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Sophia Jung Date

Impact of provider and patient characteristics on unnecessary antibiotic prescribing in The Emory Clinic outpatient setting, October 2015 – September 2017

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MPH

Epidemiology

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# Impact of provider and patient characteristics on unnecessary antibiotic prescribing in The Emory Clinic outpatient setting, October 2015 – September 2017

By

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An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
in Epidemiology
2018

## Abstract

Impact of provider and patient characteristics on unnecessary antibiotic prescribing in The Emory Clinic outpatient setting, October 2015 – September 2017

By Sophia Jung

Introduction: Within the outpatient setting, most of the antibiotics prescribed are for respiratory conditions, specifically acute respiratory infections (ARIs), but most ARIs are caused by viruses and antibiotics are not necessary. We analyzed provider specific antibiotic prescribing patterns as a step to improve prescribing practice and minimize unnecessary antibiotic use in an outpatient setting.

Methods: A cross-sectional study was conducted on eligible encounters with a primary diagnosis of acute respiratory infection from October 2015 to September 2017 in The Emory Clinic (TEC) outpatient setting. Multivariable logistic regression analysis was performed to examine patient, provider, and setting characteristics impacts on antibiotic prescribing as well as analyze provider-specific prescribing rates.

Results: About half of the 9,600 encounters (53.4%) over the two-year study period resulted in an antibiotic prescription for an acute respiratory infection. Macrolides (40.3%) and broad-spectrum penicillins (21.4%) were the most frequent antibiotics prescribed. Prescribing rates between providers were highly variable (median: 43% antibiotics prescribed, interquartile range (IQR): 27%-60% antibiotics prescribed) and varied between the 8 clinic locations (median: 45% antibiotics prescribed, IQR: 39%-59% antibiotics prescribed). Odd of antibiotic prescriptions were independently associated with patient characteristics of white race (OR: 1.59, 95% CI: 1.47-1.73), age (51 to 64 years, OR: 1.32, 95% CI: 1.20-1.46; 65+ years, OR: 1.32, 95% CI: 1.20-1.46), and comorbid condition(s) presence (OR: 1.19, 95% CI: 1.09-1.30). Of the 109 providers, 60% (65) had an O:E ratio below 1.0 where 26% (28) were statistically significant; and, 38% (41) had an O:E ratio above 1.0 where 12% (13) were statistically significant.

Conclusion: Antibiotic prescription rates for ARIs is common within TEC outpatient settings with huge variation in prescribing rates despite a universal target of zero prescriptions. Even when accounting for patient characteristics associated with antibiotic receipt, about one-third of providers prescribe more than and should be targeted for practice improvements.

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# Background

## Introduction

Antibiotic resistance is a threat to global health, affecting people of all ages. Defined by the CDC as "the ability of microbes to resist the effects of drugs", antibiotic resistance causes an estimated 2 million illnesses and 23,000 deaths annually [1]. Unnecessary antibiotic prescribing plays a key role in antibiotic resistance as it generates selective pressure for the surviving bacteria to develop defense mechanisms against future antibiotics [2-4]. Within the outpatient setting, most of the antibiotics prescribed are for respiratory conditions, specifically acute respiratory infections (ARIs), as ARIs are one of the most common diagnoses for outpatient visits [5-9]. ARIs, such as the common cold, URIs, and acute bronchitis, are most likely viral in nature; therefore, treatment with antibiotics provide no benefits to the patients [10-12].

## Consequences of unnecessary antibiotic use

Unnecessary antibiotic prescribing poses a risk at the patient level for not only acquisition of antibiotic resistant bacteria, but also adverse outcomes (e.g., *C. difficile* infections, allergic reactions) and increased health care costs [7, 9, 11, 13-16]. According to Shehab et al., approximately 80% of emergency department visits for antibiotic-associated adverse events were due to allergic reactions [15]. Furthermore, antibiotics are the single most important cause of *C. difficile*-associated diarrhea and eliminating unnecessary antibiotic prescribing a key prevention step [11, 16, 17]. In addition, the US health system spends about 20 billion USD in extra costs annually when bacteria become resistant to at least first-line antibiotic treatments [14]. It is in the outpatient setting where

most of the antibiotic expenses occur [18]. If the trend of antibiotic resistance continues, the estimated burden of death may rise to 10 million annually by 2050 [14].

Contributing factors to antibiotic prescribing for ARIs

With so many moving parts, it is essential to understand what factors are most likely contributing to unnecessary antibiotic prescribing. Studies have reported characteristics of the patient, provider, and setting-levels to explain some of the variations within antibiotic prescribing [6, 19-21]. Most of the variation of antibiotic prescribing, however, is attributable to the provider-level [6, 22]. Analyzing patterns and sources of variation in antibiotic prescribing for patients with ARI would help define reasonable interventions to change antibiotic prescribing habits of providers when caring for patients with ARIs more effectively [6]. Accountable justification and peer comparison—interventions aimed to change provider behavior—have shown promising results in reducing inappropriate antibiotic prescribing rates for acute respiratory infections [13]. The objective of this study is to identify predictors of unnecessary antibiotic prescribing for acute respiratory infections in the outpatient setting of The Emory Clinic (TEC) of Emory Healthcare. Information obtained on the variability, drivers, and adjusted rates of unnecessary antibiotic prescribing is the first step to a quality initiative utilizing feedback and behavior change interventions to reduce unnecessary antibiotic prescribing at TEC.

## Methods

Study Design

A cross-sectional study was conducted using de-identified data of eligible encounters between October 2015 and September 2017 to identify predictors of antibiotic prescribing frequency by providers to patients presenting with acute respiratory infections in TEC outpatient settings. As this study is a quality assessment/quality initiative project and not human subjects research, approval from Emory University Institutional Review Board (Atlanta, Georgia) was exempt.

Data source and study population

De-identified data of eligible encounters was obtained from The Emory Healthcare Clinic Clinical Data Warehouse. Eligible encounters were defined as all patient visits at TEC with primary diagnosis International Classification of Disease, Tenth Revision, Clinical Modification (ICD-10-CM) codes consistent with ARIs. These were based on codes used in a published study [13] and include acute nasopharyngitis (J00), acute sinusitis (J01.x), acute pharyngitis (J02.x), acute tonsillitis (J03.x), acute laryngitis and tracheitis (J04.x), acute obstructive laryngitis (J05), acute upper respiratory infections (J06.x), acute bronchitis (J20.x), acute bronchiolitis (J21.x), and unspecified acute lower respiratory infection (J22). Additional variables collected include patient age, gender, race, comorbid conditions within the last 12 months, patient co-infection (other infection documented during index encounter), provider type, prescribing provider, primary diagnosis, an antibiotic was prescribed, and if prescribed, what kind of antibiotic was given. Eligible visits with missing patient race and provider ID were excluded.

Covariate definitions

Each encounter was further categorized as potentially antibiotic appropriate or not potentially antibiotic appropriate based on categorization from Meeker et al. [13] where diagnoses of acute tonsillitis, acute sinusitis, and acute pharyngitis are considered potentially antibiotic appropriate. Patient race was categorized as White, Black and Other for encounter-level analysis, where Other includes Asian, American Indian or Alaskan native, Native Hawaiian or Other Pacific, and multiple; and re-categorized as White or Not White for provider-level analysis. Patient age was categorized into three groups: <50 years, 50 to 64 years, and 65 years and older. Patient comorbidity was organized as absence or presence of any of the following conditions: congestive heart failure, chronic lung disease, chronic kidney disease, diabetes, cancer, and HIV/AIDs. Patient co-infection was also organized as absence or presence and consisted of the following conditions: gastrointestinal infections, bacterial infections, skin/soft tissue infections, meningitis/sepsis/bacteremia, oral/dental, sexually transmitted illness, and Lyme disease. The co-infection conditions were based on the ICD-9 codes from Meeker et al. [13]. As patient co-infections were present in less than two percent (n = 179) of the eligible encounters, this variable was not included in further analysis. Providers were classified by professional training as staff physician, Advanced Practice Provider (APP, including, non-physicians including Nurse Practitioners, Physicians Assistants, Certified Nurse Midwives, Clinical Psychologists, Nonclinical Psychologists, Clinical Nurse Specialists), or resident physicians; and further categorized as Staff MD or other staff for provider-level analysis. Fifteen TEC locations were included in the study, but clinics with 10 or fewer encounters were aggregated into one group bringing a final count of ten TEC

locations. The analysis focused on the most prescribed antibiotics included were ceftriaxone, sulfamethoxazole-trimethoprim, clindamycin, ciprofloxacin, levofloxacin, moxifloxacin, cefuroxime, cephalexin, doxycycline, amoxicillin, amoxicillin-clavulanate, ampicillin, penicillin V potassium, azithromycin, and clarithromycin.

Statistical analysis

*Encounter-level analysis.* Preliminary data analysis examined differences in patient, provider and clinic characteristics between encounters with and without an antibiotic prescription. Variables that were nominally associated with antibiotic prescribing based ($P<0.10$) on a Chi-square test were considered to be eligible for multivariable analysis. Initial multivariable logistic regression at the encounter-level was performed to identify significant predictors for provider-specific antibiotic prescribing analysis among all encounters.

*Clinic and Provider-level analysis.* Clinic-level analysis consisted of calculating unadjusted prescribing rates by TEC location. For provider-level analysis, the study population was further restricted to providers with 10 or more encounters (n=9,435); removing providers with rare patient encounters from the analysis would improve credibility of results for quality improvement efforts. Additionally, the potentially appropriate antibiotic diagnosis covariate was chosen to be excluded from further analyses due to concerns of the subjective nature of this variable (providers may use codes for this group in an unreliable and subjective manner). Unadjusted provider-specific prescribing rates were computed, and variability in key predictors of prescribing

(age, race, comorbidity) were evaluated by calculating simple descriptive statistics by provider.

*Standardized Prescribing Ratio.* Model diagnostics were conducted to ascertain the best fit logistic regression model prior to using encounter-level data to estimate the predicted probability of an encounter resulting in an antibiotic prescription. The predicted probabilities were then summed by provider to produce the expected number of antibiotics prescribed. The provider-specific observed to expected (O:E) ratios and corresponding 95% confidence intervals (using the Mid-P exact test as there are less than or equal to 5 observed number of antibiotics prescribed [31]) were subsequently calculated. Statistical analyses were done using SAS, version 9.4 (SAS Institute).

## Results

Study Population and Frequency of Antibiotic Prescribing

Of 10,362 eligible visits with the primary diagnosis of an ARI, 9,600 met inclusion criteria. Table 1 shows the various frequencies of patient, provider, and setting characteristics. Patients were seen by 152 providers at 15 different TEC locations, where most encounters occurred at St Joseph's (29.3%), followed by Dunwoody (12.8%) and 1525 Clinic (13.6%). The most common ARI diagnoses were acute upper respiratory infections (32.2%), followed by acute pharyngitis (19.7%), acute bronchitis (17.0%), and acute sinusitis (16.5%). Patient age ranged from 0 to 90 years with the majority of encounters consisting of patients older than 50 (59%) and white race (55.7%). A quarter of encounters had patients with comorbidities (25.5%), and less than two percent of encounters had patients with co-infections. Approximately half 9,600 encounters resulted in antibiotics being prescribed (53.4%).

Encounter-level analysis

There were differences in the prescribing of antibiotics across the majority of the covariates (see Table 2). Unadjusted patterns show higher proportions of antibiotics prescribed among patients who are white, older than 50 years, or have underlying conditions ($P < 0.001$). There were no differences in antibiotic prescribing between male and female patients ($P = 0.1442$). Among the providers, staff MDs have a higher proportion of antibiotic prescribing than APP and residents. Of all potentially antibiotic-appropriate diagnoses made, 63% resulted in antibiotic prescribing ($P < 0.0001$).

Multivariable logistic regression analysis suggests an association of prescribing antibiotics with a majority of the considered predictors (See Table 3). Encounters with black patients (OR: 0.71, 95% CI: 0.64-0.78) or other race (OR: 0.65, 95% CI: 0.53-0.79) had lower odds of resulting in antibiotics than encounters with white patients. On the other hand, encounters with patients who were older than 50 years (51 to 64 years, OR: 1.34, 95% CI: 1.20-1.50; 65+ years, OR: 1.31, 95% CI: 1.17-1.47) or had comorbid conditions (OR: 1.23, 95% CI: 1.12-1.35) had higher odds of antibiotic prescribing than others. Among diagnoses, encounters with potentially antibiotic-appropriate diagnoses had a two-fold increase in the odds of resulting in an antibiotic than that of encounters without a potentially antibiotic-appropriate diagnosis (OR: 2.19, 95% CI: 2.00-2.41). There were no differences in antibiotic prescribing patterns between provider types.

Clinic-level and provider-level analysis

Sizable variation of unadjusted antibiotic prescribing rates was seen among the TEC clinics (see Figure 1); in which, East Cobb (75%) and St Josephs (72%) resulted in much higher proportions of antibiotic prescriptions compared to the other clinics ($P < 0.0001$). This variation is reflected in the results of the encounter-level multivariable analysis where encounters taking place at either East Cobb (OR: 10.43, 95% CI: 7.80-14.04) or St Joseph (OR: 8.33, 95% CI: 6.58-10.62) have much higher odds in receiving an antibiotic prescription than all other clinics.

After excluding providers with less than 10 encounters, there were 9,435 eligible encounters and 109 providers for provider-specific analysis. Unadjusted provider-specific prescribing rates showed high variability in prescribing patterns (median: 43%,

interquartile range (IQR): 27% to 43%) (See Appendix Figure 1 and Appendix Table 2). Variables remaining in the best fit model only included patient the patient characteristics of white race (OR: 1.59, 95% CI: 1.47-1.73), age (51 to 64 years, OR: 1.32, 95% CI: 1.20-1.46; 65+ years, OR: 1.32, 95% CI: 1.20-1.46), and comorbid condition(s) presence (OR: 1.19, 95% CI: 1.09-1.30) (see Table 4 and Appendix Table 2).

Standardized Prescribing Ratio

The histogram and point estimate plot in Figure 3 displays the total encounters and number of antibiotics prescribed as well as the variability of O:E ratio of antibiotics prescribed by providers among providers who have had 10 or more encounters during the study period. Of the 109 providers, 60% (65) had an O:E ratio below 1.0 where 26% (28) were statistically significantly lower than 1.0; and, 38% (41) had an O:E ratio above 1.0 where 12% (13) were statistically significantly above 1.0.

## Discussion

Our two-year study of outpatient visits with ARIs within the TEC locations found a high proportion of antibiotic prescribing as well as substantial variations in provider-specific prescribing rates. This is concerning as prevailing ARIs, such as the common cold, URIs, and acute bronchitis, are most likely viral in nature; therefore, treatment with antibiotics provide no benefits to the patients and are unnecessary [10-12]. The overall proportion of encounters with antibiotics should be much lower, ideally approaching zero. Second, the variability in rates suggests that it is possible to prescribe much lower and many providers should be doing a better job.

The focus of this study was to examine the impact of patient and provider characteristics for antibiotic prescribing. Similar to previous studies [5, 21, 23, 24], we found that the patient characteristics of age, race, and comorbid condition(s) presence were significant predictors within both the primary and secondary multivariable logistic regression analyses. Furthermore, at the setting level, TEC location was significantly associated with antibiotic prescribing from preliminary and initial multivariable analyses. Some studies have shown setting-level characteristics may play a role in the prescribing of antibiotics; Jones et al. found that 28% of the antibiotic prescribing variation is attributable to clinics (versus ED), while Shapiro et al. found higher odds of antibiotic prescribing within the ED setting [5, 6, 21].

Other studies have noted cultural factors (such as patient attitudes) and other external forces may also influence the prescribing of antibiotics [7, 25, 28-30]. However, in our study, there was still substantial variation in the provider-specific O:E ratios for antibiotic prescribing even after accounting for patient characteristics. This finding,

similar to other studies, suggests much of the influence in deciding to prescribe antibiotics comes from the providers [6, 7, 25]; and, that the providers have individual treatment 'styles' regardless of patient characteristics [6]. The provider-specific O:E ratios could also be used in potential intervention studies aimed to target providers for antibiotic prescribing improvement.

We acknowledge several limitations in this study. Classification of visit diagnosis was based on ICD-10-CM codes and misclassification can occur. Moreover, there is a potential that a patient may have had a more severe illness that was diagnosed at the time of visit which could indicate the need for antibiotics; however, this does not explain the considerable degree of antibiotic prescribing variation within our study population. Additionally, interactions between the patient, provider, and setting predictors were not considered. Provider analysis was restricted to only providers with 10 or more encounters during the 2-year study period, and provider-specific ratios were calculated after assuming normal distribution on the logit scale.

Despite the limitations of this study, important conclusions can be drawn from the results. Antibiotic prescription rates for ARIs are higher than is recommended within TEC outpatient settings. There is a large variation in the prescribing habits among and between TEC providers even when accounting for the key patient characteristics that influence whether antibiotics are prescribed. These data lay the foundation for quality improvement interventions to reduce antibiotic prescribing rates. Such efforts can focus on both specific clinics and specific providers. These provider-specific data should be useful as part of an effort to feed-back provider-specific prescribing rates as part of efforts to reduce unnecessary antibiotic use in this setting.

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# Tables

**Table 1.** Characteristics of eligible encounters with acute respiratory infections from The Emory Clinic locations, October 2015 to September 2017 (N = 9,600)

| Variable | Frequency | % |
|---|---|---|
| **ARI Diagnosis** | | |
| Acute obstructive laryngitis (croup) and epiglottitis | 5 | 0.1 |
| Unspecified acute lower respiratory infection | 12 | 0.1 |
| Acute bronchiolitis | 53 | 0.6 |
| Acute nasopharyngitis (common cold) | 525 | 5.5 |
| Acute laryngitis and tracheitis | 751 | 7.8 |
| Acute bronchitis | 1,629 | 17.0 |
| Acute upper respiratory infections of multiple and unspecified sites | 3,095 | 32.2 |
| Acute tonsillitis | 58 | 0.6 |
| Acute sinusitis | 1,584 | 16.5 |
| Acute pharyngitis | 1,888 | 19.7 |
| **Potentially Antibiotic-Appropriate Diagnosis** | | |
| Yes | 3,530 | 36.8 |
| No | 6,070 | 63.2 |
| **Patient Sex** | | |
| Male | 2,808 | 29.3 |
| Female | 6,792 | 70.8 |
| **Patient age** | | |
| 0 to 50 years | 3,957 | 41.2 |
| 51 to 64 years | 2,518 | 26.2 |
| 65+ years | 3,125 | 32.6 |
| **Patient Race** | | |
| White | 5,344 | 55.7 |
| Black | 3,758 | 39.2 |
| Other ¶ | 498 | 5.2 |
| **Patient Comorbidities Present** | | |
| Yes | 3,405 | 35.5 |
| No | 6,195 | 64.5 |
| **Patient Co-infection Present** | | |
| Yes | 179 | 1.9 |
| No | 9,421 | 98.1 |

| | | |
|---|---|---|
| **Provider Types** | | |
| Staff MD | 7,233 | 75.3 |
| APP* | 1,427 | 14.9 |
| Resident | 940 | 9.8 |
| **Clinic locations**‡ | | |
| TEC GIM - PCPC 1525† | 500 | 5.2 |
| Other (Fam Med - Midtown, Old 4th Ward; GIM - Executive Health, Micropractice, Resident Medicine) | 116 | 1.2 |
| TEC GIM Geriatric Clinic | 339 | 3.5 |
| TEC GIM - East Cobb | 589 | 6.1 |
| TEC GIM - 1365 Clinic | 702 | 7.3 |
| TEC GIM - MOT (Midtown Medical Office Tower) | 938 | 9.8 |
| TEC GIM - Decatur, TEC GIM Lithonia | 1,075 | 11.2 |
| TEC GIM - 1525 Clinic | 1,304 | 13.6 |
| TEC Fam Med - Dunwoody | 1,228 | 12.8 |
| TEC GIM - ST Josephs | 2,809 | 29.3 |
| **Antibiotics received** | | |
| Yes | 5,128 | 53.4 |
| No | 4,472 | 46.6 |
| **Antibiotic types**§ | | |
| Ceftriaxone (IV/IM) | 15 | 0.3 |
| Sulfamethoxazole-trimethoprim | 26 | 0.5 |
| Clindamycin | 83 | 1.6 |
| Fluoroquinolones (Ciprofloxacin, Levofloxin, and Moxifloxacin) | 196 | 3.8 |
| Cephalosporins (Cefuroxime and Cephalexin) | 344 | 6.7 |
| Doxycycline | 487 | 9.5 |
| Amoxicillin | 815 | 15.9 |
| Broad spectrum penicillin (Amoxicillin-clavulanate, Ampicillin, Penicillin V potassium) | 1,096 | 21.4 |
| Macrolides (Azithromycin and Clarithromycin) | 2,066 | 40.3 |

*APP = Advanced Practice Provider (non-physician members including Nurse Practitioners (NPs), Physicians Assistants (PAs), Certified Nurse Midwives, Clinical Psychologists, Nonclinical Psychologists, Clinical Nurse Specialists)

¶ The other sub-category of race includes Asian, American Indian or Alaskan native, Native Hawaiian or Other Pacific, and multiple

‡TEC GIM = The Emory Clinic General Internal Medicine, Fam Med = Family Medicine

†PCPC = Patient-Centered Primary Care

§Percentages provided are antibiotics given just among encounters where antibiotics were prescribed (n = 5,128)

**Table 2.** Antibiotic prescribing during The Emory Clinic outpatient visits for acute respiratory infections, October 2015 and September 2017 (N = 9,600)

| | | Antibiotics Prescribed | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **n** | **Yes** | **%** | **No** | **%** | **RR¶** | **95% CI** | | **p value*** |
| **Diagnoses categories** | | | | | | | | | |
| Acute URI | 5 | 1 | 20 | 4 | 80 | - | - | - | <0.0001 |
| Unsp acute LRI | 12 | 8 | 67 | 4 | 33 | - | - | - | |
| Acute obs laryngitis and epiglottitis | 53 | 34 | 64 | 19 | 36 | - | - | - | |
| Common cold | 525 | 202 | 38 | 323 | 62 | - | - | - | |
| Acute laryngitis and tracheitis | 751 | 521 | 69 | 230 | 31 | - | - | - | |
| Acute bronchitis | 1,629 | 1,138 | 69 | 491 | 31 | - | - | - | |
| Acute bronchiolitis | 3,095 | 1,011 | 33 | 2,084 | 67 | - | - | - | |
| Acute tonsillitis | 58 | 38 | 66 | 20 | 34 | - | - | - | |
| Acute sinusitis | 1,584 | 1,392 | 88 | 192 | 12 | - | - | - | |
| Acute pharyngitis | 1,888 | 783 | 41 | 1,105 | 59 | - | - | - | |
| **PAA diagnosis** | | | | | | | | | |
| No‡ | 6,070 | 2,915 | 48 | 3,155 | 52 | - | - | - | - |
| Yes | 3,530 | 2,213 | 63 | 1,317 | 37 | 1.31 | 1.26 | 1.35 | <0.0001 |
| **Patient Sex** | | | | | | | | | |
| Female‡ | 6,792 | 3,614 | 53 | 3,178 | 47 | - | - | - | - |
| Male | 2,808 | 1,540 | 55 | 1,268 | 45 | 1.03 | 0.99 | 1.07 | 0.1442 |
| **Patient Race** | | | | | | | | | |
| White‡ | 5,344 | 3,140 | 59 | 2,204 | 41 | - | - | - | |
| Black | 3,758 | 1,760 | 47 | 1,998 | 53 | 0.80 | 0.77 | 0.83 | <0.0001 |
| Other | 498 | 228 | 46 | 270 | 54 | 0.78 | 0.71 | 0.86 | <0.0001 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Patient Age** | | | | | | | | | |
| 0 - 50 years‡ | 3,957 | 1,896 | 48 | 2,061 | 52 | - | - | - | |
| 51 - 64 years | 2,518 | 1,409 | 56 | 1,109 | 44 | 1.17 | 1.11 | 1.22 | <0.0001 |
| 65+ years | 3,125 | 1,823 | 58 | 1,302 | 42 | 1.22 | 1.17 | 1.27 | <0.0001 |
| **Patient Comorbidities** | | | | | | | | | |
| Absent‡ | 6,195 | 3,201 | 52 | 2,994 | 48 | - | - | - | |
| Present | 3,405 | 1,927 | 57 | 1,478 | 43 | 1.10 | 1.05 | 1.14 | <0.0001 |
| **Provider type** | | | | | | | | | |
| Staff MD‡ | 7,233 | 4,186 | 58 | 3,047 | 42 | - | - | - | |
| APP | 1,427 | 612 | 43 | 815 | 57 | 0.74 | 0.70 | 0.79 | <0.0001 |
| Resident | 940 | 330 | 35 | 610 | 65 | 0.61 | 0.56 | 0.66 | <0.0001 |
| **Clinic locations†** | | | | | | | | | |
| PCPC 1525 | 500 | 115 | 23 | 385 | 77 | - | - | - | |
| Other§ | 116 | 27 | 23 | 89 | 77 | 1.10 | 0.70 | 1.46 | 0.9493 |
| Geriatric Clinic | 339 | 207 | 61 | 132 | 39 | 2.65 | 2.21 | 3.18 | <0.0001 |
| East Cobb | 589 | 439 | 75 | 150 | 25 | 3.24 | 2.74 | 3.83 | <0.0001 |
| 1365 Clinic | 702 | 283 | 40 | 419 | 60 | 1.75 | 1.46 | 2.11 | <0.0001 |
| MOT (Midtown Office Tower) | 938 | 467 | 50 | 471 | 50 | 2.16 | 1.82 | 2.57 | <0.0001 |
| Decatur, Lithonia | 1,075 | 571 | 53 | 504 | 47 | 2.31 | 1.95 | 2.74 | <0.0001 |
| 1525 Clinic | 1,304 | 509 | 39 | 795 | 61 | 1.70 | 1.43 | 2.02 | <0.0001 |
| Dunwoody | 1,228 | 491 | 40 | 737 | 60 | 1.74 | 1.46 | 2.07 | <0.0001 |
| St Josephs | 2,809 | 2,019 | 72 | 790 | 28 | 3.13 | 2.66 | 3.67 | <0.0001 |

*P value from Chi-square test ¶ Unadjusted Risk Ratios
‡ Reference group †Reference group for clinic location is PCPC 1525
§ The Other sub-category within Clinic locations includes Midtown, Old 4th ward, Exec Health, Micropractice, Resident Med

**Table 3.** Multivariate model of antibiotic prescribing among The Emory Clinic encounters with acute respiratory infections (N = 9,600)

| Variables | aOR* | 0.95 CI | | p value |
|---|---|---|---|---|
| **Patient race¶** | | | | |
| Black | 0.71 | 0.64 | 0.78 | 0.0402 |
| Other¶ | 0.65 | 0.53 | 0.79 | 0.0097 |
| **Patient age¶** | | | | |
| 51-64 years | 1.34 | 1.20 | 1.50 | 0.0022 |
| 65+ years | 1.31 | 1.17 | 1.47 | 0.0170 |
| **Patient comorbidity** | 1.23 | 1.12 | 1.35 | <.0001 |
| **PAA diagnosis§** | 2.19 | 2.00 | 2.41 | <.0001 |
| **Provider type¶** | | | | |
| APP‡ | 0.98 | 0.85 | 1.12 | 0.1691 |
| Resident | 0.77 | 0.63 | 0.94 | 0.0183 |
| **Clinic locations¶** | | | | |
| Other¥ | 1.26 | 0.75 | 2.07 | <.0001 |
| Geriatric | 5.09 | 3.71 | 7.04 | <.0001 |
| East Cobb | 10.43 | 7.80 | 14.04 | <.0001 |
| 1365 Clinic | 1.98 | 1.52 | 2.59 | <.0001 |
| MOT† | 3.74 | 2.90 | 4.84 | 0.0319 |
| Decatur, Lithonia | 4.39 | 3.40 | 5.70 | <.0001 |
| 1525 Clinic | 2.29 | 1.80 | 2.94 | <.0001 |
| Dunwoody | 2.81 | 2.14 | 3.70 | 0.0987 |
| St Josephs | 8.33 | 6.58 | 10.62 | <.0001 |

*Adjusted odds ratio – adjusted for all other covariates

¶Reference groups for the nominal variables are as follows: patient race = white, patient age = 0 to 50 years, provider type = Staff MD, Clinic location = PCPC 1525

¶The other sub-category of race includes Asian, American Indian or Alaskan native, Native Hawaiian or Other Pacific, and multiple

§ Potentially Antibiotic Appropriate diagnosis

‡ APP = Advanced Practice Provider (non-physician members including Nurse Practitioners (NPs), Physicians Assistants (PAs), Certified Nurse Midwives, Clinical Psychologists, Nonclinical Psychologists, Clinical Nurse Specialists)

¥ The Other sub-category within Clinic locations includes Midtown, Old 4th ward, Exec Health, Micropractice, Resident Med

† MOT = Midtown Office Tower

**Table 4.** Multivariable logistic regression models of antibiotic prescribing for acute respiratory infections among providers with ≥ 10 encounters at The Emory Clinic (N = 9,435)

| | **Model 1: All variables** | | | | **Model 2: Excluding Clinic Location** | | | | **Model 3: Excluding Staff MD and Clinic Location**[§] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | **aOR**[*] | **95% CI** | | **p value** | **aOR**[*] | **95% CI** | | **p value** | **aOR**[*] | **95% CI** | | **p value** |
| **White Race**[¶] | 1.47 | 1.33 | 1.61 | <0.0001 | 1.54 | 1.41 | 1.68 | <0.0001 | 1.59 | 1.47 | 1.73 | <0.0001 |
| **Patient comorbidity**[¶] | 1.18 | 1.08 | 1.30 | 0.0005 | 1.18 | 1.08 | 1.29 | 0.0004 | 1.19 | 1.09 | 1.30 | 0.0001 |
| **Patient age**[¶] | | | | | | | | | | | | |
| 51-64 yrs | 1.22 | 1.09 | 1.36 | 0.0069 | 1.25 | 1.12 | 1.38 | 0.0288 | 1.32 | 1.20 | 1.46 | 0.0030 |
| 65+ yrs | 1.13 | 1.01 | 1.27 | 0.6336 | 1.26 | 1.14 | 1.39 | 0.0108 | 1.32 | 1.20 | 1.46 | 0.0029 |
| **Staff MD**[¶] | 1.02 | 0.91 | 1.16 | 0.6979 | 1.89 | 1.71 | 2.08 | <0.0001 | - | - | - | - |
| **Clinic Locations**[¶] | | | | | | | | | | | | |
| Other[¥] | 0.50 | 0.23 | 1.00 | <0.0001 | - | - | - | - | - | - | - | - |
| Geriatric | 4.65 | 3.39 | 6.42 | <0.0001 | - | - | - | - | - | - | - | - |
| East Cobb | 9.02 | 6.78 | 12.07 | <0.0001 | - | - | - | - | - | - | - | - |
| 1365 Clinic | 2.02 | 1.55 | 2.63 | 0.0001 | - | - | - | - | - | - | - | - |
| MOT | 3.57 | 2.78 | 4.59 | 0.0007 | - | - | - | - | - | - | - | - |
| Decatur and Lithonia | 3.96 | 3.08 | 5.12 | <0.0001 | - | - | - | - | - | - | - | - |
| 1525 Clinic | 2.15 | 1.70 | 2.75 | 0.0002 | - | - | - | - | - | - | - | - |
| Dunwoody | 2.64 | 2.08 | 3.38 | 0.5067 | - | - | - | - | - | - | - | - |
| St Josephs | 7.92 | 6.28 | 10.04 | <0.0001 | - | - | - | - | - | - | - | - |
| **Goodness-of-Fit**‡ | **p value** | | | | **p value** | | | | **p value** | | | |
| Pearson | <0.0001 | | | | 0.0081 | | | | 0.2378 | | | |

| | | | |
|---|---|---|---|
| Deviance | <0.0001 | 0.0086 | 0.2378 |
| Hosmer-Lemeshow | 0.9225 | 0.2201 | 0.3134 |

*Adjusted odds ratio

¶ Reference groups for the nominal variables are as follows: white race = not white race, patient comorbidity = absence of any comorbidities, patient age = 0 to 50 years, staff MD = not Staff, Clinic location = PCPC 1525

† MOT = Midtown Medical Office Tower

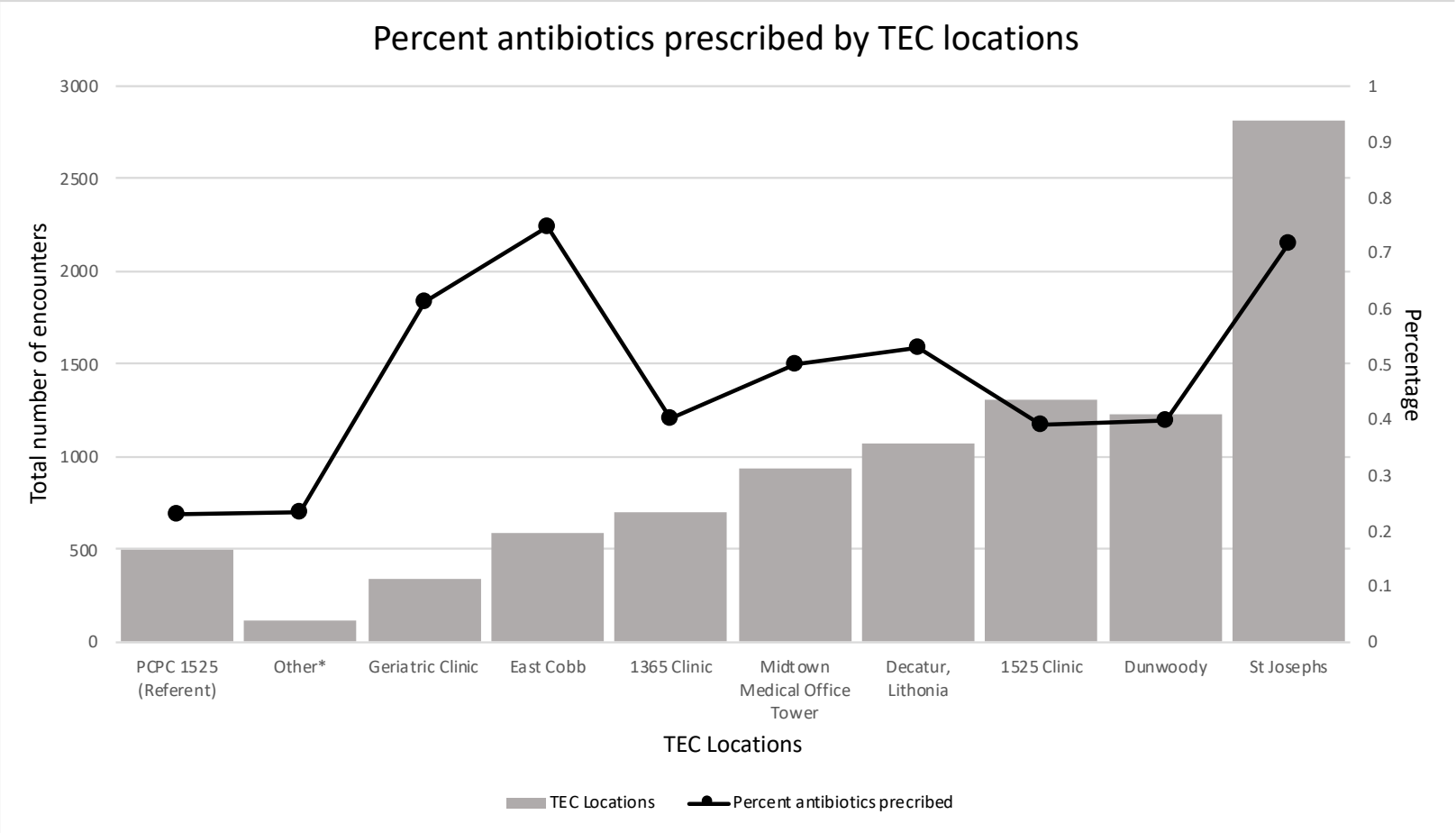
¥ The Other sub-category within Clinic locations includes Midtown, Old 4th ward, Exec Health, Micropractice, Resident Med

‡Goodness-of-Fit: three separate statistical measures indicating whether the model is a good fit to the data when the null hypothesis (the model does not lack fit) is true. Among the three models, Model 3 is the most fit for the data

§Best fit model according to the goodness-of-fit statistical test

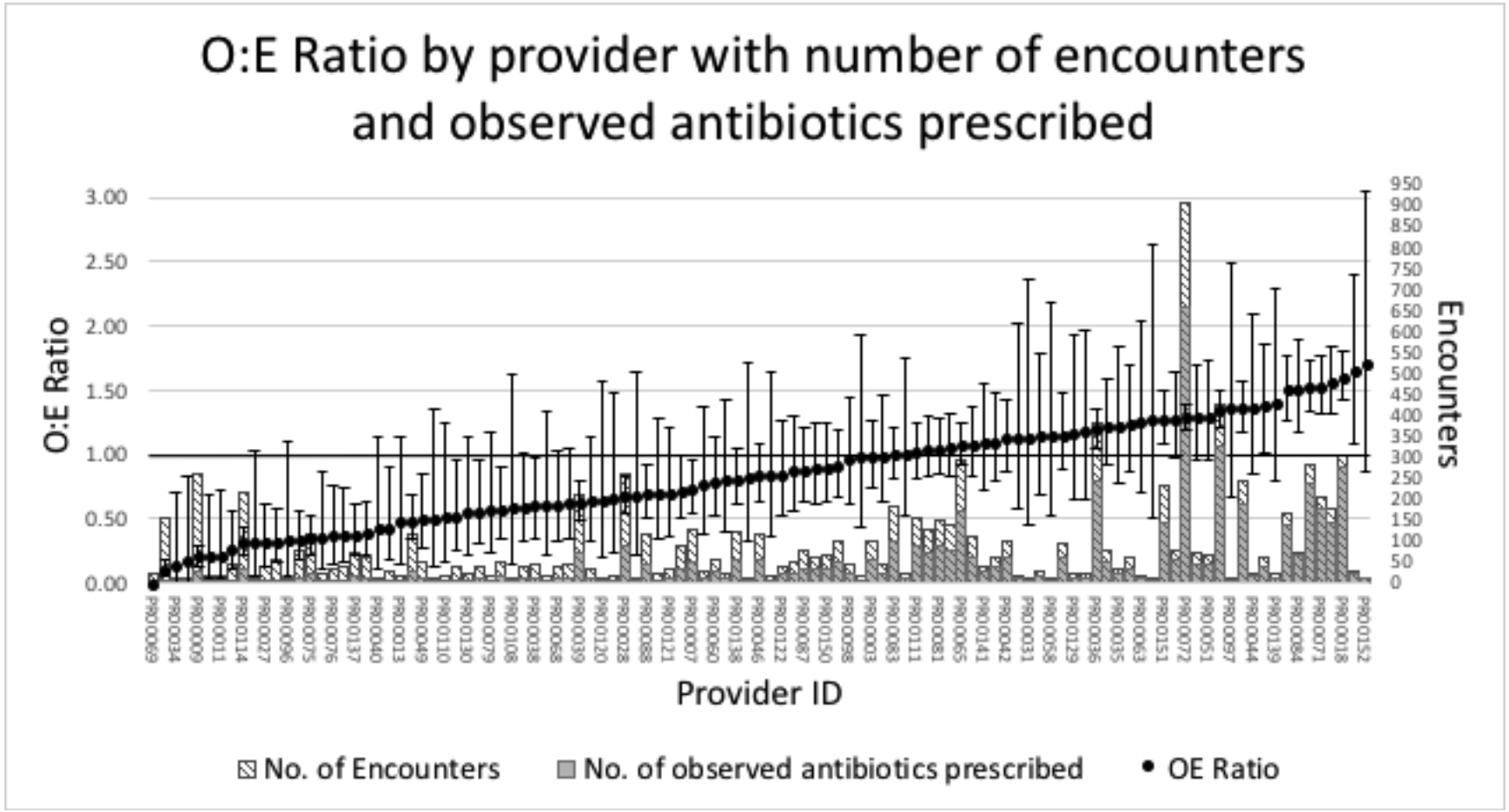
# Figures

**Figure 1.** Histogram of total number of encounters overlaid by a trend line of unadjusted percent antibiotic prescribed by TEC locations between October 2015 and September 2017 (N = 9,600). The unadjusted percentage of antibiotics prescribed by TEC location ranges from 23% to 75%. The locations with the highest percentage are St Josephs (75%) and East Cobb (72%).




* The Other sub-category within Clinic locations includes Midtown, Old 4th ward, Exec Health, Micropractice, Resident Med

**Figure 2.** Stacked bar graph of total number of encounters and observed antibiotics prescribed overlaid by caterpillar plot of observed:expected (OE) ratio of antibiotics prescribed by provider at TEC from October 2015 to September 2017 (N = 9,435). OE ratios were calculated using predicted probabilities from a multivariable logistic model adjusting for patient characteristics of age, race, and presence of comorbid conditions. Error bars denote 95% CI.



## Appendix Tables and Figures

**Appendix Table 1**. Differences in encounter descriptors including antibiotic prescribing and indications, by Provider Type or Clinical Location, at The Emory Clinic locations, between October 2015 and September 2017 (N = 9,600)

| | All | Comorbidities | | | | Age | | | | Potentially Antibiotic Appropriate Diagnosis | | | | Any Antibiotics Prescribed | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Present | % | Absent | % | ≥ 65 | % | <65 | % | Yes | % | No | % | Yes | % | No | % |
| **All encounters** | 9,600 | 3,405 | 35 | 6,195 | 65 | 3,125 | 33 | 6,475 | 67 | 3,530 | 37 | 6,070 | 63 | 4,125 | 53 | 4,472 | 47 |
| **Provider type** | | | | | | | | | | | | | | | | | |
| Staff MD | 7,233 | 2,641 | 37 | 4,592 | 63 | 2,490 | 34 | 4,743 | 66 | 2,559 | 35 | 4,674 | 65 | 4,186 | 58 | 3,047 | 42 |
| APP* | 1,427 | 519 | 36 | 908 | 64 | 516 | 36 | 911 | 64 | 556 | 39 | 871 | 61 | 612 | 43 | 815 | 57 |
| Resident | 940 | 245 | 26 | 695 | 74 | 119 | 13 | 821 | 87 | 415 | 44 | 525 | 56 | 330 | 35 | 610 | 65 |
| **Clinic locations** | | | | | | | | | | | | | | | | | |
| PCPC 1525† | 500 | 110 | 22 | 390 | 78 | 46 | 9 | 454 | 91 | 207 | 41 | 293 | 59 | 115 | 23 | 385 | 77 |
| Other‡ | 116 | 33 | 28 | 83 | 72 | 31 | 27 | 85 | 76 | 33 | 28 | 83 | 72 | 27 | 23 | 89 | 77 |
| Geriatric Clinic | 339 | 201 | 59 | 138 | 41 | 338 | 100 | 1 | 0 | 75 | 22 | 264 | 78 | 207 | 61 | 132 | 39 |
| East Cobb | 589 | 208 | 35 | 381 | 65 | 232 | 39 | 357 | 61 | 162 | 28 | 427 | 73 | 439 | 75 | 150 | 25 |
| 1365 Clinic | 702 | 242 | 34 | 460 | 66 | 318 | 45 | 384 | 56 | 275 | 39 | 427 | 61 | 283 | 40 | 419 | 60 |
| MOT§ | 938 | 359 | 38 | 579 | 62 | 302 | 32 | 636 | 69 | 323 | 34 | 615 | 66 | 467 | 50 | 471 | 50 |
| Decatur, Lithonia | 1,075 | 483 | 45 | 592 | 55 | 408 | 38 | 667 | 62 | 281 | 26 | 794 | 74 | 571 | 53 | 504 | 47 |
| 1525 Clinic | 1,304 | 491 | 38 | 813 | 62 | 392 | 30 | 912 | 70 | 406 | 31 | 898 | 69 | 509 | 39 | 795 | 61 |
| Dunwoody | 1,228 | 335 | 27 | 893 | 73 | 109 | 9 | 1,119 | 92 | 641 | 52 | 587 | 48 | 491 | 40 | 737 | 60 |
| St Josephs | 2,809 | 943 | 34 | 1,866 | 66 | 949 | 34 | 1,860 | 68 | 1,127 | 40 | 1,682 | 60 | 2,019 | 72 | 790 | 28 |

*APP = Advanced Practice Provider (non-physician members including Nurse Practitioners (NPs), Physicians Assistants (PAs), Certified Nurse Midwives, Clinical Psychologists, Nonclinical Psychologists, Clinical Nurse Specialists)

‡ The Other sub-category within Clinic locations includes Midtown, Old 4th ward, Exec Health, Micropractice, Resident Med

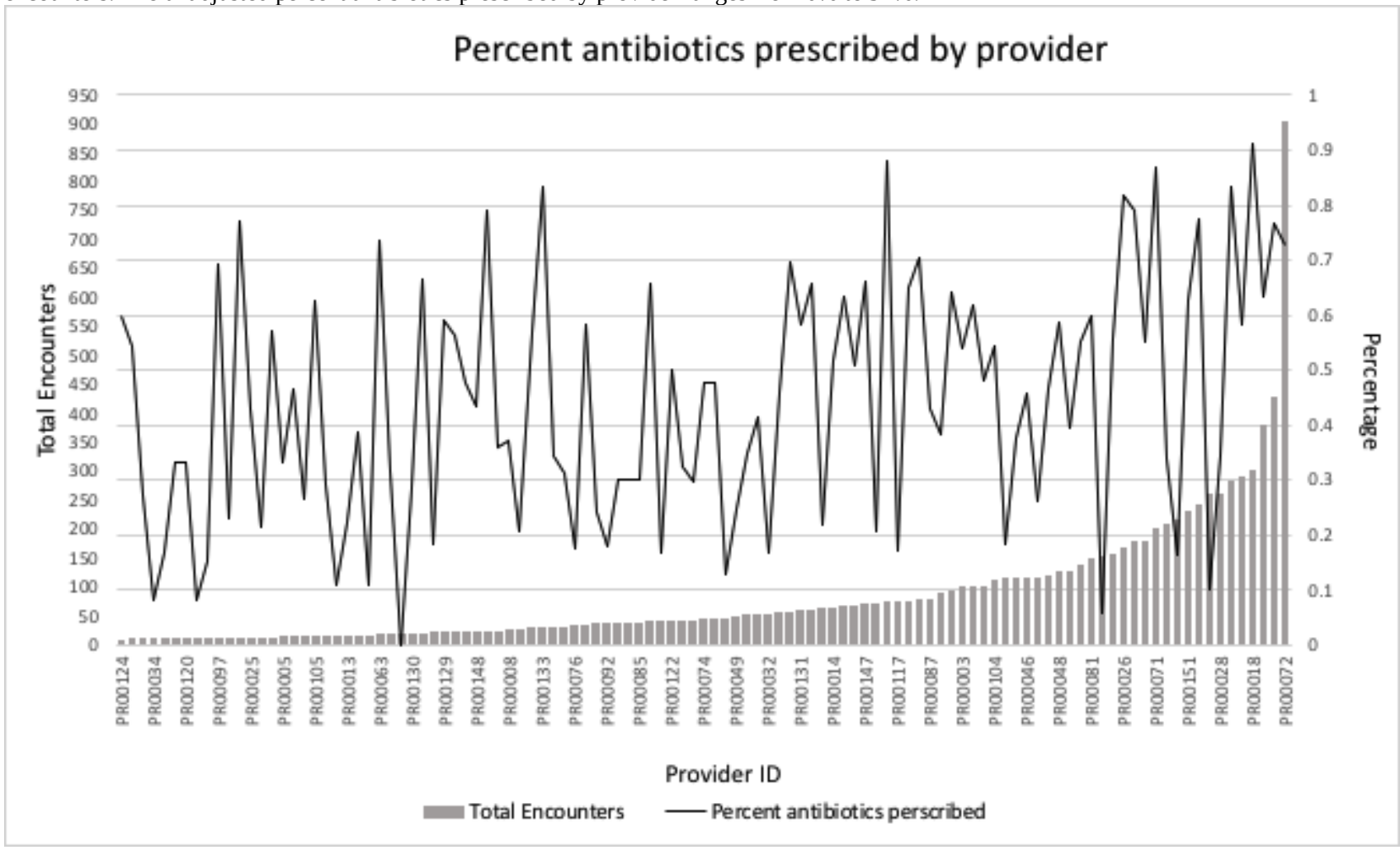
†PCPC = Patient-Centered Primary Care

§ MOT = Midtown Medical Office Tower

**Appendix Table 2.** Mean, median and distribution of summary metrics of patient and encounter characteristics by provider (Oct. 2015 to Sept. 2017)

| **Among all providers (N=152)** | **Mean** | **Std** | **Minimum** | **25%** | **Median** | **75%** | **Maximum** |
|---|---|---|---|---|---|---|---|
| Number of Encounters | 63 | 105 | 1 | 8 | 23 | 74 | 905 |
| Percentage of white patients | 48 | 26 | 0 | 31 | 48 | 67 | 100 |
| Percentage of patients 65 years or older | 27 | 28 | 0 | 7 | 21 | 37 | 100 |
| Percentage of encounters with comorbidities | 33 | 21 | 0 | 22 | 33 | 42 | 100 |
| Percentage of respiratory antibiotics prescribed | 40 | 27 | 0 | 20 | 37 | 59 | 100 |
| **Among only providers with ≥ 10 encounters (N=109)** | | | | | | | |
| Number of Encounters | 87 | 116 | 10 | 21 | 46 | 112 | 905 |
| Percentage of white patients | 48 | 20 | 2 | 31 | 47 | 64 | 89 |
| Percentage of patients 65 years or older | 28 | 24 | 0 | 11 | 25 | 36 | 100 |
| Percentage of encounters with comorbidities | 32 | 13 | 0 | 24 | 33 | 40 | 64 |
| Percentage of respiratory antibiotics prescribed | 44 | 22 | 6 | 27 | 43 | 60 | 91 |

**Appendix Figure 1.** Bar graph of total number of encounters overlaid by line trend of percentage of antibiotics prescribed by provider among providers with 10 or more encounters (N=9, 534). Among the TEC providers, 28% have 100 or more encounters while 12% have 200 or more encounters. The unadjusted percent antibiotics prescribed by provider ranges from 0% to 91%.



**Appendix Figure 2.** Scatter plots showing crude relationships of percentage of antibiotics prescribed by provider with a) percentage of white patients, b) percentage of patients 65+ years, and c) percentage of patient with comorbid conditions present by providers among providers with ≥ 10 encounters at The Emory Clinic (N = 109, Oct 2015 to Sept 2017)