ORIGINAL RESEARCH

Impact of Geodemographic Factors on Antibiotic Prescribing for Acute, Uncomplicated Bronchitis or Upper Respiratory Tract Infection

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Objective: **To assess the impact of geodemographic factors on antibiotic prescribing for adult acute, uncomplicated bronchitis or upper respiratory tract infection.**

Methods: **A retrospective, observational study of 63,051 single health-system, outpatient discharges with a primary diagnosis of bronchitis or upper respiratory tract infection in 2019. Univariate analyses of prescribing predictors and multivariable stepwise logistic modeling were performed.**

Results: **Patients who were older (aOR 1.02; 95% CI 1.02, 1.02), male (1.10; 1.06, 1.14), black (1.29; 1.22, 1.38), smoked (1.18; 1.14, 1.23), seen in urgent care (1.26; 1.22, 1.31) and living in an area with more owner-occupied housing (1.41; 1.30, 1.53) were more likely to receive antibiotics. Patients who were Asian (0.88; 0.77, 0.99), had Medicare (0.83; 0.78, 0.87), Medicaid (0.84; 0.79, 0.87) or Exchange insurance (0.90; 0.82, 0.98), or seen in the emergency department (0.43; 0.40, 0.46) were less likely to receive antibiotics. Distance from a patient's address and their encounter location did not predict antibiotic prescribing.**

Conclusions: **Antibiotic prescribing interventions for adult acute bronchitis and upper respiratory tract infections could target patients living in an area with higher socioeconomic status. (J Am Board Fam Med 2022;35:733–741.)**

Keywords: **Antibiotics, Antimicrobial Stewardship, Bronchitis, Pharmaceutical Preparations, Respiratory Tract Infections, Retrospective Studies**

Introduction

Acute bronchitis is characterized by self-limited inflammation of the lower respiratory tract bronchioles and a predominant viral etiology. Upper respiratory infections and acute bronchitis are common and account for substantial outpatient health care utilization.[1,2] The risk of antibiotic use for acute bronchitis and upper respiratory tract infection outweighs the possible benefit, yet antibiotics are often prescribed and account for 44% of all outpatient antibiotic prescriptions.[2–4] This, among other causes of outpatient antibiotic overprescribing, has prompted calls to reduce inappropriate ambulatory antibiotic use to slow antibiotic resistance development.[3,5,6] Despite this attention, reducing antibiotic prescribing for bronchitis and upper respiratory tract infections has proven challenging. Interventions targeting antibiotic prescribing for acute bronchitis and upper respiratory tract infections have demonstrated a positive impact, but prescribing rates continued to remain higher than expected.[7–9] Moreover, multiple studies continue to report high rates of antibiotic prescribing for upper respiratory infections in the ambulatory setting.[10–15]

These studies are instructive but have not fully examined the inherent variability in antibiotic prescribing for bronchitis and upper respiratory tract infections nor its determinants. Patient-, prescriber-

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and/or encounter-level characteristics have been shown to influence antibiotic prescribing.[11,14,16,17] Geodemographic characteristics may also impact prescribing. A study investigating pediatric patients residing in high-poverty or rural Ohio counties found that these patients were more likely prescribed antibiotics for uncomplicated upper respiratory tract infections.[18] In addition, regional United States (US) variation in outpatient antibiotic prescribing for adults and pediatrics also exists.[19,20] We sought to determine the impact of geodemographic factors on antibiotic prescribing among ambulatory adults with acute, uncomplicated bronchitis or upper respiratory tract infections to inform local interventions aimed at reducing antibiotic prescribing for adults with bronchitis or upper respiratory tract infection. We hypothesized that ambulatory adults residing far from the encounter setting and/or in high-poverty ZIP codes would be more likely to be prescribed antibiotics for acute, uncomplicated bronchitis or upper respiratory tract infections.

Methods

Study Design

We conducted a retrospective, observational study of adult patients (≥ 18 years old) in a single, predominantly urban and suburban, Midwestern, US health-system seen and discharged from an emergency department (n = 15), urgent care (n = 33), or clinic (n = 129) with a primary diagnosis of bronchitis or upper respiratory tract infection (Appendix Table) between January 1, 2019 and December 31, 2019. While some sites were located within independent academic medical centers, most were community clinical sites. Within the system there is an antimicrobial stewardship committee with limited outpatient oversight. Internal surveillance of antibiotic prescribing for adults with a primary diagnosis of bronchitis or upper respiratory tract infection was initiated by this committee. The population density of counties represented by this investigation range from 38 – 3953/square mile in 2018 (6/20 counties density ≤ 100).[21] In designing our study we were unable to find any scholarly article on what diagnosis codes should be used. Online coding sites such as 2022 ICD-10-CM Diagnosis Code J20: Acute bronchitis (icd10data.com) or ICD-10-CM Coding for Bronchitis - AAPC Knowledge Center (https://www.aapc.com/blog/31581-icd-10-cm-coding-for-bronchitis/) suggest using more specific bronchitis ICD-10 codes for bronchitis. We chose to include all codes referring to a specific etiologic agent, including bacterial agents. The concern was that clinicians may have selected 1 of the codes based on 'clinical impression' to justify antibiotic use. We did not want to miss such cases. In addition, we did not collect other patient diagnoses beyond their primary diagnosis of bronchitis or upper respiratory tract infection.

Data Collection

Data were systematically extracted from the electronic health record using SAP Business Objects Business Intelligence Platform 4.1 version 14.1.5.1568 software (SAP America, Newtown Square, PA). Patient-level data elements were collected, including age, race, ethnicity, gender, height, weight, body mass index (BMI), vital signs, smoking status, address and ZIP code of residence at the time of the encounter, time spent waiting for the appointment (ie, minutes to room), appointment length (ie, minutes in room), and whether antibiotics were prescribed during the encounter. Patient race and ethnicity were extracted directly as reported in the electronic medical record. Age was assessed continuously and further dichotomized as >65 years of age and ≤ 65 years of age. Smoking status was dichotomized as any current or past smoking exposure and no smoking exposure. Body mass indices were assessed categorically as underweight (BMI < 18 kg/m^2), normal weight (BMI 18 to 24.99 kg/m^2), overweight (BMI 25 to 29.99 kg/m^2), and obese (BMI ≥30 kg/m^2). The following maximum values were utilized to eliminate outliers: appointment wait time (120 minutes), appointment length (120 minutes), BMI (100 kg/m^2), and heart rate (200 beats per minutes). For BMI, a minimum value of 13 kg/m^2 was used and a maximum value of 100 kg/m^2 was used. While patient-specific outlier values were excluded from the analysis, patients with outlier values were retained in the study.

Patient geodemographic variables were collected as well. Each patient's address was geocoded to a US Census Bureau Zip Code Tabulation Area based on 2010 US Census data; the latest year for which data were available on study initiation. In addition, US Census American Community Survey 2018 (latest year from which data were available) block group level demographic information including median household income, percent owner occupied housing, proportion of households without a vehicle, median age of housing, and average household size data were collected and linked to each subject based on street address at time of encounter.

An antibiotic prescription was defined as a prescription for an oral antibiotic deemed to be prescribed for an upper respiratory tract infection that was written on discharge from the outpatient facility. These antibiotics included: amoxicillin, amoxicillin-clavulanic acid, azithromycin, cefuroxime, cefprozil, cefdinir, cefditoren, cefixime, cefpodoxime, ceftibuten, clarithromycin, doxycycline, levofloxacin, and moxifloxacin. All other antibiotics and/or antimicrobials were excluded from the analysis. When developing the report used to generate our study data for internal quality improvement purposes, it became clear that prescriptions for other antibiotics, such as trimethoprim/sulfamethoxazole and minocycline which could be prescribed for bronchitis or upper respiratory tract infections, were uncommon and accounted for approximately 1% of all oral antibiotics prescribed.

Prescriber-level data included prescriber type (physician, nurse practitioner [NP], or physician assistant [PA]) and medical specialty for physicians. Encounter-level data included facility type (emergency department, urgent care, ambulatory clinic, or telehealth encounter) and facility ZIP code.

Statistical Analysis

All patient encounters during the study period were obtained. Patients were included in the analysis only once, and for those patients with more than 1 encounter, only the index encounter was included. Descriptive characteristics were summarized using means and standard deviations (S.D.) or medians and interquartile ranges (IQR) for continuous variables; frequency and percentages were used for categorical variables. Patient-, prescriber-, and encounter-level characteristics were compared between those patients who did and did not receive an antibiotic. Categorical variables were compared using Pearson's $\chi 2$ test or Fisher exact test, as appropriate. Continuous variables were compared using 2-sample *t* test for independent samples. Univariate analyses were used to determine significant predictors for antibiotic prescribing. Predictors with a $P<.05$ in the univariate analysis were included in a forward, stepwise multivariable logistic model and variables with a $P<.20$ were retained in the model. All tests were 2-tailed, and a $P<.05$ was considered statistically significant. SAS version 9.4 software (SAS Institute, Cary, NC) was used for all statistical analyses. In addition, the distance from a patient's address and their encounter location was determined.

Results

In total, 63,051 unique patients were included in the analysis. The study population mean age was 48.4 years (standard deviation 18.2). Overall, 62.7% were female and 78.7% were non-Hispanic Caucasians. Over 90% of patients had a diagnosis code of J20.9 (Acute bronchitis, unspecified), J40 (Bronchitis, not specified as acute or chronic) or J06.9 (Acute upper respiratory infection, unspecified).

Slightly over half (52.1%) of patients were prescribed antibiotics. Macrolides (98.6% azithromycin), tetracyclines (100% doxycycline), penicillins, cephalosporins, and fluroquinolones comprised 54.6%, 19.9%, 15.9%, 7.8%, and 1.8% of antibiotics prescribed, respectively. Overall, 60.7%, 34.0%, and 5.3% of antibiotics were prescribed in urgent care facilities, ambulatory clinics, and emergency departments, respectively. In addition, the proportion of patients prescribed antibiotics in urgent care facilities, ambulatory clinics, and emergency departments were 55.2%, 53.2% and 29.4%, respectively.

Table 1 describes patient-level characteristics. There were multiple differences in patient-level characteristics between those prescribed and not prescribed antibiotics; notably: patient age, race/ethnicity, gender, smoking status, setting, provider type, and insurance type. Table 2 presents between group differences in encounter-level characteristics and geodemographic factors. The mean distance from a patient residence to the encounter location was similar among those prescribed and not prescribed antibiotics (9.9 miles vs 10.0 miles; $P=.41$). Table 3 presents results of the multivariable analysis.

Discussion

This study affirms that various patient-, prescriber- and/or encounter-level characteristics influence antibiotic prescribing for adults with acute bronchitis or upper respiratory tract infections while revealing the potential impact of various geodemographic factors. Our study identified that antibiotic prescribing was associated with older age, male gender, and smoking status. In our current study, patients

Table 1. Patient Demographics and Characteristics for Those Prescribed and Not Prescribed Antibiotics

Variable, N (%)*	Overall (n = 63,051)	Never Prescribed (n = 30,194)	Prescribed (n = 32,857)	P value
Race/ethnicity				
White non-Hispanic	49,619 (78.7)	23,126 (76.6)	26,493 (80.6)	<0.001
Black non-Hispanic	6,965 (11.1)	3,469 (11.5)	3,496 (10.6)	
Hispanic	4,665 (7.4)	2,647 (8.8)	2,018 (6.1)	
Asian	1,164 (1.9)	619 (2.1)	545 (1.7)	
Other	638 (1.0)	333 (1.1)	305 (0.9)	
Patient over 65	12,338 (19.6)	5,078 (16.8)	7,260 (22.1)	<0.001
Male	23,493 (37.3)	10,762 (35.6)	12,731 (38.8)	<0.001
Ever smoker	27,422 (43.5)	12,453 (41.2)	14,969 (45.6)	<0.001
BMI categories				
Underweight	736 (1.2)	335 (1.1)	401 (1.2)	0.310
Normal weight	9,207 (14.6)	4,274 (14.2)	4,933 (15.0)	
Overweight	13,151 (20.9)	5,979 (19.8)	7,171 (21.8)	
Obese	23,077 (36.6)	10,447 (34.6)	12,630 (38.4)	
Missing	16,880 (26.8)	9,159 (30.3)	7,721 (23.5)	
Insurance type				
Private	34,030 (54.0)	15,897 (52.7)	18,133 (55.2)	<0.001
Medicaid	8,401 (13.32)	4,881 (16.2)	3,520 (10.7)	
Medicare	14,998 (23.8)	6,295 (20.9)	8,703 (26.5)	
Exchange	2,316 (3.7)	1,131 (3.8)	1,185 (3.6)	
Other	162 (0.3)	82 (0.3)	80 (0.2)	
Missing	3,144 (5.0)	1,908 (6.3)	1,236 (3.8)	
Provider type				
Physician	41,899 (66.5)	20,502 (67.9)	21,397 (65.1)	<0.001
Nurse practitioner	11,446 (18.2)	5,195 (17.2)	6,251 (19.0)	
Physician assistant	9,441 (15.0)	4,378 (14.5)	5,063 (15.4)	
Other provider type	265 (0.4)	119 (0.4)	146 (0.4)	
Location of visit				
Emergency department, N (%)	5,955 (9.4)	4,203 (13.9)	1,752 (5.3)	<0.001
Urgent care, N (%)	36,109 (57.3)	16,174 (53.6)	19,935 (60.7)	
Clinic, N (%)	20,987 (33.3)	9,817 (32.5)	11,170 (34.0)	

*All data are presented as the number (percentage) for that variable, binary or categorical, within each column: overall, never prescribed and prescribed.
Abbreviation: BMI, body mass index.

of African American race and white race were more likely to be prescribed antibiotics, as were those living in US Census block groups with more owner-occupied housing. Privately insured patients were prescribed antibiotics more often than those with public or exchange insurance coverage. Notably, patient travel distance to their encounter did not impact prescribing nor did provider type (eg, Physician, Nurse Practitioner). Due to the large sample size, there are certainly predictor variables which are statistically significant, but not clinically or socio-demographically relevant (eg, visit time intervals, age of housing). However, taken together, our results regarding private insurance and percent owner occupied housing suggest that perhaps higher socioeconomic status influences antibiotic prescription for acute bronchitis and upper respiratory tract infection, in addition to factors of age, race/ethnicity, smoking and care setting.

Collectively, this study's results suggest that certain geodemographic factors are associated with antibiotic prescribing independent of other, known determinants of antibiotic prescribing among adults with acute, uncomplicated bronchitis or upper respiratory tract infections. We suggest that patients of higher socioeconomic status may be more likely to be prescribed antibiotics for a condition known to derive no benefit from such medication. In 1 US

Table 2. Continuous Variable Comparison for Those Prescribed and Not Prescribed Antibiotics*

Variable	Overall (n = 63,051)	Never Prescribed (n = 30,194)	Prescribed (n = 32,857)	*p*-Value
Patient age, years	63,051 (48.4 ± 18.2)	30,194 (45.8 ± 18.4)	32,857 (50.8 ± 17.7)	<0.001
Time to room, minutes	55,778 (14.2 ± 16.4)	25,242 (13.4 ± 15.6)	30,536 (14.8 ± 17.0)	<0.001
Time in room, minutes	55,699 (30.0 ± 19.3)	25,203 (31.4 ± 19.4)	30,496 (28.8 ± 19.0)	<0.001
Respiratory rate, beats per minute	38,441 (17.2 ± 2.6)	17,567 (17.2 ± 2.6)	20,874 (17.3 ± 2.6)	0.068
Systolic blood pressure, mm Hg	53,218 (124.8 ± 14.5)	24,171 (124.7 ± 14.6)	29,047(124.8 ± 14.5)	0.512
Diastolic blood pressure, mm Hg	53,430 (75.9 ± 9.8)	24,274 (75.8 ± 9.8)	29,156 (75.9 ± 9.8)	0.786
Temperature, degrees Fahrenheit	53,405 (98.3 ± 0.7)	24,340 (98.3 ± 0.7)	29,065 (98.3 ± 0.7)	0.969
Heart rate, beats per minute	55,224 (82.5 ± 14.3)	25,101 (82.4 ± 14.3)	30,123 (82.6 ± 14.3)	0.031
Median age housing[a], years	61,272 (40.7 ± 8.4)	29,342 (40.4 ± 8.5)	31,930 (41.0 ± 8.3)	<0.001
Owner occupied housing[a], percent	61,272 (66.1 ± 24.2)	29,342 (64.5 ± 24.6)	31,930 (67.7 ± 23.7)	<0.001
Households without vehicles[a], percent	61,272 (7.3 ± 9.6)	29,342 (7.9 ± 10.0)	31,930 (6.9 ± 9.1)	<0.001
Distance from clinic, miles	61,233 (10.0 ± 20.8)	29,312 (10.0 ± 21.9)	31,921 (9.9 ± 19.8)	0.414

*Data indicate the number of patients who have a given characteristic as well as the mean ± standard deviation for that variable: among the overall population, among those never prescribed an antibiotic and among those prescribed an antibiotics.
[a]Median age of housing, owner occupied housing, and households without vehicles per block group as collected annually by the American Community Survey.

study, white patients reported twice as many antimicrobial drug prescriptions per capita as persons of other races/ethnicities.[22] Further, white adult patients and adults with commercial insurance were more likely to receive inappropriate antibiotic prescriptions for upper respiratory infections ostensibly by viruses in a cohort from North Carolina.[23] Interestingly, in our study African American patients were more likely to receive antibiotics; an observation that differs from previous studies and is challenging to explain.[9,22] Goyal et al. reported that non-Hispanic white children were more likely than non-Hispanic Black and Hispanic children to receive antibiotics for viral, acute respiratory tract infections in the ED.[24] Gerber et al. found, by estimating within-clinician associations, that African American children treated by the same clinicians received fewer antibiotic prescriptions and upper respiratory tract infection diagnoses than children of other races.[25] Another study, of parenteral antibiotic prescribing for pediatric emergency department use, observed higher odds of prescribing for White patients and those with private insurance.[26] Evidently patient race and insurance status affect antibiotic prescribing for ambulatory children and adults; and our results corroborate this in adults with bronchitis or upper respiratory tract infection across 3 distinct ambulatory care settings.

Table 3. Association Between Patient, Prescriber, Facility, Geographic, and Socioeconomic Characteristics and Antibiotic Prescribing

Variable	Adjusted Odds Ratio Estimates	95% Confidence Interval
Black race/ethnicity[a,b]	1.29	1.22, 1.38
Hispanic race/ethnicity[a,b]	0.94	0.87, 1.00
Asian race/ethnicity[a,b]	0.88	0.77, 0.99
Other race/ethnicity[a,b]	0.87	0.73, 1.04
Male	1.10	1.06, 1.14
Patient age	1.02	1.02, 1.02
Smoking	1.18	1.14, 1.23
Median age housing, years	1.00	1.00, 1.00
Owner occupied housing percent	1.41	1.30, 1.53
Medicaid insurance[a,c]	0.84	0.79, 0.89
Medicare insurance[a,c]	0.83	0.78, 0.87
Exchange insurance[a,c]	0.90	0.82, 0.98
Other insurance[a,c]	0.98	0.71, 1.36
Emergency department setting [a,d]	0.43	0.40, 0.46
Urgent care setting[a,d]	1.26	1.22, 1.31

[a]Assessed as a categorical variable.
[b]Reference Caucasian.
[c]Reference Private Insurance.
[d]Reference Ambulatory Clinic Location.

Conceptually, this makes sense within the larger context of health care disparities and inequities. It may be suggested that explanatory geodemographic factors from the pediatric literature would hold true among adults. However, this evidence is important: in the US outpatient setting, adults are prescribed antibiotics more often and in higher numbers than children.[27] While speculative, it stands to reason that patients of means may be more strident in their demand for antibiotic therapy and/or make clinicians more concerned with a potential lower patient satisfaction evaluation; 2 factors known to influence antibiotic prescribing in this population and could serve as targets for antimicrobial stewardship intervention.[28,29]

The current study indicates that future interventions to reduce antibiotic prescribing for adults with bronchitis or upper respiratory tract infections must consider the influence of geodemographic factors. For example, if resources are limited, high volume ambulatory settings providing care to more affluent patients could be prioritized; specifically, urgent care settings. In addition, public relations campaigns dispelling the need for antibiotics to treat acute, uncomplicated bronchitis or upper respiratory tract infections could target persons of higher socioeconomic status. The impact of geodemographic factors on unnecessary antibiotic prescribing should also be socialized with physicians and nonphysician prescribers to prompt self-reflection and behavioral change. Future scholarship in this area must account for geodemographic factors to not exclude their potential impact on antibiotic prescribing decisions. Despite its revealing observations, our study is limited by its retrospective, observational nature. Because we did not exclude patients with other diagnoses and/or comorbid conditions prone to antibiotic prescribing for acute bronchitis and/or upper respiratory tract infections it is possible these patients may confound observed associations in our study. For example, we observed that people who have smoked are more likely to receive antibiotics, but chronic obstructive pulmonary disease could account for many of these cases. We did not include codes for acute exacerbation of chronic obstructive lung disease. It is also unknown if antibiotic prescriptions written were filled by patients. For patients with more than 1 encounter, only the index encounter was included. Repeat analyses of patients might have shown that patients who received antibiotics were high risk to receive antibiotics again. In addition, patient addresses could have changed during or immediately before the study period as well, without an update in the electronic medical record, potentially modifying the geodemographic impact on prescribing. We also utilized 2010 US Census and US Census American Community Survey 2018 data as the 2020 data were not yet available. Our study is strengthened by its large sample of diverse patients that increase the generalizability of our findings as well as the variety of patient-, prescriber- and treatment-level data collected and analyzed. Regarding generalizability of our data, the portion of our health system represented herein was recently shown to very favorably compare with Census data on all individuals in the region, inclusive and exclusive of our own patients.[30] Table 4 compares basic demographic data percentages of subjects in this study with 2020 US Census data and the National Ambulatory Medical Care Survey (NAMCS) 2018 data.[31,32] Comparisons are favorable, except for percentage Hispanic subjects in our study, given the differences in populations included in each comparison dataset. For example, our percentage over 65 more closely approximates Census data, and our percentage male more closely approximates NAMCS data as the latter includes data on ambulatory physician office care visits.[32]

Conclusions

In summary, certain geodemographic factors, most notably–broadly–higher socioeconomic status, were associated with a higher rate of antibiotic prescribing for adults with acute, uncomplicated bronchitis or upper respiratory tract infections, in addition to familiar determinants of prescribing. Antimicrobial stewards and health care policy makers should acknowledge the role of patient geodemographics when developing interventions to reduce antibiotic

Table 4. Percentage Comparisons of Patient Demographics in Present Study to US Census 2020 and National Ambulatory Medical Care Survey (NAMCS) 2018 Data

Variable, %	Present Study	2020 Census[31]	NAMCS[32]
Race/ethnicity			
White non-Hispanic	78.7	60.1	70.3
Black non-Hispanic	11.1	13.4*	7.6
Hispanic	7.4	18.5	14.9
Patient over 65	19.6	16.5	32.7
Male	37.3	49.2	41.1
Insurance type			
Private	54.0	—	57.0
Medicaid	13.3	—	12.9
Medicare	23.8	—	27.7

*Includes Hispanic and non-Hispanic Patients of Black Race.

prescribing for bronchitis and/or upper respiratory tract infections.

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Appendix

Appendix Table. Diagnosis Codes of Interest

ICD-10 Code
J20.0 Acute bronchitis due to Mycoplasma pneumoniae
J20.1 Acute bronchitis due to Hemophilus influenza
J20.2 Acute bronchitis due to streptococcus
J20.3 Acute bronchitis due to coxsackievirus
J20.4 Acute bronchitis due to parainfluenza virus
J20.5 Acute bronchitis due to respiratory syncytial virus
J20.6 Acute bronchitis due to rhinovirus
J20.7 Acute bronchitis due to echovirus
J20.8 Acute bronchitis due to other specified organisms
J20.9 Acute bronchitis, unspecified
J40 Bronchitis, not specified as acute or chronic
J06.9 Acute upper respiratory infection, unspecified
J00 Acute nasopharyngitis [common cold]