits per capita, followed by non-Hispanic Blacks, Hispanics, and non-Hispanic people of multiple or other races (Table). Rates of visits with antibiotics prescribed followed the same trend, but the proportion of visits with antibiotics prescribed (5.5% 95% confidence interval 4.9% to 6.0%) did not vary significantly by race/ethnicity ($p = 0.57$, $\chi^2$ test). Racial/ethnic disparities in numbers of visits explained 100% of the disparity in antibiotic prescribing rates for Blacks relative to whites, 78% of the disparity for Hispanics, and 69% of the disparity for people of multiple or other races. The proportion of visits with antibiotic prescriptions that were appropriate, potentially appropriate, or inappropriate did not vary significantly by race/ethnicity ($p = 0.19$, $\chi^2$ test).

These results imply that (1) whites' higher antibiotic use is due primarily to increased healthcare visit rates and (2) whites' higher antibiotic use represents a mix of greater appropriate use and greater inappropriate use. The key advantage of this study is that it uses a nationally representative survey intended for analyzing healthcare utilization and prescribing practice by covariates such as race/ethnicity.

This study's major limitation is that it only addresses rates of healthcare utilization, not rates of underlying disease or access to care. For example, survey data suggest that Black and Hispanic populations have comparable or lower rates of appropriate antibiotic use compared to whites (Table). But if these populations have similar or higher rates of antibiotic-treatable disease, then these populations may be disproportionately undertreated and not receiving antibiotics when indicated. Thus, antibiotic stewardship goals should be informed by research into differing rates of antibiotic-treatable disease and healthcare seeking and access across different populations.

**STATEMENTS**

**Competing interests**

SWO is an employee of Biobot Analytics, Inc. YHG has consulted for GSK, holds grants from Pfizer and Merck, and serves on the scientific advisory board for Day Zero Diagnostics.
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Data availability and ethics
Source data are openly available from the National Center for Health Statistics (https://ftp.cdc.gov/pub/Health_Statistics/NCHS/Datasets, https://www.cdc.gov/nchs).
Table. Visits to physician offices and hospital emergency departments (rate per 100,000 population), visits that include an antibiotic prescription (rate and proportion of all visits), and visits with antibiotic prescriptions that were considered appropriate, potentially appropriate, or inappropriate (rate and proportion of visits with an antibiotic prescription), each stratified by race/ethnicity. Ranges represent 95% confidence intervals.

|                          | Non-Hispanic White | Non-Hispanic Black | Hispanic | Non-Hispanic Other |
|--------------------------|--------------------|--------------------|----------|--------------------|
|                          | Rate (rate range)  | Rate (rate range)  | Rate (rate range) | Rate (rate range) |
| Annual no. of visits,    | 7022 (6641 to 7404) | — (— to —)        | — (— to —)       | — (— to —)        |
| rate per 100,000         |                    |                    |                      |                    |
| population              |                    |                    |                      |                    |
| Visits with an antibiotic| 400 (341 to 459)   | 330 (266 to 395)   | 294 (229 to 360)    | 203 (140 to 267)   |
| prescription            | 6% (5 to 7)        | 6% (5 to 7)        | 5% (4 to 7)         | 5% (3 to 7)        |
| Appropriate             | 62 (48 to 75)      | 70 (50 to 89)      | 45 (26 to 64)       | †                   |
| Potentially             | 141 (110 to 172)   | 107 (77 to 136)    | 109 (70 to 148)     | 84 (41 to 127)     |
| appropriate             | 35% (30 to 41)     | 32% (26 to 40)     | 37% (28 to 47)      | 41% (28 to 57)     |
| Inappropriate           | 197 (158 to 236)   | 148 (104 to 192)   | 140 (102 to 178)    | 96 (55 to 138)     |
|                         | 49% (43 to 55)     | 45% (36 to 54)     | 48% (39 to 57)      | 47% (32 to 63)     |

* Benjamini-Hochberg false discovery rate < 0.05, t-test comparing rate to whites’ rate
† Value not reported because relative standard error > 30%
SUPPLEMENTAL METHODS

Identifying visits with antibiotics
A visit was classified as an antibiotic visit if any of the visit’s prescribed medicines included any of: penicillins (Multum Lexicon therapeutic category code 013), cephalosporins (009), macrolide derivatives (011), quinolones (014), lincomycin derivatives (240), sulfonamides (015), tetracyclines (016), urinary antiinfectives (017), oxazolidinone antibiotics (486), or amebicides (e.g., metronidazole; 002).

Classifying antibiotic appropriateness
Following the general methodology of Fleming-Dutra et al.⁴, who classified ICD-9 diagnostic codes into Tier 1 (“antibiotics are almost always indicated”), Tier 2 (“antibiotics may be indicated”), and Tier 3 (“antibiotics are not indicated or the indication was unclear”), Chua et al.⁶ classified ICD-10 codes as antibiotic “appropriate”, “potentially appropriate”, or “inappropriate”. More appropriate codes are given priority in classifying the visit. For example, a visit with at least one appropriate code is classified as appropriate.

Attributing disparity in antibiotic use attributable to disparity in numbers of visits
We generally follow the general approach of Kissler et al.⁵:
1. For each race/ethnicity r, compute the rate of annual visits V_r, rate of annual visits with antibiotics prescribed A_r, and proportion of visits with antibiotics prescribed p_r = A_r / V_r.
2. Compute the antibiotic prescribing rate A'_r = V_r × p_ref that would be expected if race/ethnicity r had the same proportion of visits with antibiotics prescribed as the reference race (whites).
3. Compute the proportion of disparity explained 1 - (A_0 - A'_r) / (A_0 - A_r)

Implementation
All analyses were performed using R (version 4.0.5). The R package survey (version 4.0) was used to account for the complex survey design in variance estimation. Code to reproduce these analyses is available at github (https://github.com/gradlab/abx-race-2021; doi: 10.5281/zenodo.5739297).

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