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# A mixed methods exploration of antibiotic prescribing and stewardship

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Dissertation

# A MIXED METHODS EXPLORATION OF ANTIBIOTIC PRESCRIBING AND STEWARDSHIP

by

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## ABSTRACT

Unnecessary prescribing of antibiotics for viral respiratory tract infections is common and contributes to emerging antibiotic resistance and patient morbidity and mortality. Interventions aimed at promoting judicious use of antibiotics, such as prescribing guidelines, are often ineffective. Approaching the problem of overprescribing from new perspectives is key to making progress towards more effective antimicrobial stewardship. Exploring characteristics shared between patients and providers, attitudes of new antibiotic stewards, and the role of prescribing on subsequent use offer opportunities to better understand antibiotic stewardship and overprescribing at a time when new perspectives are needed to inform better interventions.

This dissertation contains three studies that incorporate novel perspectives to investigate the patient, provider, and practice factors that promote judicious use of antibiotics and solicit a better understanding of the current state of stewardship from future antibiotic stewards. Study 1, A Qualitative Study of the Knowledge and Attitudes of Infectious Disease Fellows, sought to understand the attitudes and beliefs of infectious

disease fellows on the front line of antibiotic stewardship. Fellows highlighted the importance of formal and informal education, explained the challenges faced when practicing stewardship, and suggested improvements to fellowship programs to encourage better antibiotic stewardship training.

Study 2, Patient-Provider Race and Sex Concordance in Prescribing, explored how race and sex concordance between patients and providers predicted overprescribing. Results showed that racial concordance was one of the most important predictors of overprescribing, suggesting that concordance can be more important to the prescribing outcome than some clinical indicators and that improving cross-cultural communication may be a way to combat overprescribing.

Study 3, Early Prescribing Behavior as a Predictor of Future Antibiotic Exposure and Resource Utilization, described how the decision whether or not to prescribe antibiotics at a child's first acute bronchitis visit affected that child's likelihood of returning for an additional acute bronchitis complaint and being prescribed an antibiotic. The results of this study suggested that the prescribing behavior of providers can affect future visits and subsequent prescribing.

## TABLE OF CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

## LIST OF ABBREVIATIONS

CPT ..... Current procedural terminology

EMR ..... Electronic medical record

GI ..... Gastrointestinal

HMO ..... Health maintenance organization

ICD-9 ..... International Classification of Diseases, Ninth Revision

ID ..... Infectious disease

IDSA ..... Infectious Disease Society of America

MSA ..... Metropolitan Statistical Area

NAMCS ..... National Ambulatory Medical Care Survey

NHAMCS ..... National Hospital Ambulatory Medical Care Survey

NICU ..... Neonatal intensive care unit

OR ..... Odds ratio

POS ..... Point-of-service

PPO ..... Preferred provider organization

RR ..... Risk ratio

RTI ..... Respiratory tract infection

# CHAPTER ONE: REVIEW OF THE RELEVANT LITERATURE

## Overview: The state of antibiotic prescribing

Overprescribing of antibiotics is widespread, and continues to persist despite substantial research and efforts to improve practice (1–5). The consequences of overprescribing – prescribing an antibiotic when it is not clinically indicated – range from large community-level effects such as antimicrobial resistance or burdensome costs, to patient-level effects such as treatment failure, morbidity, and mortality (6, 7). Antimicrobial resistance in particular can have wide-reaching effects by making infections more difficult to cure in the future. Resistant bacteria such as *Streptococcus pneumoniae* resistant to penicillin and macrolides or *Staphylococcus aureus* resistant to oxacillin are increasingly causing community-acquired infections (8, 9). To better address the threat of antibiotic overprescribing and encourage judicious use of antimicrobial agents, this dissertation aims to understand how important patient, provider, and practice factors interact in the prescribing process and how this knowledge can be leveraged to inform more effective stewardship interventions.

### The need for stewardship

Antibiotic stewardship efforts are crucial to protect the usefulness of lifesaving antibiotics and prevent increased patient morbidity. Overuse of antibiotics has been definitively linked to resistance, and pathogen resistance to an antimicrobial renders the treatment less effective or useless and can fail to cure the infection (10–18). In addition to resistance, overuse of antibiotics can have other negative consequences for the patient. Antibiotics can negatively affect the bacterial flora in the gastrointestinal (GI)

tract, triggering GI related side-effects (19). In adults, antibiotics can cause mild to severe diarrhea, particularly dangerous for the infirm or elderly, and when caused by the *Clostridium difficile* pathogen, can be life threatening (20). Children may experience additional side-effects, as they tolerate antibiotics differently (for example non-*Clostridium difficile* diarrhea happens in 50% of children exposed to amoxicillin-clavulanic acid and is much less common in adults) (21). Compared to adults, the rate of overprescribing has fallen in pediatric populations thanks to effective interventions (22, 23). However, the rate still remains unacceptably high. The persistence of overprescribing and its detrimental effects create a need for more intensive antibiotic stewardship efforts to promote the judicious use of antimicrobial agents.

**Predicting overprescribing**

The first step in developing effective interventions to curb antibiotic misuse is to understand the prescribing process – what factors predict prescription of an antibiotic when it is not necessary. Previous literature has described many factors associated with antibiotic prescribing (24, 25). In this dissertation I focus on how better understanding the prescribing process and stewardship can present opportunities for innovative interventions. Specifically, I examine the role of patient and provider race concordance; explore how repeat visits influence, or are influenced by, antibiotic prescribing, and examine the attitudes and beliefs of infectious disease (ID) fellows towards antibiotic stewardship. A better understanding of these predictors can help inform the creation of customized, effective interventions.

Race and prescribing

Numerous factors have been found to be associated with antibiotic prescribing in the literature, and the race of the patient is a common demographic control variable included in predictive models alongside other characteristics such as age and sex (26). The results of these studies have been mixed, where some found non-white patients more likely to be unnecessarily prescribed an antibiotic for a respiratory tract infection (RTI) (27–29), others found them to be less likely (24, 30–38), and some studies failed to find any association (25, 39–43). However, there has been very little discussion of why race was included, or what the association between race and prescribing means. For example, one study included race as an *a priori* variable of "clinical significance" but failed to explain why race was clinically important for antibiotic prescribing of acute RTIs and did not present the predicted effect of race on prescribing (44). More research is needed to understand the exact way in which race affects prescribing and to directly explore the reasons behind such an association.

The most common finding regarding patient race and prescribing in the literature has been that minority patients are less frequently prescribed antibiotics. For example, a study using data from the National Ambulatory Medical Care Survey (NAMCS), a nationally representative database of outpatient visits, examined trends in prescribing for acute cough in patients over 14 years (37). The authors found that white patients had 1.75 times the odds of receiving a prescription for an antibiotic compared to non-white patients, one of the larger effects in the predictive model (37). The authors, however, did not comment on the effect of race, noting only that "[t]he

association of certain patient characteristics with the increased use of antibiotics by primary care physicians suggests that there may be important nonclinical barriers to promoting more judicious use of antibiotics" (37). Previous research which has found that non-white patients are less often prescribed antibiotics for RTIs has been corroborated by single-site or regional studies in the South (36), the West (32), the Northeast (24, 30, 31), and the Midwest (30), as well as in other national-level analyses (33–35, 38, 45).

On the other hand, there is also evidence for minority patients being *more* at risk for being overprescribed antibiotics, although this is less common in the literature. For example, one small study (n~500) found evidence that minority race led to more prescriptions, but in multivariable analysis only Latino and Asian parents had significantly greater expectations for antibiotics and the differences in actual prescribing rates failed to reach statistical significance (27). A second study was substantially larger, but based in Taiwan, where the minority group (Aborigine) may not be comparable to the U.S. (28). That study found minority patients had 1.09 greater odds of receiving a prescription for nasopharyngitis, upper RTIs, or acute bronchitis. Additionally, a larger study found that geographic regions with larger shares of black residents were more likely to have higher rates of antibiotic prescribing, but this study did not control for any other factors, such as region of residence which may have biased the results (29) (for example the South has a higher share of black residents and providers from that region have been found to prescribe more on average independent of patient race) (46, 47).

Finally, another group of research studies failed to find any relationship between race and prescribing. For example, a study combining NAMCS data with National Hospital Ambulatory Medical Care Survey (NHAMCS) data failed to find an association between race and prescribing of antibiotics in over 20,000 visits for acute respiratory infections (25). This finding was replicated in other studies with large sample sizes, including data from Veterans Affairs' hospitals (40, 42) and nationally representative databases (43), as well as smaller, prospective studies (39, 41). Across these studies, the findings regarding the relationship between race and prescribing were mixed.

Studies that included race grouped it with other patient characteristics and hypothesized that the effect may be due to differences in patient culture and patterns of health care use (24, 27, 35). Such differences included the patient's expectations and the provider's perceptions of patient expectations (24, 30, 32), language barriers (27), or that the lower prescribing — while appropriate for viral RTIs — may suggest disparities in care (24, 30, 45). One paper suggested that there may be differential rates of respiratory tract infection between races (35). However, this was empirically refuted in the definitive study on otitis media by Paradise et al. (48) and the approximately 700 articles which cite it. Woods et al. also discussed the racial variation in prescribing for otitis media, and hypothesized several possible explanations: providers who worked predominately with minorities overall were more adherent to guidelines; providers were more adherent when treating minority children in particular; patient expectations led to overprescribing in non-minority populations; providers treating predominately minority

patients had differential exposure to pharmaceutical representatives compared to those treating majority patients; providers caring for minority patients tended to opt for cheaper visit resolutions; or structural racism (49). Testing each of these specific concepts in a single study would be exceedingly difficult as they likely overlap. An innovative methodological approach to evaluating the role of race in prescribing is needed to address conflicting results in the literature.

Studying the interaction of provider and patient race may allow us to better understand how race affects prescribing. One study of racial variation in patients' expectation for antibiotics concluded future research should investigate patient-provider racial concordance (27). Studies of race concordance – evaluating the effects when the patient and provider have matching races and when they do not – are rare in general and non-existent in studies of antibiotic prescribing for RTIs. In the literature that does exist, concordance was often interpreted as a way to include aspects of the patient-provider relationship into analyses (50). An early, seminal article studying race and gender concordance evaluated how concordance affected how physicians involved their patients in treatment decisions (participatory decision making) (50). The authors found that when patients and physicians shared the same race, patients were more likely to score the visit as highly participatory, suggesting that racial concordance was capturing elements of cross-cultural communication. Better cross-cultural communication may make it easier for providers to explain why antibiotics are unnecessary for RTIs, and perhaps make it more likely that patients will understand and believe their provider. Poor cross-cultural communication may increase misunderstanding which could erode

the patient's trust in the doctor or the health care system overall (51). Other research has also found racial variation in health literacy around antibiotics (52, 53), and effective communication is likely key to educating the patient. Given the important role of concordance found in other literature and the largely unexplained significant associations found between race and prescribing, future research should incorporate this important perspective into models of antibiotic prescribing for RTIs.

To properly examine the effect of race, future research needs to control for other important variables in the prescribing process. For example, previous literature has found that the age of the patient was associated with prescribing, with older adults (25, 54, 55) and younger children (56–58) less likely to be prescribed an antibiotic, even though guidelines often do not differ based on age (59). Other demographic factors are also important including sex, where previous research has found men less likely to be prescribed (24, 25, 60, 61), and geography, where substantial variation has been documented (62–70), such as more frequent prescribing in the Southeastern United States (29, 46, 47, 71, 72). Geographic region may indicate cultural differences (73), socioeconomic determinants (74), health education (75, 76), or some other important source of antibiotic prescribing differences. Numerous studies have found that patients with more comorbidities are often more likely to be prescribed antibiotics for viral RTIs (38, 40, 77–81), while in children early exposure to any antibiotics has been linked to *future* development of comorbidities such as asthma or eczema (82, 83). To better address the threat of antibiotic overuse, researchers need to build predictive models that comprehensively and innovatively explain the prescribing process.

Repeat visits

If a patient strongly demands an antibiotic from his or her provider, some doctors may yield to this pressure and prescribe, even when they are well aware of clinical guidelines to the contrary. Patient demand is cited by providers as a cause of antibiotic prescribing and has been verified in empirical research (84–90). For example, a study of nearly 3,500 adult patients concluded that those who expected antibiotics tended to get them (86), and interviews with U.S. providers found that while providers were aware of clinical guidelines, patient demand was the main barrier to responsible prescribing because they were worried about patient satisfaction with their care (91). The story is similar for pediatric patients. A study examining the relationship between parents, physicians, and antibiotics surveyed 610 pediatricians and found that 48% of the physicians reported that parents always, most of the time, or often pressured them to prescribe antibiotics, and 53% of them thought that parental demand was the single largest contributor to overprescribing in children (92). When patients seek antibiotics it can complicate the decision of the provider about whether or not to prescribe.

An important consequence of antibiotic seeking may be an increase in repeat visits if an antibiotic is denied. One study of 17 million upper respiratory visits found that prescribing an antibiotic for a viral respiratory tract illness reduced the likelihood of the patient returning for a second visit for the same complaint (93). The increase in repeat visits among those not initially prescribed was small (2 percentage points). However, if antibiotic-seeking is rewarded, patients may expect antibiotics for RTIs, increasing future prescribing and visits for viral RTIs (94). Consequences associated

with unnecessary repeat visits include additional opportunities to be unnecessarily prescribed, increased medical costs, and inefficient use of medical resources (93). If denying a patient an antibiotic simply results in a dissatisfied patient and repeat visits – which occupies provider time – it may be difficult for the provider to focus on the long term harms of prescribing when prescribing an antibiotic provides the path of least resistance (94). Compared to the literature on overprescribing in general, very few studies have focused on how prescribing is associated with repeat visits for similar complaints, and more research could provide better insight on the issues faced by prescribers.

Previous literature has demonstrated that provider behavior can affect antibiotic seeking behavior in patients. For example, providers may be able to educate receptive patients in order to reduce repeat visits. In general, educating the patient or parent can have a large effect on prescribing. For example, a survey at 36 day care centers in Massachusetts found that greater parent knowledge about RTIs was associated with a lower rate of antibiotic seeking in response to symptoms including clear rhinorrhea (odds ratio (OR) of 0.45), green rhinorrhea (OR=0.66), and cough (OR-0.57) (95). Large-scale interventions targeting patients have also shown some success (96, 97), and research consistently finds patients who are better educated about antibiotics and RTIs are less likely to receive an antibiotic when it is not necessary (98–100). This has important implications for populations with lower health literacy overall such as those of lower socioeconomic status (101) and non-white patients (101, 102), reinforcing the need for the effective cross-cultural communication outlined earlier in this chapter. This

education may be important for discouraging antibiotic-seeking, especially in pediatric patients, and may reduce antibiotic seeking over time. To that end, public educational interventions at the local (103, 104) and national levels (such as the CDCs "snort, sniffle, sneeze, no antibiotics, please" campaign (105)) may be an important tool to address gaps in health literacy.

Provider attitudes

Ultimately, only the provider has the ability to prescribe antibiotics, so it is important to understand the attitudes and beliefs of providers towards prescribing and how stewardship works to promote judicious use of antibiotics. Previous literature has suggested that prescribing attitudes can change over time in practice with multiple reports having found that providers more recently out of medical school – residents – prescribed more appropriately than more experienced physicians (106–108). However, many residents may be at risk for overprescribing. A survey of 182 residents across 11 primary care programs found that while over 99% believed they had a good knowledge about treatment for upper RTIs, 57% of them also thought that antibiotics should be prescribed for acute bronchitis (109). In actual practice, however, residents have been shown to prescribe less frequently than more experienced physicians. A study using NAMCS and NHAMCS found that more experienced physicians prescribed antibiotics for 34% of visits for respiratory diagnoses where antibiotics are rarely indicated compared to 21% for residents (110). These findings suggest that while recent exposure to medical education may promote appropriate prescribing relative to other physicians, there is still room for improvement, such as through education and feedback

interventions (111).

Fellows, physicians who further specialize after completing a residency in internal medicine, are more advanced than residents, but still learning from more experienced attending physicians. The Infectious Diseases Society of America (IDSA), the professional society for infectious disease practitioners, describes the goal of ID fellowship to "provide training and supervised experience at a sufficient level for the ID fellow to acquire the competency of a specialist in the field of infectious diseases" (112). Fellows gain this experience through didactic learning, direct patient contact, and other educational experiences (112). ID fellowship programs routinely include opportunities for fellows to engage in antibiotic stewardship activities as the IDSA recommends that any antimicrobial stewardship team be led by an infectious disease physician (113). In this way, infectious disease fellowship programs are training the "stewards of tomorrow," and, fellows are often specifically trained to promote antibiotic stewardship (114, 115).

A significant research gap exists regarding how ID fellows view their role in stewardship. This includes how they interact with other providers to encourage stewardship, the importance they place on stewardship, and whether they feel they have the tools necessary to promote stewardship beyond their fellowship. Because ID fellows play an instrumental role in promoting stewardship, their insights are useful for understanding how stewardship works on-the-ground and the effect this could have on intervention efforts. Key to improving stewardship is understanding the attitudes and beliefs of those who are responsible for promoting stewardship now and in the future.

**Describing antimicrobial stewardship**

According to the Association for Professionals in Infection Control and Epidemiology, "antimicrobial stewardship is a coordinated program that promotes the appropriate use of antimicrobials (including antibiotics), improves patient outcomes, reduces microbial resistance, and decreases the spread of infections caused by multidrug-resistant organisms" (116). These coordinated programs can take on different forms depending on where they are implemented and the professionals involved in the implementation. In general, there are four broad strategies for implementing antimicrobial stewardship. These strategies include education and guidelines, formulary restrictions and preauthorization, audit (or "review") and feedback, and computer assistance (115). Each strategy has unique characteristics that may be more or less effective depending on the setting, and it is possible to combine strategies for a broader approach to antibiotic management.

Education and guidelines interventions involve creating prescribing guidelines for antibiotic use and then educating clinicians as to proper antimicrobial use (117). A study of one 600-bed hospital found that total antibiotic use fell 50% following the introduction of educational lectures on proper antibiotic prescribing (118). This type of intervention may also be effective in the initial decision regarding which antibiotic to use. The introduction of guidelines and educational programs in an emergency department in The Netherlands approximately doubled the number of sputum and urine cultures obtained (28% to 50% and 50% to 100%, respectively) which had the potential to improve resistance tracking and future stewardship efforts in emergency settings

(119). This approach was also validated in a randomized control trial setting. A cluster randomized controlled trial of 24 nursing homes in the US and Canada found that education decreased the inappropriate use of antimicrobials for urinary tract infections (120). However, education alone may not be enough to change outcomes. Analysis of data from 50 intensive care units at 20 US hospitals failed to find a significant change in rates of vancomycin (a powerful antibiotic often restricted) prescribing following dissemination of the national guidelines on vancomycin use (121). A possible alternative is to combine education with another strategy. Combining education with audit and feedback has been shown to be successful, as described by a randomized controlled trial in Pennsylvania and New Jersey which found that a one hour education session followed by a year of quarterly audit and feedback reduced broad-spectrum prescribing by 12.5 percentage points (122). In a study of 1,626 patients at a Canadian teaching hospital researchers paired education about appropriate antibiotics in the surgical setting with a formulary restriction reflecting that education, leading to an increase in appropriate prescriptions from 36% to 79% (123). A step-wise intervention beginning with education followed by formulary restrictions and then by prospective audit may also be an effective way to encourage judicious use of antibiotics. Following the implementation of this intervention in a 250-bed hospital in Argentina, a large decrease in prescribing resulted in cost savings of over $900,000 paired with a rise in the proportion of all prescriptions which were appropriate from 27% to 63% (124).

Formulary restriction and preauthorization involve removing certain antibiotics from hospital formularies (formulary restriction) or requiring providers to obtain

approval before using certain powerful antibiotics (preauthorization) (113). The IDSA has found both strategies can be useful in immediately curbing the use of antibiotics (113). For example, a study of an intervention that restricted use of ceftazidime and ceftriaxone found use of those agents decreased by 95–97% and 86–95%, respectively (125). Moreover, there is evidence that this effect may be sustainable. In a study of over 1,000 infants in the NICU restricting ceftazidime led to a 96.5% reduction in use which was sustained at six months (96.1% reduction) (126). However, this sustainability may differ based on site or patient population: a study of restricting cefuroxime for over 200 elderly care units in the UK found that after one month of the intervention use was reduced by 75%, but by six months this reduction had fallen to 60% (127). Like educational interventions, it may be effective to combine these interventions with other strategies. At a major teaching hospital in Australia restricting use of cefotaxime and ceftriaxone as well as employing audit and feedback reduced the prescription of those drugs from 38 defined daily doses per 1,000 occupied beds to just under 16 (128).

In audit and feedback strategies, select antimicrobials are reviewed to assess appropriateness and the results are reviewed with either individual providers or groups of staff (113). In the outpatient setting audit and feedback often takes place at a predetermined time interval (such as quarterly audits) and frequently presents aggregate data on prescribing performance (129). In the inpatient setting, audit and feedback is concerned with individual providers and patients, and often occurs in a more targeted fashion (129). These programs are time and labor intensive (as they require an additional professional to review prescribing decision, although this is often required

for preauthorization as well), but can have profound effects. A five-month audit and feedback program instituted in a hospital with 1,100 beds resulted in a 27% reduction in total antibiotic use – due to both fewer antibiotic initiations as well as shorter durations – without negatively affecting patient outcomes (130). However, the effectiveness of audit and feedback may be conditional on how regularly the review is conducted. A study of 55 ICUs where drug use was reviewed "periodically" failed to find a significant change in vancomycin use, even when combined with education (121). However, the lack of details about the audit and feedback intervention in the study suggests that it may not have been implemented across the sites with high fidelity, which could have biased the observed effect (131). For example, another study combining education with audit and feedback in Norway involved giving structured written and oral feedback to providers every three months, and over the course of the 4-year combined intervention, antibiotic use was reduced by 50% (118). Audit and feedback can be a powerful tool to educate and train providers, but requires careful thought about implementation compared to a restriction-based strategy.

Finally, computer assistance involves leveraging electronic health records and computerized provider order entry platforms to guide physicians to order the correct antibiotic with a series of prompts and other pop-ups (115). One vignette study found an 11.5 percentage point reduction in aggressive antibiotic treatment such as the use of broad-spectrum antibiotics depending on the way prescribing options were presented in the electronic health record (132). However, other researchers have also cautioned that over-reliance on computerized prompts can work against educating providers to the

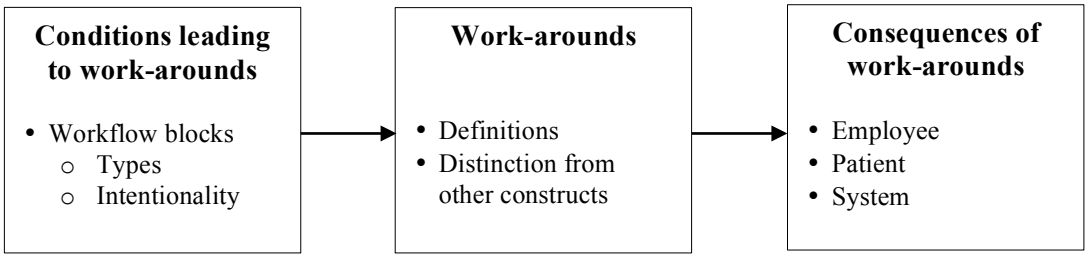
disadvantages of overprescribing (133). In an effort to combat MRSA infection rates, a Veterans Affairs hospital used a computer pop-up to discourage providers from prescribing fluoroquinolones. As a result, fluoroquinolone use dropped 34%, however use of other antibiotics such as cephalosporins increased (134). It may be useful to combine computer assistance with other strategies. A major academic, urban medical center in Ohio found that implementing electronic order forms for uncomplicated urinary tract infections in the emergency department increased guideline adherence from 44% to 68%, and then rose further to 82% after adding the audit and feedback strategy (135).

**Conceptual framework**

A conceptual model to understand what factors inform the prescribing decision is at the core of this dissertation. By combining the Cabana model (2) explaining physician noncompliance with clinical guidelines and Halbesleben's organizational theory explaining provider behavior (136), I created a comprehensive conceptual model to understand how patient, provider, and practice factors interact in the prescribing process.

The Halbesleben model defines work-arounds in the health care setting while differentiating them from related, but distinct, constructs (136). The authors defined the work-around from previous literature as "work patterns an individual or a group of individuals create to accomplish a crucial work goal within a system of dysfunctional work processes that prohibits the accomplishment of that goal or makes it difficult" (136, 137). The conceptual model of work-arounds is presented in Figure 1.1. The

**Figure 1.1**: Halbesleben conceptual model of work around. Figure adapted from Halbesleben et al. (137).




authors examined the conditions leading to work-arounds, work-arounds themselves, and the consequences of work-arounds. Halbesleben et al. frame conditions leading to work-arounds as blocks to workflow. The authors identified several different types of blocks, which were characterized as institutional (protocols, administrative blocks) or individual (the people involved). For example, an institutional block may be an administrative form, which a provider believes is unnecessary and delays him or her from visiting with a patient. These blocks can be intentional or unintentional. In the above example, if the administrative form is a safety checklist meant to slow the provider down so he or she can think about the upcoming visit, the block is intentional, because it is meant to encourage thoughtful consideration and protect patient safety. On the other hand, if the purpose of the form is to bring the provider up to date on the patient's conditions and speed up the visit, the block is unintentional because it was meant to promote efficiency but instead slowed the provider down.

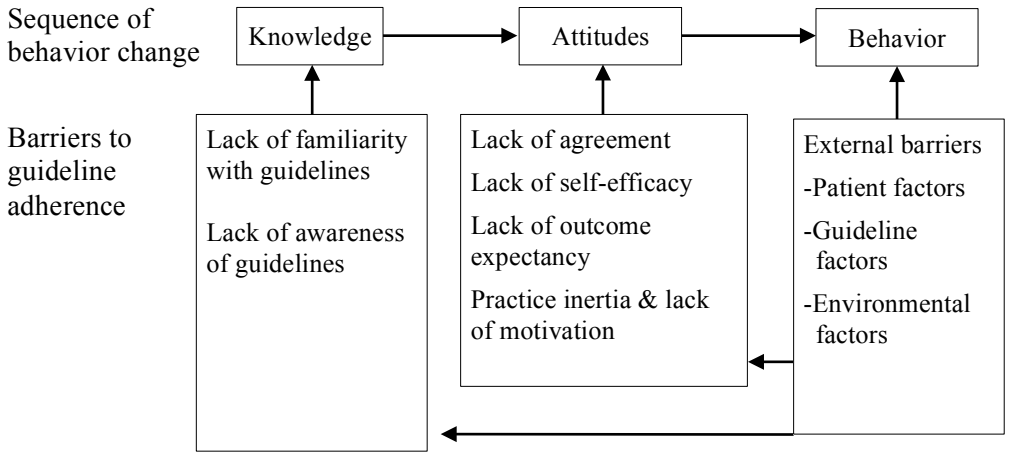
**Table 1.1:** Work arounds and related constructs

| Behavior | Description |
|---|---|
| Work-around | Deliberate, non-malicious, response to some external stimuli in order to achieve a desired outcome |
| Error | A mistake leading to an unintended outcome |
| Deviance | Deliberate action primarily for personal gain |

Next, the authors defined the concept of the work-around by contrasting it with similar constructs (Table 1.1). Halbesleben first defined error, where the outcome is unintended and accidental. In work-arounds, an individual consciously chooses to violate the established work process in order to achieve some goal. Next, the construct of deviance is similar to work arounds in function – deliberately violating the established work process – but differ in motives. Deviances generally tend to be self-serving (136) whereas for work-arounds the motive is simply to complete a desired task. Finally, work-arounds produce consequences, which can either be positive or negative (136)(Figure 1.1). Employee satisfaction can be affected by work-arounds, either positively if the work-around makes the job easier or negatively if the work-around is seen as a hassle. Patients may be negatively affected if the work-around circumvents safety protocols and leads to an increase in medical errors. Finally, work-arounds can affect the system if one work-around leads to more work-arounds if employees see them as acceptable. Ascertaining these consequences is important to assess whether the change in workflow should be stopped or whether it is an effective solution to delivering positive results in the face of workflow blocks.

Cabana et al. proposed that a collection of barriers stand between providers and guideline adherence (Figure 1.2). These barriers affect physician knowledge of, attitudes towards, and behavior in relation to guidelines (2). First, lack of awareness and lack of familiarity are barriers to a physician's knowledge of a guideline. It is possible that a physician is simply unaware of the existence of a guideline, so cannot adhere to it. Even if a physician is casually aware of a guideline, they may not be

**Figure 1.2**: Cabana model of barriers to physician adherence to practice guidelines. Figure adapted from (2).




familiar enough with the recommendations to correctly apply the guidelines (2). Next, the authors outlined four barriers to positive attitudes towards the guideline: lack of agreement, where physicians who disagree with a guideline are less likely to follow it; lack of self-efficacy, where physicians believe they are unable to adhere to the guideline; lack of outcome expectancy, where physicians do not believe that the guideline will yield the desired outcome; and inertia of previous practice, where physicians may not have sufficient motivation to change ingrained practices. Finally, the authors note that "appropriate knowledge and attitudes are necessary but not sufficient for adherence" (2). External barriers can still challenge a physician's ability to follow guidelines, including patient, environmental, guideline, and practice factors.

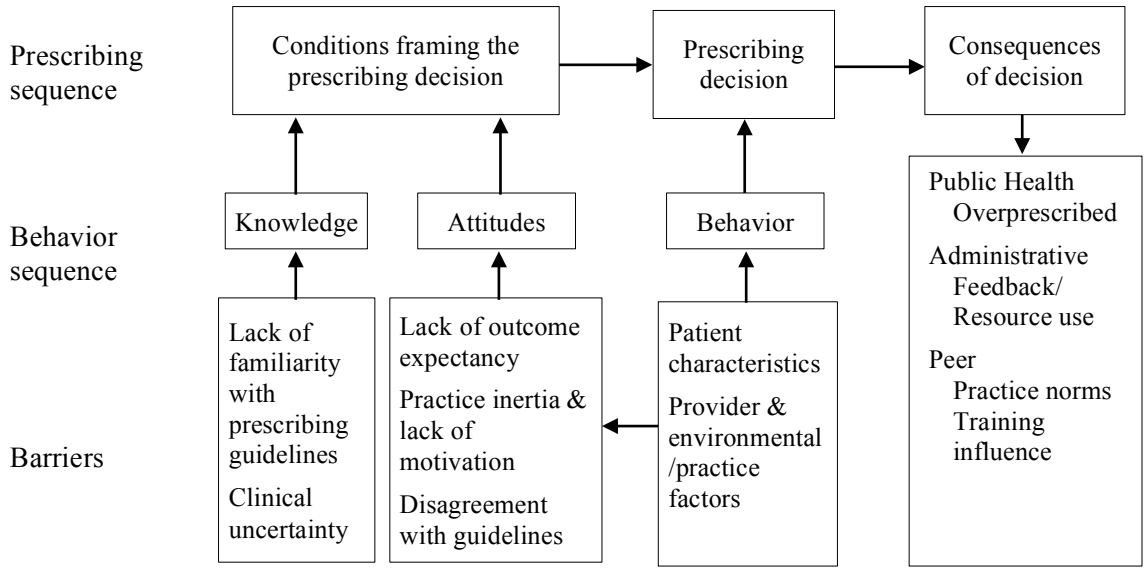
The models described by Halbesleben and Cabana are useful stand-alone models to describe certain health services questions, but do not fully explain prescribing alone. Halbesleben's model lacks details of what barriers prevent guideline adherence, and the

Cabana model does not address the consequences of guideline non-adherence. To address those limitations, I created a combined model of the prescribing process.

The conceptual model

Incorporating elements of Cabana and Halbesleben's theories of physician behavior yielded my conceptual model, presented in Figure 1.3. The model is organized as a prescribing sequence of three distinct domains: how the prescribing decision is framed by the provider (what influences how the provider thinks about prescribing in general); the actual prescribing decision (whether or not the provider prescribes an antibiotic at a visit), and; the consequences of the decision to prescribe or not to prescribe an antibiotic. This dissertation will use the conceptual model to examine stewardship and the consequences of overprescribing. These domains are described in detail below.

**Figure 1.3**: Conceptual model



Conditions framing the prescribing decision: knowledge and attitudes

The conditions framing the prescribing decision are informed by the workflow blocks Halbesleben et al. characterize as either institutional or individual (136). In the context of prescribing, institutional blocks could include unclear guidelines or administrative policies that deliberately discourage judicious antibiotic use (136). However, this seems unlikely. While this may exist in some facilities, stewardship programs are established in part to make such guidelines clear and promote their implementation (113). Many of the barriers or blocks described by Cabana et al. are related to provider knowledge and attitudes, which would imply workflow blocks are individual rather than institutional (136). If blocks to workflow are individual, this may suggest that directly engaging with what providers know about stewardship and how they think about judicious antibiotic use can be important for promoting proper antibiotic use.

Regarding knowledge, if a provider is unaware of a particular guideline, or unaware of its applicability to a certain diagnosis, this is a barrier to appropriate care (Cabana defines this as "lack of familiarity" and "lack of awareness," respectively (2)). Also important to the prescribing process is clinical uncertainty – a provider might be concerned that a patient with a nonspecific upper respiratory infection has an underlying bacterial infection. Both are important for framing how a provider thinks about prescribing. If a provider is cautious, he or she may be less comfortable trusting his or her own diagnosis of a viral RTI, resulting in a higher propensity to prescribe "just in case." And if a provider has no knowledge of a certain guideline, they will not

be in a position to carefully contemplate the issue.

Attitudes also contribute to how a provider thinks about stewardship and the prescribing process, and are influenced in part by knowledge. Perhaps a provider is aware of the guidelines regarding antibiotic prescribing and viral respiratory infections but disagrees with them. This disagreement would prompt the provider to work-around the guideline and prescribe anyway. Alternatively, the provider could broadly agree with the guidelines, but deem them unimportant (Cabana's "lack of outcome expectancy"). This is especially relevant for antibiotic overprescribing where the primary consequence is bacterial resistance. If a provider does not expect this to be a major problem, or values it less than the potential possibility (however small) that he or she missed a bacterial diagnosis, then the provider will prescribe an antibiotic. Finally, pure inertia may play an important role in prescribing; providers who have been practicing the same way for many years see little impetus for change, particularly with a lack of immediately observed negative clinical outcomes accompanying their prescribing behavior.

The prescribing decision

The actual prescribing decision – deciding to prescribe or not to prescribe an antibiotic – is the behavior of interest. It is here that Cabana et al. observe that while provider knowledge and attitudes drive behavior, external barriers such as patient and environmental factors are relevant as well (2). Patient factors can include explicit demand for an antibiotic, and environment can include a busy clinic with little time for each patient encounter. There may also be interactive effects between patient, provider,

and practice factors, such as cross-cultural communication (patient race or provider race may modify the effect on prescribing). In this dissertation I am narrowing my focus to how these factors influence the decision to prescribe when it is unnecessary – overprescribing.

Consequences of the prescribing decision

My proposed model presented above extends the Cabana model by including the consequences of the prescribing decision. Each of the outlined consequences could apply to prescribing or not prescribing. For this dissertation I focus on overprescribing, the consequences of which are especially important when seeking to understand why overprescribing is so prevalent: if providers see no negative consequences of overprescribing when it is easier (either clinically or in terms of patient satisfaction), it may be more difficult to institute change. However, any consequences that the provider does observe – increasing resistance among patients' bacterial infections or a patient who was correctly not prescribed returning for care – can directly lead back to knowledge and attitudes. I conceptualize the consequences of prescribing as related to *public health* if the patient was overprescribed, *administrative* if the provider faces feedback or performance critique based on prescribing habits, and *peer* if a provider's standing among his or her peers is affected by his or her prescribing (Figure 1.3). If the consequences are negative, this implies overprescribing is harmful and effort should be made to end it. If, however, prescribing is seen as beneficial in achieving desirable outcomes at minimal cost, then the consequences may encourage providers to keep prescribing. While my literature review of unnecessary antibiotic prescribing has

demonstrated it is clearly harmful, providers engage in the practice in order to achieve some outcome they view as beneficial; more work is needed to understand what these desired outcomes are and how best to combat overprescribing.

**Summary and dissertation aims**

Significance of the research

The introduction of antibiotics fundamentally changed the battle against infectious disease, shifting from a paradigm where treatment was limited in availability and effectiveness to ready access to life-saving drugs. However, antimicrobial resistance threatens medical advances in this area, creating untreatable and fast-spreading "super bugs" (8). Literature has demonstrated that resistance to antibiotics is associated with worse health outcomes, longer hospital stays, and higher mortality (138). This dissertation will inform the urgent public health efforts that are needed to better understand stewardship and prescribing in order to slow the emergence of resistance.

Unnecessary use of antibiotics is the driving force behind the increase in bacterial resistance (139), but while surveys of physicians have found that they understand the threat of resistance, they are opposed to any restrictions on their own practice (140). However, despite the familiarity with guidelines over 50% of antibiotics given to patients with an upper RTI are inappropriate (60, 141). Findings from the literature suggest that effective and sustainable improvements in prescribing are not possible without a comprehensive understanding of the driving forces behind prescribing behavior.

A lack of understanding about the attitudes and beliefs of prescribers may contribute to the ineffectiveness of many stewardship interventions that do not incorporate suggestions from those working in the environment. One method to better understand antibiotic prescribing and stewardship as well as the challenges to good prescribing practices is to directly engage with prescribers through qualitative interviews (60, 142). Previous qualitative research generated several hypotheses to explain physician noncompliance with prescribing guidelines, including that providers were likely to follow the lead of their peers (143), providers did not see many of the negative consequences in their patients' (144), and that, within the field, the immediate risks of missing an unlikely diagnosis outweighed any risk from overprescribing (145). But there are no studies exploring the attitudes and beliefs of providers at the frontline of stewardship efforts, infectious disease fellows (113). These providers may have unique insights into how stewardship works and can be improved as they are among the most involved with day-to-day stewardship.

The threat posed by overprescribing has led to intervention efforts by the federal government (141) as well as state and academic establishments (146) – so far to limited effect (147). Many major interventions to date have focused on large-scale educational campaigns to inform providers and patients of current clinical guidelines, and interventions combining multiple approaches are less common. To reverse this trend, more research is needed to approach stewardship and overprescribing with innovative methods and measures. The conceptual model supporting this dissertation contextualizes the research by acknowledging that genuine lack of knowledge is often

not at the root of overprescribing and, indeed, focusing exclusively on education of providers misses the barriers and behaviors that are part of prescribing. In three distinct papers I explore new perspectives – including testing the effect of race concordance on prescribing, interviewing infectious disease fellows, and evaluating the effect of prescribing behavior – to better understand the prescribing process and to inform new interventions to more effectively promote the judicious use of antibiotics. Without thoughtful and innovative empirical investigation, future stewardship interventions are not likely to improve.

Dissertation structure

The unifying motivation of this dissertation is to explore, in a novel way, stewardship and overprescribing for RTIs, answering the question: **What patient, provider, or practice factors promote judicious use of antimicrobial agents and how can insights from future stewards increase our understanding of the current state of antibiotic stewardship?** Below I describe the goal of each paper:

Paper 1. Examine the knowledge and attitudes of current ID fellows towards stewardship to understand how they perceive their role as antibiotic stewards;

Paper 2. Determine patient, provider, and practice characteristics associated with unnecessary prescribing at the time of the visit including the role of patient-provider race and sex concordance; and

Paper 3. Assess the long-term consequences of overprescribing by studying how a provider's decision to prescribe antibiotics at a child's first encounter for acute bronchitis affects the likelihood of a future encounter and prescription.

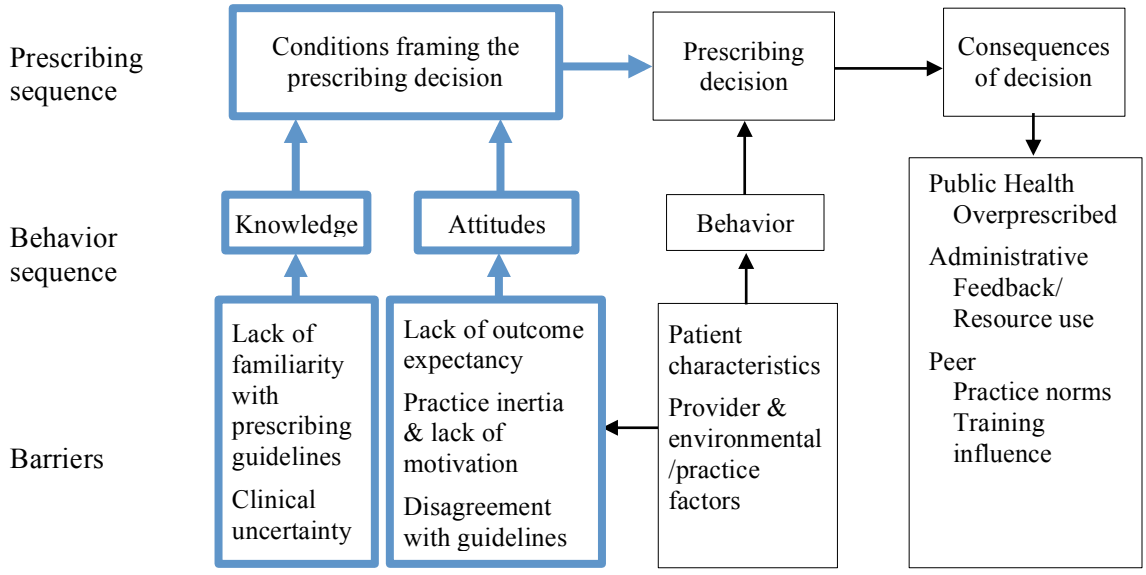
Together, these studies will test how my conceptual model adds to the understanding of the complex prescribing process, specifically related to the phenomenon of overprescribing, and how stewardship functions in a real world setting. This dissertation will touch on each distinct point in the prescribing sequence from the attitudes and beliefs of providers around stewardship, to the determinants of overprescribing at the time of a visit, and how prescribing can affect future visits and prescribing. Following the three papers, I will conclude with a discussion of what my findings mean for future interventions and how the research community can continue to explore solutions to the current crisis of bacterial resistance due to unnecessary antibiotic prescribing.

# CHAPTER TWO: A QUALITATIVE STUDY OF THE KNOWLEDGE AND ATTITUDES OF INFECTIOUS DISEASE FELLOWS – REAL WORLD EXPERIENCES OF ANTIMICROBIAL STEWARDSHIP

## Summary

A key component of promoting stewardship is to understand the knowledge, attitudes, and beliefs of the stewards of the future: fellows working with and around antimicrobial stewardship. Specifically, this chapter will use qualitative research methods to examine the knowledge and attitudes of current ID fellows towards stewardship to understand how they perceive their role as antibiotic stewards. Findings from this chapter will describe how antibiotic stewardship functions "on the ground" and how fellows see their role as stewards as well as informing a framework for effective ways to promote antibiotic stewardship.

**Figure 2.1**: Conceptual domains of Chapter 2



The conceptual domain addressed in this study is bolded in Figure 2.1. I use this qualitative study to more thoroughly explore stewardship by soliciting the perspectives of current ID fellows. Through their perspectives I explored how stewardship is taught to and learned by fellows, and how that education is spread to other medical services to impact the prescribing process. The fellows discussed the benefit of proper stewardship and any barriers to stewardship such as organizational inertia that they experienced.

**Research question**

The goal of this chapter is to examine the knowledge and attitudes of current ID fellows towards stewardship to understand how they perceive their role as antibiotic stewards.

**Background**

There is a substantial body of quantitative literature describing the unnecessary use of antibiotics and the factors associated with that misuse (147). However, antibiotic use for RTIs remains stubbornly high (24, 25). Interventions designed to address overprescribing often fail for reasons we do not fully understand. For example, one group used information from previous studies to create an intervention involving persuasive communication to improve antibiotic management of uncomplicated upper RTIs, but this intervention did not alter the intention of the providers to prescribe antibiotics (148). However, like other literature documenting failed interventions, there was no in-depth communication with those providing the persuasive communication either before or after the intervention. That information could have provided insight into why the intervention did not work and inform future, more effective interventions. Indeed, compared to quantitative studies, qualitative explorations of antibiotic prescribing are rare. Yet a

systematic review of qualitative studies of antibiotic prescribing concluded that antibiotic prescribing was a "complex process" involving multiple factors and suggested that further qualitative exploration is necessary and would be beneficial (6). One benefit of qualitative research is better understanding the attitudes and beliefs behind the actions of physicians and their effect of the practice environment to inform future interventions. Interventions that are unsuccessful at changing behavior may be improved by asking providers directly their opinions of stewardship and the largest barriers to proper prescribing. By exploring the context and challenges faced by those tasked with supporting an intervention, qualitative techniques can inform future interventions that better reflect the realities in the work environment.

In a large medical center, the responsibility of promoting proper antibiotic use often rests with the Department of Infectious Diseases, and specifically the ID fellows. However, there are no published qualitative studies of ID fellows' perspectives on stewardship, even though these fellows may have the best insight into how antibiotic stewardship is promoted at the facility and what hampers proper use. Instead, existing qualitative studies focus on the non-ID providers who are targeted by antibiotic stewardship programs (6). By soliciting insight from ID fellows I can better understand the role of stewardship in the hospital, how stewardship is communicated to other medical services, the challenges faced by fellows shouldering the burden of promoting judicious antibiotic use, and what role their commitment to the importance of stewardship might play in their future practice.

## Methods

### Instrument development

Review of the literature as well as prior work on the subject (24) informed the creation of a semi-structured qualitative interview guide (Appendix A). The guide included questions and probes related to the primary research question seeking to understand the knowledge and attitudes of future stewards and explore the aspects of the fellowship that best promote stewardship. Questions addressed the responsibilities and day-to-day routines of the fellows, their interactions with other providers, and general thoughts on antibiotic stewardship, their future careers, and potential improvements in their own fellowship program around antibiotic stewardship. I created the interview guide with input from the research team and pilot-tested the guide with an ID fellow at a safety-net hospital. Following pilot-testing, the guide was updated to include new questions generated from the pilot interview, the structure was re-organized for better flow, and several questions were rewritten to improve clarity. The Boston University Medical Center Institutional Review Board approved the research.

### Recruitment

Fellows were recruited through email. The director of the ID fellowship at a large urban teaching hospital sent information regarding the study to other fellowship program directors across the country and asked them to forward the information to their respective fellows (see Appendix A). Any interested fellows were directed to email the study interviewer. The only criteria for inclusion were that the individual was a current ID fellow and another fellow from the same state had not already been interviewed.

My goal was to interview the fellows to gain a deeper understanding of their experience. I used iterative sampling, soliciting an interview from a different fellow from a different state until I reached saturation, where no new information or themes emerged from the data, which occurred after 17 interviews.

Data collection

Fellows who agreed to participate scheduled a time at their convenience for a 30-minute audio recorded telephone interview. The interviews took place between December 2014 and June 2015. Fellows were assured that their participation would be kept confidential and were given a description of the study prior to the interview. To protect fellow confidentiality the IRB granted a waiver of documentation of consent and gave permission to obtain verbal consent only so that no identifying information was solicited during the recording. Interviews lasted an average of 37 minutes, with a range from 28 to 50 minutes. Each fellow was compensated with a $50 gift card for his or her time.

Data analysis

Interviews were transcribed verbatim and after each interview was transcribed, the recording was reviewed again and the transcription checked for accuracy. Grounded theory was used to analyze the data (149). This method included an inductive analysis of the transcripts to extract theory from the data through a systematic analysis of each interview (150). To generate themes from the data, two members of the study team first independently reviewed the initial two transcripts to identify emergent concepts. The transcripts were reviewed line-by-line to describe important quotations and passages by conceptually grouping them. I developed codes from these concepts, coded the initial two

transcripts, and then met with a member of the study team to explore how well each concept categorized information, to add new codes where needed, and to revise the definition of each code as necessary. Through this process of refining existing categories, the resulting codes better reflected the data and I obtained consensus for the coding scheme. This yielded a comprehensive codebook containing all codes and definitions that could be used to code future transcripts. Using this codebook I coded the subsequent 15 transcripts independently.

**Results**

Fellow characteristics

I interviewed a total of 17 ID fellows from 17 states across the U.S. between December 2014 and June of 2015 (Appendix A). The characteristics of the final study sample are described in Table 2.1. My sample included twelve men and five women. The majority identified as white, two identified as Hispanic, and four fellows identified as Asian. The range of time in fellowship was between one and three years, and most interviewees were in their second or third year of fellowship.

**Table 2.1** Characteristics of Infectious Disease Fellows

| Gender | *n* | % |
|---|---|---|
| Male | 12 | 71% |
| Female | 5 | 29% |
| Race/Ethnicity | | |
| White | 11 | 65% |
| Hispanic | 2 | 12% |
| Asian | 4 | 24% |
| Region | | |
| Northeast | 4 | 24% |
| Midwest | 4 | 24% |
| South | 5 | 29% |
| West | 4 | 24% |
| Year in Fellowship | | |
| 1 | 4 | 24% |
| 2 | 11 | 65% |
| 3 | 2 | 12% |

Summary of findings

The results of the analysis are presented in four distinct thematic categories that work to further our understanding about the attitudes and beliefs of ID fellows and how

stewardship works: (1) how antibiotic stewardship is taught and learned in the fellowship, (2) the role of the fellow in promoting stewardship, (3) how their stewardship role involves interactions with other providers and pharmacists, and (4) fellows' suggestions as to what would improve the fellowship program antibiotic stewardship training.

How antibiotic stewardship is taught and learned in the fellowship

For all fellows interviewed, there was a distinction between actual clinical experience and fellowship tasks versus didactic learning through classes or seminars. By and large fellows referred to this distinction as "informal" versus "formal" education. Examples of formal didactic education include morning conference, a short "crash course" before the start of fellowship, or a national antibiotic conference. Informal education encompassed daily clinical responsibilities such as consulting with other providers or dispensing prescribing advice. All fellows also agreed that informal education was by far the most dominant form of education because, as one fellow put it, "I feel like antimicrobial stewardship itself is kind of a part of what we do on a daily basis." One fellow summed up the importance of informal education:

> "We have random lectures about stewardship […] but given the volume I think given the amount of work we have especially the antibiotic approvals of course in the process when you're doing ID consults I mean it's part of it so it's sort of a given you'll just learn it while you're working."

And another fellow noted that while "we get some training as far as didactics during our fellowship", "most of that quickly becomes "how do we, along with our attending physicians, commonly use this antibiotic in clinical practice."

Didactics were seen as most valuable at the very beginning of the fellowship experience in order to lay the "groundwork" for later clinical experience. One fellow thought that early didactics were "absolutely essential" in order to be in the position to "ask clinical questions about the finer points of which drug you're using." Another echoed this sentiment emphasizing the importance of didactics in conveying a baseline of knowledge, a "general awareness" not just for ID fellows, but for other medical providers in the hospital. Only one fellow thought the entire enterprise of antibiotic stewardship education was fruitless, remarking "I don't think education works very well, unfortunately. I wish it did. I mean I think I think at the end of the day what you need is top-down heavy-handed control." This fellow may have been referring not to his own education but rather the value of educating other clinicians, which he may be interpreting as less effective than simply taking charge with formulary restrictions or other top-down control mechanisms.

The role of the fellow in promoting stewardship

Fellows defined their role in two main ways. First, fellows described how stewardship fit into fellowship and stewardship shaped their role as fellows. While many fellows stated that antibiotic stewardship flowed through most of what they did, this expressed itself in different ways, including in interactions with other providers and independent research. Second, fellows described how their stewardship role was often a burdensome aspect of the fellowship, especially when they were required to carry an antibiotic pager for long periods of time.

*Stewardship in the fellowship*

When beginning fellowship, fellows were faced with two primary roles: (1) responding to antibiotic pages and (2) serving as consults for other medical services. The emphasis on these roles varied between programs as well as across years of fellowship.

All fellows worked at a hospital that used restriction as a form of antibiotic stewardship, some with a single restricted antibiotic and some with so many fellows need to carry around a list of them all. In some cases, restricted antibiotics were approved by the pharmacy, but in the majority of programs fellows were the gatekeepers of restricted antibiotics and carried a special antibiotic approval pager to handle these requests. This responsibility rotated among fellows, and first-year fellows tended to cover the pager more often than second- or third-year fellows.

Consulting for other medical services on the use of antibiotics or other ID topics was the primary clinical work of the fellows. These experiences ranged from highly cerebral, where fellows were able to solve a mystery to correctly diagnose a disease or propose an effective treatment course, to exercises in antibiotic approval from physicians who already knew what they wanted and expected the fellow to approve the request without much independent thought. Most consults were in between these scenarios, and several fellows gave similar examples of consults that focused on de-escalation of antibiotics (switching from a broad- to a narrow-spectrum antibiotic for example) or suggesting the proper approach for deciding on antibiotic treatments e.g., for urinary tract infections or methicillin-resistant *Staphylococcus aureus*. Another common consult had to do with asymptomatic bacteriuria, explained by a second-year fellow in the Northeast:

> "The point is that in ID we recognize […] treating what we call asymptomatic bacteriuria, a patient who has some bacteria in their urine but has no symptoms, there's a lot of literature that says you don't need to treat that, that's not an infection, and giving them an antibiotic you know doesn't help them at all is a situation where they're treating something that wasn't really an infection, they gave an antibiotic that clearly caused harm and they want to know what else to give them and I said just don't give them anything you don't, you have no infection to treat here."

The fellow was illustrating a case where doctors had treated asymptomatic bacteriuria with trimethoprim/ sulfamethoxazole, which can have the adverse effect of contributing to renal failure, which it did in his illustration. The fellow concluded with the observation that sometimes his role is simply to "provide reassurance …in not treating something that they think may be an infection but actually isn't."

*Burden of stewardship in fellowship*

The major burden of stewardship was the antibiotic pager. Oftentimes, among those who had to carry such a pager, fellows were required to respond to pages at all hours of the night. At the facility with a single restricted antibiotic, it was rare to get a night time page as the hospital "luckily [didn't have] that many cases that were put on linezolid overnight." Conversely, a first-year fellow currently covering the pager was frustrated with the number of overnight pages:

> "[I]t's really common that most of the pages I get overnight are antibiotics [...] Here we actually have to approve it overnight which is I think not the greatest

> thing just because at three o'clock in the morning when I'm getting awakened for the 4th time that night I'm probably not providing adequate medical care."

A different first-year fellow who reported receiving between eight and ten pages for restricted antibiotics a day expressed concern that such frequent pages may conflict with other medical care, noting that it "interferes […] when you have a lot [of] consults and patients to see and you're the only one doing it." Among fellows who did not have dedicated antibiotic pagers, pharmacists tended to be the first line of approval or there were certain antibiotics that physicians could begin administering to a patient as long as they requested a formal ID consult soon after. One fellow explained the rationale of his program for not requiring fellows to carry antibiotic pagers:

> "[The program doesn't] really believe that there's a lot of true education in [having fellows carry the antibiotic pager] and first-year fellows probably don't necessarily have the knowledge to make those decisions either, it really is an attending-level decision on whether you're like giving an antibiotic or not. And particularly when they're talking about those antibiotics that we're trying to quote-unquote protect."

One fellow also noted that while pharmacists were the gatekeepers for restricted antibiotics during normal operating hours, fellows were invited to cover the antibiotic pager as an elective for those interested in stewardship. In her program, however, fellows already covered the antibiotic pager after hours, and several of her day-to-day consults were little more than requests for restricted antibiotics.

Interacting with other providers and pharmacists in a stewardship role

Interacting with others was a major part of how fellows promoted stewardship. Two types of interactions were identified: where fellows consulted with other services and encouraged stewardship directly and when fellows interacted with pharmacists and received assistance to better promote stewardship. When interacting with other services fellows either consulted in depth to select the correct antibiotic treatment or responded to antibiotic approval requests and described the successes and challenged they faced in both.

*Consulting with other services and antibiotic approvals*

One of the most important responsibilities of the fellow is to serve as a consult for other medical services. Frequently, these consults involve selecting the correct antibiotic – type, dosing, and length of therapy. Fellows described two overarching types of interactions: formal consults which often entailed earnest solicitation of advice from the fellow and antibiotic approval requests where the fellow was approached with a preconceived idea of the appropriate treatment course.

When agents are restricted and providers are required to go through ID fellows as gatekeepers tensions can grow. One fellow expressed his frustration, remarking “of the opinions that are ignored, ID typically rates number one.” Sometimes this is because residents in other services are requesting antibiotic approvals on behalf of an attending physician who has given them specific orders for antibiotics, and other times simple physical exhaustion is a culprit as one fellow explained “when I have to approve agents at night, you're not going to make any friends if you're going to be a really strict draconian.”

These exchanges, though, can also be a form of education, forcing fellows to be able to explain antibiotic restrictions:

> "sometimes [other medical services] get really angry at you when you won't give them a certain antibiotic at two in the morning, this happens a lot, and you just kind of like get used to communicating your knowledge to them. I think that prepares you for working with people later on. Some people are really mean. It does kind of test your deeper understanding of things. Like when somebody's really pushing you for something because they just don't understand […] [It] really makes you have to know what you're talking about."

At the end of the day, at many hospitals the treating physician can override antibiotic restrictions if he or she deems it medically necessary. When this occurred, fellows most often mentioned surgeons as the stubborn prescribers:

> "especially surgeons, we have a little harder time with them. […] they say 'well we'll see what we can do.' […] If they're not going to respond it's most likely to be a surgeon or an urologist."

However, even fellows who described tensions with other services were quick to point out that most interactions were positive, and that all providers were acting in the way they felt was best for the patient. In general, many services who called for consultations were genuinely seeking advice from an ID expert and, as one fellow put it, were "happy for the helping hands." One fellow described how she learned to approach other services in a "nice way" during her fellowship and discovered that many other providers appreciated it when she provided them with a rationale for different antibiotic treatment strategies. This

education by the fellow was a way to foster engagement and buy-in from the other providers, leaving them "very receptive and happy."

*The importance of pharmacists*

Clinical pharmacists are also important antibiotic stewards in the hospital. Programs that did not have a fellow carry around an antibiotic pager for release of restricted antibiotics often used pharmacists for this role; pharmacists in some programs took over stewardship roles overnight if the fellows were not on call, although this was rare. One antimicrobial stewardship program was started and wholly run by pharmacists. Beyond administering stewardship programs, the pharmacists were very involved in assisting the fellows in stewardship responsibilities. When asked if he felt prepared for the stewardship responsibilities he faced during his first year of fellowship, one fellow responded:

> "Oh no, that's why we had our trusty pharmacist. I owe her a lot of what I know now, she would tell me 'yea you gotta call them and ask them this way' and I developed my own way of telling them but I wasn't prepared before and she would say 'yea this medication is not indicated for this' and I've been learning from her a lot so without her it would be really, really, really tough. So yea, we will always have the pharmacist."

While only this fellow used the moniker "trusty," the sentiment of the pharmacist as a knowledgeable source that could help fellows answer complex questions around antibiotic choice, dosing, and duration was widespread. One fellow named the ID pharmacists the aspect he "liked most about [the] training program" regarding antibiotic

stewardship because of the insight he gained when rounding with the pharmacists as well as the ability to call a pharmacist with any sort of drug related question. In many hospitals the pharmacists also tracked antimicrobial resistance, and this was useful information for the fellows when they needed information concerning a patient. One fellow gave an example when pharmacist review of labs was useful for successful stewardship with other medical services: some surgical teams bristled at the notion of an ID doctor noticing an odd blood culture and suggesting proper antibiotics ("why is [he] reviewing [my] patients?") while this was seen as a routine and non-threatening when done by a pharmacist.

Improving the antibiotic stewardship in the fellowship program

Soliciting feedback on what fellows believe can be improved about antibiotic stewardship in the fellowship program provides useful insight. Overall, fellows were very happy to open up about the potential improvements for their fellowship program. In fact, one fellow gave that as his prime motivation for participating in the interview:

> "I've seen the potential problems associated with [antimicrobial stewardship] so I think one thing was just talking with somebody about the issues and kind of providing that feedback. This is the first time as an ID fellow that my opinion has been asked for in a study [laugh]."

This characterization of antimicrobial stewardship programs not asking for feedback was rebutted by one other fellow who commented that he felt like the program was asking about ways to improve the program "all of the time," but either way fellows were not hesitant to share their thoughts about deficits in their programs. Several fellows expressed

that while there was nothing explicit they would change in their program, they believed sharing their experiences could add to the discussion around the best way to conduct stewardship. For those with direct suggestions, two main concerns were cited: restriction policies and stewardship education.

*Updating restriction policies*

For those who had to carry an antibiotic approval pager, this pager was the primary source of burden in their daily routine and also the aspect they wanted to see changed. One fellow explained his main suggestion was to have a dedicated pharmacy team to deal with the antibiotic restriction program rather than relegating that to fellows. One fellow had a specific suggestion for the overnight pager:

> "Have a pharmacist somebody who is actually working in the hospital overnight carry the pager say 7pm until 7am or some time like that. I think that would … for the fellows I think it would help us be at our best while we're actually performing consults on a daily basis."

This fellow stated that generic clinical consults were the main, more important, task and overnight pages were so disruptive that the fellow was not able to perform as well the next day. In general, fellows agreed that pharmacists were qualified to decide whether or not an antibiotic could be approved and that carrying the pager was both non-educational and could potentially result in less appropriate care. Fellows did not mind doing tedious work, but tedious work that failed to provide either education or better clinical care was often viewed as counterproductive to the goals of antibiotic stewardship.

*Improving education*

Fellows recognized the benefit of formal stewardship education, but felt that their programs often were not committed enough to the educational aspects of the fellowship. For education, fellows felt that the other services in the hospital could benefit from structured stewardship lectures as well, with one fellow suggesting that the hospital:

> "[R]equire more of those direct interfaces with the stewardship committee in the hospital, and maybe it's on a quarterly basis or a semi-annual basis because they are certainly informative and you, you see how those discussions are happening and what the areas of focus are for the hospital committees."

This interface with the hospital stewardship committee was suggested as beneficial not only to the fellow, but to the entire hospital community as well. Other fellows commented on the potential benefit of educating all providers about the benefits of stewardship to not only improve good antibiotic use but also to improve communication and understanding between ID and other medical services. Additionally, very few fellows knew how antibiotics were selected to be restricted. Often they knew of the committee that decided such things, but were unaware of the inner workings.

**Discussion**

This study responds to recent calls in the literature for qualitative research in order to better understand antibiotic stewardship (6) and adds to knowledge about how stewardship works in a fellowship program. Fellows described the challenges they faced when practicing stewardship. Their descriptions provided a context for failed stewardship interventions documented in the literature which rarely follow-up with staff to explore

why the intervention was unsuccessful (148). Additionally, my results are useful for framing how fellows view stewardship for program directors. When asked about stewardship overall, fellows frequently interpreted stewardship to mean antibiotic restriction programs and responding to requests for antibiotics. Stewardship encompasses much more, and strategies to promoted judicious use of antibiotics include more than restrictions. The fact that fellows view stewardship in this way is an important message for fellowship program directors designing stewardship curricula.

In the interviews, fellows described the methods, related to both education and practice, they believed to be most helpful in promoting stewardship and aspects of fellowship that should be improved. This insight could be helpful for understanding how an intervention might fit into the day-to-day stewardship experience. For example, fellows addressed potential challenges to promoting the judicious use of antibiotics, describing tension with other providers who did not agree with stewardship guidelines and suggesting that some stewardship policies, such as requiring fellows to carry a pager overnight, may be so burdensome as to be counterproductive. The attitudes of the fellows about working with other specialties contribute to the understanding of how the interaction between other providers and ID fellows influences the stewardship mission. The perspective of the ID fellow has never been directly explored in this way, and provides greater understanding for how stewardship is promoted among non-ID providers (115).

This study has several limitations. I interviewed ID fellows, so any inferences are restricted to that sample. As with any qualitative study, the results are not meant to be

generalizable; instead they represent an in-depth exploration of the attitudes and beliefs of my study sample. While not generalizable, this in-depth analysis is useful for designing interventions or exploring different methods to implement stewardship programs, as this level of detail is not available in quantitative research.

Based on these results, I have four recommendations. First, fellowship programs may benefit by leveraging the aspects of the program fellows found the most valuable – complex problem-solving and working with other physicians to provide the best possible clinical care and promote antibiotic stewardship. Fellows embraced the role of stewardship and saw the responsibility of choosing the right drug, dosing, and duration as a part of the larger clinical puzzle, and enjoyed it. Dedicating more time to these sorts of tasks may encourage inter-specialty communication around stewardship. If less popular tasks such as antibiotic approval were framed as problem-solving puzzles, perhaps by encouraging dialogue during approval requests and emphasizing the importance of routine approvals to the overall goal of stewardship, fellows might see these activities as less burdensome and more effective for promoting stewardship.

Next, fellows may also be receptive to more formal educational settings, and this might help them communicate better with other providers during consults to better teach stewardship to other providers. This could mean increased cross-service seminars, or interactive classes emphasizing the importance and practice of stewardship. Education could affect more than just the fellows themselves – a good environment that promotes stewardship may address some of the interpersonal conflicts faced by fellows.

Additionally, programs may want to re-frame aspects fellows thought were most

frustrating and least useful. Fellows do not mind any task inherently, but bristle at things they view to be non-educational and unhelpful to the patient, such as answering antibiotic pages in the middle of the night. At a busy hospital where time is limited, fellows are forced to pick their battles, as one put it, and this hampers their ability to promote good stewardship. Sometimes conflict over antibiotic approvals with other services and tediousness made fellows wonder if what they were doing was "worth it" and it is likely important to emphasize those things such as positive collaboration and medical problem solving that yield vivid examples of the importance of stewardship. Part of fellowship may be to teach fellows that certain stewardship tasks, which feel tedious and unhelpful, are actually necessary. Fellowship programs may be able to communicate the message more effectively by emphasizing how these tasks benefit patient care or re-frame tedious tasks as problem solving activities to encourage active engagement on the part of the fellow.

Finally, programs may want to encourage fellow engagement in how the stewardship program is run. In my interviews, fellows wanted to provide their suggestions for a better program, and by and large enjoyed working with others to promote stewardship. Using these desires in a creative way might promote better stewardship education throughout a health care institution. For example, working with fellows to implement improvements to the program could encourage more active engagement with the institution and promotion of stewardship if fellows are invested in the success of their proposed changes. If there are specialties which are struggling to meet stewardship goals, such as reducing overprescribing, fellows could act as

ambassadors to these other providers to explain how their day-to-day responsibilities promote stewardship. If fellows want to take on responsibilities aimed at improving stewardship, encouraging them to work with other specialties – such as in special interactive seminars, or more cross-specialty rounding – could promote stewardship throughout the institution.

This study has explored the successes and challenges faced by ID fellows and my findings contribute to a more comprehensive understanding of the attitudes and beliefs of ID fellows. Future studies should aim to collect a diversity of options and specifically ask participants about the recommendations I have presented here to ascertain how relevant and realistic they are. The insights from this study can inform future research and interventions to better ensure more judicious use of antibiotics and improve clinical care.

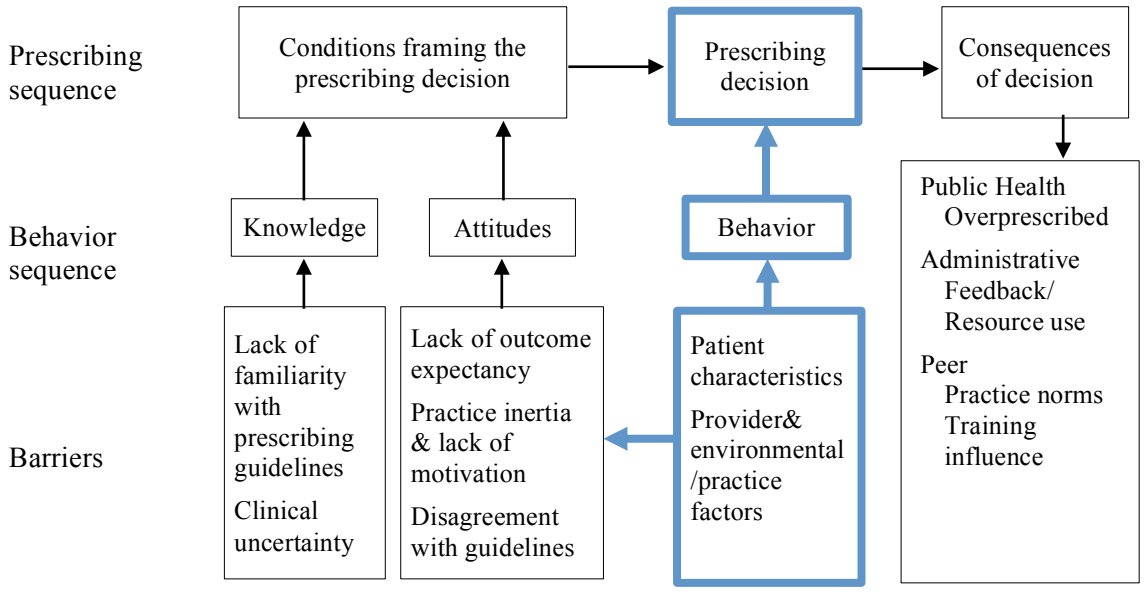
# CHAPTER THREE: PATIENT-PROVIDER RACE AND SEX CONCORDANCE IN PRESCRIBING

## Summary

Overprescribing is by far the most common form of inappropriate prescribing which leads to increased antimicrobial resistance and can increase morbidity and mortality in some patients. To model overprescribing, I conducted a retrospective analysis in a large urban hospital of prescribing rates for those diagnosed with acute bronchitis, a viral infection that does not require antibiotic treatment in healthy children and adults. Incorporating variables that describe provider background and practice, patient demographics, and relevant clinical attributes can identify mechanisms influencing prescribing behavior.

Figure 3.1 displays the domains of my conceptual model that this chapter addresses. The primary focus is the behavior of prescribing – i.e. which factors influence

**Figure 3.1**: Conceptual domains of Chapter 3



an inappropriate outcome. In this quantitative study I analyzed which patient, provider, or practice factors are associated with overprescribing.

**Research question**

The goal of this chapter is to determine the patient, provider, and practice characteristics associated with unnecessary prescribing for acute bronchitis at the time of visit including the role of patient-provider race and sex concordance.

**Background**

Antibiotics are prescribed for acute bronchitis over 50% of the time despite clinical guidelines strongly advocating against the practice (138). Efforts to combat overprescribing in outpatient settings have proven largely unsuccessful (151). This lack of success is worrisome given increasing bacterial resistance; the CDC estimates that over two million individuals were infected with antibiotic-resistant bacteria in 2013 (138). Better characterizing the prescribing decision may inform the development of more effective antibiotic stewardship interventions. Previous research has demonstrated associations between overprescribing and patient factors including age, sex, and comorbidities (24, 54); physician factors such as years in practice, teaching experience, patient volume, and specialty (24, 38); and variation in geographic region (24).

The patient-provider relationship is likely very important. Patient expectations, the provider's perception of a patient's preferences, and communication have been suggested predictors of antibiotic overuse. Race and sex may impact the patient-provider relationship by affecting communication during the clinical encounter. Providers knowledgeable about a patient's culture may be better able to clearly explain medical

diagnoses, and a patient with a sense of shared experience may be more likely to trust their provider's judgment (50). Studies of cross-cultural communication have found, for example, that black patients treated by black doctors rated the visits as more participatory than when treated by white providers (50). Similar trends have been observed in studies of gender concordance where care of a female patient by a female provider is more likely to be patient centered (152). However, other research has failed to find significant associations between medical care and patient-provider race or sex concordance (153). Measures of sex and race concordance have not yet been used to examine unnecessary antibiotic prescribing for acute bronchitis. The objective of this study was to examine the effect of race and sex concordance with other predictors on prescribing in cases of acute bronchitis.

**Methods**

Design

I used retrospective electronic medical record (EMR) data to identify outpatient visits for acute bronchitis at a large, urban safety-net hospital. Visit data on patients and providers were abstracted from the EMR via the hospital's clinical data warehouse. Provider characteristics not in the medical record were abstracted from publicly available physician profiles. Study staff reviewed the professional headshot, educational history, and provider name to assign race. The Boston University Medical Center Institutional Review Board approved all study activities.

Visits

Visits for acute bronchitis (*ICD-9* codes 466.x, 490) conducted between 2008 and 2010

in the outpatient clinic by either Family Medicine or General Internal Medicine attending physicians were included if the clinician had at least ten visits for RTIs in the dataset. All visits included in the study involved patients over 18 years of age.

Variables

The primary outcome was the prescription of an antibiotic for an acute bronchitis visit. A sample of charts was reviewed to confirm that the ICD-9 diagnosis of bronchitis matched the documented clinical indicators. Visits where patients were diagnosed with both acute bronchitis and another infection that might warrant an antibiotic were excluded because it was unclear which diagnosis was considered in the prescribing decision.

The primary independent variables were: 1) race concordance between patient and provider and 2) sex concordance between patient and provider. Race was recorded in six categories – white, black, Hispanic/Latino, Asian, Middle Eastern or other/unknown. Patient race was based on self-report. The EMR combines race and ethnicity, thus Hispanic/Latino was included in this category. To determine provider race, a five-person panel used a consensus method to assign one of the six racial categories based on a photo (154), surname (154, 155), and/or medical school (155). Panel members were given a card for each race category to hold up each time they were presented with a photo, surname, and school. If there was disagreement, the panel was given the opportunity to reach consensus. When consensus could not be reached, race was assigned as "other/unknown," although this only happened in two cases. Provider sex was recorded as male or female.

Other covariates included patient factors — age, sex, health insurance, race, and

history of chronic lung or heart disease — and provider factors — age, sex, race, specialty (Family vs. General Internal Medicine), and U.S. region of residency training. Race and sex covariates reflect only the race and sex of the individual patient or provider and are distinct from the concordance variable, which measures the agreement in either sex or race between patients and providers.

Statistical Analysis

I performed chi-square tests to analyze differences between patient and provider characteristics in visits resulting in an antibiotic prescription compared with visits where no antibiotic was prescribed. Multivariable regressions were used to examine the predictors of antibiotic prescribing. Relative risks from the multivariable model were estimated with a binomial complementary log-log (cloglog) model including random effects to control for individual provider heterogeneity and to ensure that any findings around concordance were not artifacts of individual prescribing practices. Methods of estimating the relative risk from the cloglog model are described elsewhere (156).

I conducted several sensitivity analyses to evaluate model fit. To investigate patient complexity, I tested inclusion of the Charlson score (157, 158), and I evaluated the effect of including the interaction of race and sex concordance. Sensitivity analyses using other regression link functions and using the model with a random subsample of 1/3 of the dataset further validated the results. Furthermore, I investigated the effect of different concordance structures by estimating predicted probabilities of different interactions of race and sex concordance for white/nonwhite and male/female pairs (Appendix B). This allowed us to investigate whether a particular pairing was

disproportionally affecting the results. All analyses were conducted in Stata 13.1.

**Results**

There were 1,177 visits for acute bronchitis included in the study. These 1,177 visits were overseen by 70 unique providers. Most visits were among patients who were female and non-white (Table 3). The majority of physicians were female and white. Overall, 831 (71%; 95% CI 68%–73%) visits resulted in an antibiotic prescription. Visits in which patients received an antibiotic were more often among patients under 65 years old (72% vs. 64% under age 65), female sex (75% vs. 63%), and with a history of lung disease (75% vs. 67%) (Table 3.1). An antibiotic was more often prescribed when the physician was female (76% vs. 65%), under age 45 (78% vs. 68%), and a Family Medicine provider (84% vs. 67%) compared to visits not ending in a prescription.

In the adjusted model, visits where the patient and provider shared the same race had an 17% lower risk of resulting in an antibiotic prescription compared to visits which were not race concordant (RR=0.83, CI 0.75–0.92) (Table 3.1). This result was unchanged if Hispanic/Latino patients were excluded. Sex-concordant visits were not associated with antibiotic prescriptions (RR=0.94, CI 0.88–1.01).

**Table 3.1**: Risk of prescribing an antibiotic for an acute bronchitis visit

| | Total visits, n=1,177 | | Prescribed an antibiotic 831 (71% of visits) | | p-value for prescribed | Adjusted risk ratio (95% CI) | |
|---|---|---|---|---|---|---|---|
| | n | (% of visits) | n | (% prescribed) | | | |
| Race Concordant Visit | | | | | | | |
| Concordant | 454 | (38.6) | 287 | (63.2) | <0.01 | 0.83 | (0.75 – 0.92) |
| Not concordant | 723 | (61.4) | 544 | (75.2) | | 1.00 | (Reference) |
| Sex Concordant Visit | | | | | | | |
| Concordant | 725 | (61.6) | 506 | (69.7) | 0.44 | 0.94 | (0.88 – 1.01) |
| Not concordant | 452 | (38.4) | 325 | (71.9) | | 1.00 | (Reference) |
| **Visit-Level Patient Characteristics** | | | | | | | |
| Sex | | | | | | | |
| Male | 447 | (38.0) | 281 | (62.9) | <0.01 | 0.89 | (0.82 – 0.97) |
| Female | 730 | (62.0) | 550 | (75.3) | | 1.00 | (Reference) |
| Age group | | | | | | | |
| Under 65 years old | 945 | (80.3) | 682 | (72.2) | | 1.00 | (Reference) |
| Over 65 years old | 232 | (19.7) | 149 | (64.0) | 0.02 | 0.84 | (0.70 – 1.02) |
| Race* | | | | | | | |
| White | 552 | (46.9) | 382 | (69.3) | | 1.13 | (1.06 – 1.21) |
| Black | 413 | (35.1) | 298 | (72.2) | | | |
| Asian/Pacific Islander | 34 | (2.9) | 21 | (63.6) | 0.52 | 1.00 | (Reference) |
| Middle Eastern | 8 | (0.7) | 5 | (62.5) | | | |
| Hispanic/Latino | 170 | (14.4) | 124 | (72.9) | | | |
| Insurance | | | | | | | |
| Commercial | 490 | (41.6) | 335 | (68.4) | | 1.00 | (Reference) |
| Medicare | 306 | (26.0) | 220 | (71.9) | | 1.06 | (0.94 – 1.20) |
| Medicaid | 277 | (23.5) | 202 | (72.9) | 0.49 | 1.00 | (0.90 – 1.10) |
| Other Insurance | 54 | (4.6) | 41 | (75.9) | | 1.07 | (0.93 – 1.22) |
| Uninsured | 50 | (4.3) | 33 | (66.0) | | 0.98 | (0.87 – 1.11) |
| History of Heart Disease | | | | | | | |
| Yes | 109 | (9.3) | 82 | (75.2) | 0.27 | 1.13 | (1.01 – 1.26) |
| No | 1,068 | (90.7) | 749 | (70.1) | | 1.00 | (Reference) |
| History of Chronic Lung Disease | | | | | | | |
| Yes | 550 | (46.7) | 411 | (74.7) | <0.01 | 1.08 | (0.98 – 1.18) |
| No | 627 | (53.3) | 420 | (67.0) | | 1.00 | (Reference) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Visit Level Provider Characteristics** | | | | | | | | |
| Sex | | | | | | | | |
| Male | 587 | (49.9) | 382 | (65.0) | <0.01 | 0.92 | (0.76 – 1.10) | |
| Female | 590 | (50.1) | 449 | (76.1) | | 1.00 | (Reference) | |
| Age group | | | | | | | | |
| Under 45 years old | 467 | (39.7) | 366 | (78.4) | <0.01 | 0.95 | (0.80 – 1.12) | |
| Over 45 years old | 710 | (60.3) | 465 | (65.5) | | 1.00 | (Reference) | |
| Race | | | | | | | | |
| White | 821 | (69.8) | 557 | (67.8) | <0.01 | 1.02 | (0.81 – 1.28) | |
| Non-White | 356 | (30.3) | 274 | (77.0) | | 1.00 | (Reference) | |
| Provider Residency Training | | | | | | | | |
| Northeast | 1,047 | (89.0) | 741 | (70.8) | | 1.00 | (Reference) | |
| South | 38 | (3.2) | 35 | (92.1) | <0.01 | 1.24 | (0.99 – 1.57) | |
| Midwest | 76 | (6.5) | 40 | (52.6) | | 0.90 | (0.55 – 1.47) | |
| West | 16 | (1.4) | 15 | (93.8) | | 1.29 | (1.10 – 1.50) | |
| Specialty of provider | | | | | | | | |
| Family Medicine | 267 | (22.7) | 223 | (83.5) | <0.01 | 1.16 | (0.97 – 1.38) | |
| General Internal Medicine | 910 | (77.3) | 608 | (66.8) | | 1.00 | (Reference) | |

*For bivariate and multivariable analyses of race categories were collapsed to white vs. non-white due to sample size.

Male patients were less likely to be overprescribed (RR=0.89, 95% CI 0.82–0.97) and those with a history of heart disease (RR=1.13, CI 1.01–1.26) or who were white (RR=1.13, CI 1.06–1.21) were more likely. There was a higher risk of overprescribing (RR=1.29, CI 1.10–1.50) if the visit was conducted by a provider who had completed residency in the western U.S., although this result was based on a small sample.

The results did not substantially change in sensitivity analyses. Because the data did not include potentially relevant clinical variables, such as underlying immunosuppression, I considered adding a measure which has been used to measure patient complexity (158), the Charlson Comorbidity Index (CCI). Inclusion of the CCI did not change the results and was insignificant (p=0.3) and was thus excluded. I also

tested the effect of being in a visit which was both sex and race concordant. When I modeled only the effect of this dual concordance, the concordant visits were less likely to end with a prescription (RR=0.84, 95% CI 0.74–0.95). When the model included dual concordance as well as the independent effects of race concordance and sex concordance, only race concordance was significant (RR=0.87, 95% CI 0.76–1.00). This suggests that in the data, any effect of a combined race/sex concordance variable is driven by the association between race concordance and prescribing.

I examined the marginal effects and predicted probabilities from the model to investigate the impact of different concordance pairings. Appendix B shows the marginal effects of each variable in the cloglog model and confirmed the findings above that race concordance had the largest single effect with a marginal effect seven times larger than sex concordance. Complementary with the overall results, both white/white and nonwhite/nonwhite concordance pairs had a lower predicted prescribing prevalence. The predicted probabilities presented some evidence that prescribing is higher when the patient is white and the provider is non-white compared to the reverse form of racial discordance. The predicted probability of receiving a prescription for a white patient with a non-white provider was 77% and 90% depending on the gender of the dyad compared to a range of 61% to 77% for a non-white patient and white provider (Appendix B).

**Discussion**

The study demonstrated that race concordance between patient and provider was associated with more appropriate antibiotic prescribing. I found that for acute bronchitis visits where the provider and patient were of the same race, providers were 17% less

likely to prescribe an antibiotic prescription. I did not find a significant relationship for sex concordance. Previous studies have focused on the relationship between either provider factors or patient factors and unnecessary prescribing (54). To my knowledge, sex and race-concordance have never been used in an explanatory model of antibiotic prescribing, and the results of this study suggest that further concordance research would be fruitful.

While past research has suggested that patient-provider communication may be an important area of focus, there is no consensus on the area of communication that is weakest or the best way to improve it (151). Some authors suggest that cross-cultural communication can affect prescribing (50). This is particularly important in urban safety-net medical centers, which often serve racially diverse and socioeconomically disadvantaged populations who may experience disparities in care (159). My analysis is not able to determine how, exactly, concordance affects the probability of receiving a prescription. It could be that a provider was less able to convince a non-concordant patient that antibiotics were unnecessary because he or she could not culturally connect with the patient. Or perhaps patients are more likely to trust, and take advice from, providers with whom they feel a sense of shared identity. Future research should consider employing strategies identified in studies on health care disparity, including cross-cultural communication and awareness, to better understand the dynamics of the patient-provider relationship in prescribing.

The study has several limitations. Race data were not collected directly from physicians. It is possible several providers were misclassified, affecting the results.

However, previous research has demonstrated strong agreement between observed and self-reported race (160). Hispanic/Latino origin is an important cultural variable, but is difficult to estimate with clinical records or via visual inspection so some Hispanic/Latino providers may not have been included. After excluding patients who identified as Hispanic/Latino the results were unchanged, but further research is important to evaluate potential variations in care. The study was limited by the data available in the EMR, so some important variables were excluded, such as duration of symptoms or immunosuppression, which may be important. Identification of bronchitis relied on ICD-9 codes in the medical record, which may be imperfect. A sample of chart reviews confirmed ICD-9 coding accuracy and past research suggests that these codes reliably identified bronchitis (161).

In conclusion, patient-provider race concordance predicted antibiotic prescribing. While gender concordance was not significant, the direction was the same and it may prove significant in a larger study. Race concordance is not the only aspect of the patient-provider relationship, but it may measure elements important to that relationship such as cultural competency, patient-centered explanations of care, or trust. The findings can be used to inform efforts to improve antimicrobial stewardship interventions, which to date have had limited success and have largely focused on provider knowledge and behavior (151). Interventions directed towards the patient have been less frequent and often are limited to provision of informational materials (151). Future research should explore the mechanisms behind the effect of patient-provider race concordance, perhaps through qualitative interviews of patient/provider dyads. Non-clinical indicators such as race and

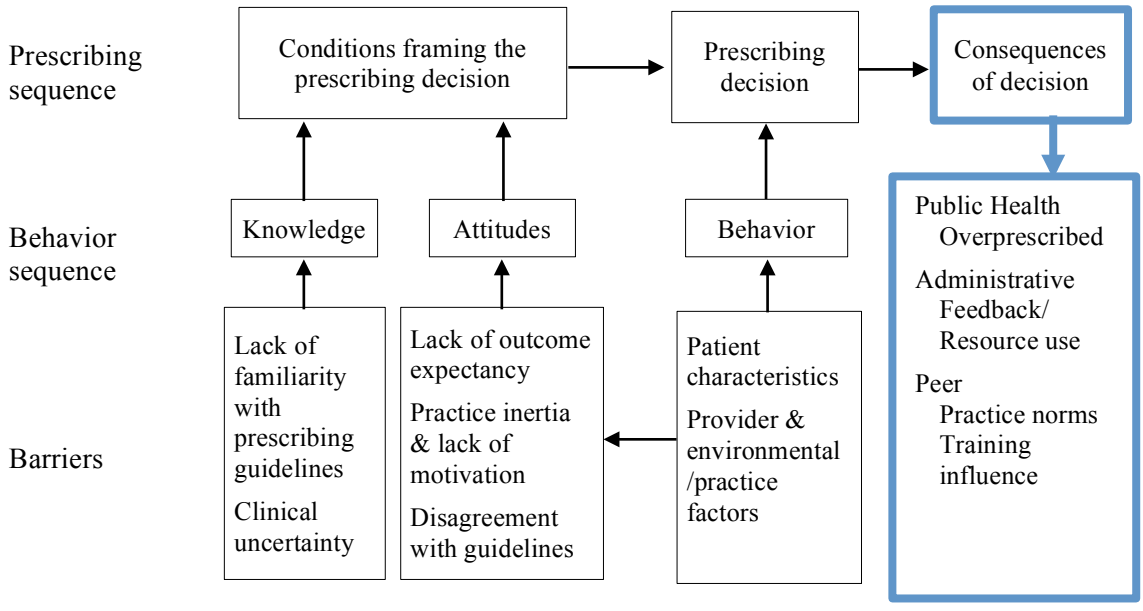
sex concordance may enhance our understanding of how to combat overprescribing and inform the design of future interventions.

# CHAPTER FOUR: THE EFFECT OF OVERPRESCRIBING IN CHILDREN ON FUTURE BRONCHITIS VISITS AND PRESCRIBING

## Summary

Many studies of unnecessary antibiotic prescribing do not extend beyond the act of prescribing. These studies are important, but leave out a critical part of the prescribing process: how overprescribing affects future antibiotic use. In this chapter I evaluate the final step in the prescribing sequence: the consequences of prescribing, bolded in Figure 4.1. The long-term public health consequences of overprescribing, such as resistance, are well studied. But an important consequence is how overprescribing might affect future behavior of patients, which will be the focus of this chapter. If a patient unnecessarily receives an antibiotic, that patient may believe an antibiotic is always required for the same set of symptoms, and will come to expect it.

**Figure 4.1**: Conceptual domains of Chapter 4



**Research question**

This chapter assessed the long-term consequences of overprescribing by studying how a provider's decision to prescribe antibiotics at a child's first encounter for acute bronchitis affects the likelihood of a future encounter and prescription.

**Background**

In the United States, antibiotics are overprescribed to children with viral RTIs contributing to ten million unnecessary prescriptions per year (72, 162). Those unnecessary antibiotics contribute to antimicrobial resistance and can result in drug-related adverse events such as diarrhea or *Clostridium difficile* (138, 163). Early antibiotic exposure has been linked to later development of asthma and obesity (82, 164). Previous literature has extensively reviewed how a variety of patient, provider, and practice characteristics affect prescribing – particularly unnecessary antibiotic prescribing - for viral RTI (24, 38) – but the prescribing process is complex and overprescribing remains high (24). New ways of looking at the prescribing process are necessary to better understand the drivers of overprescribing.

Health care providers identify patient expectation for antibiotics as one of the major drivers of prescribing (39, 90, 98). However, there is little literature on how patients come to expect antibiotics. Parents often seek outside advice when it comes to the health of their children, and often follow the advice of their doctor. In this case, early childhood medical visits may be formative – the first few visits communicate to the parent and child what the "right" answer is. If a child is given antibiotics for bronchitis the first time he or she is diagnosed, the parent may expect the same treatment at

subsequent visits. This may suggest targeted interventions during early medical interactions could have substantial downstream implications for lifetime antibiotic exposure. This study describes patient, provider, and practice factors associated with early childhood prescribing for privately insured children and explores how early prescribing behavior affects longer-term antibiotic and health care utilization including future acute bronchitis visits and prescribing.

## Methods

### Study sample

The analytic sample was constructed using data from the Truven Health Analytics MarketScan Commercial Claims and Encounters databases (MarketScan) of 2008–2013. MarketScan includes medical claims data from over 100 employer sponsored health care plans across the United States for patients aged 0 to 64 and is a yearly cross-section of insured employees and their dependents. Individuals are followed longitudinally for as long as they are enrolled in a participating health care plan. These claims data are linked to an individual who is tracked over time and the dataset is statistically de-identified. The database includes inpatient, outpatient, and pharmaceutical claims and identifies the date of service, characteristics about the facility providing the service, and a host of financial variables such as patient copayment amount. The Boston University Institutional Review board ruled this study "not human subjects research" and exempt from review.

To examine long-term outcomes I created a cohort of children who had a visit for acute bronchitis (*ICD-9* codes 466.x, 490) at some point during their enrollment. All of the children were born in 2008 and followed through 2013. Of the 420,975 unique

children born in 2008, 48,031 had a diagnosis of acute bronchitis and 24,210 were enrolled continuously through the end of the study period, 2013.

Analysis 1: characterizing antibiotic use

The first objective of this study was to characterize antibiotic prescribing in the entire sample of children with at least one acute bronchitis episode in order to better understand what patient, provider, and practice characteristics are most important in predicting prescribing.

*Dependent variable*

The dependent variable for the first analysis was whether or not the child received an antibiotic at his or her first episode for acute bronchitis. Consistent with what has been done in other studies of antibiotic prescribing, an episode of care is the two week period following the initial visit for acute bronchitis where any subsequent visits for the same diagnosis are part of the same episode (93), and if an antibiotic prescription was picked up within four days of a visit, it was attributed to that visit (24). Antibiotics included in the analysis are listed in Appendix C.

*Independent variables*

Independent variables included patient, provider, and facility characteristics found to be important in previous literature (see Chapter 1). In children I controlled for sex, age, geographic region where they sought care (Northeastern, Midwestern, Southern, or Western United States), whether they sought care in an urban environment (identified by Metropolitan Statistical Area, or MSA), and type of private insurance including health maintenance organizations (HMO), preferred provider organizations (PPO), point-of-

service (POS) and other (which can include high deductible health care plans, exclusive provider organizations, consumer-driven health plans, comprehensive plans, and basic/major medical plans – see Appendix C for full definition of each plan type). Because comorbidities in children have been shown to affect prescribing in other research (78), I used the medical claims to identify comorbidities present by the time of the episode according to a validated coding algorithm for pediatric patients (165). I identified the following chronic conditions in the cohort: functional or anatomic asplenia; HIV infection; chronic renal failure; malignant neoplasms; solid organ transplant; congenital immunodeficiency; diseases of the white blood cells; cochlear implant; chronic heart disease; chronic lung disease; diabetes; asthma; neurological disorders; chronic liver disease; trisomy 21; neuromuscular disorders; disorders relating to low birthweight. A full description of the coding algorithm, which used ICD-9 diagnosis codes, ICD-9 procedure codes, and current procedural terminology (CPT) codes can be found in Appendix C. Provider characteristics include the specialty of the provider (such as pediatrician) and practice factors include the site of care (such as a physician's office) as well as factors which may influence a practice such as day of the week (a facility with less weekend staff may be more likely to prescribe on weekends) and season of the year (RTI visits during flu season may be more likely to be attributed to the flu and less likely to receive an antibiotic).

*Analysis plan*

To understand the differences between children who were and were not prescribed antibiotics for acute bronchitis I used a three step process: (1) I presented the

descriptive statistics summarizing the characteristics in children that did and did not receive antibiotics; (2) conducted bivariate analysis to assess the differences between the groups, and; (3) constructed a predictive model of antibiotic prescription using multivariable methods and assessed the quality of the predictive model with goodness-of-fit statistics.

In the first step, descriptive statistics were generated for all variables stratified by prescribing outcome of the first episode. For categorical variables such as sex and insurance, the number and percentage of participants falling into each category were calculated, and for continuous variables such as age, the mean and standard deviation were calculated. Because the data are longitudinal – individual children followed over time – variables were assessed at the time of the first bronchitis visit. For example, age is the mean age of the cohort at the time of the first acute bronchitis episode.

Next, differences in independent variables between those receiving and not receiving antibiotics were assessed in bivariate analysis. For categorical variables such as geography and sex, chi-square analysis was used. If any group had a low cell count (under five), Fisher's exact test was used instead, and any variable with a cell size of one or fewer was excluded from further analysis due to sample size. For continuous variables I used the student's t-test, unless non-normality was detected, in which case the non-parametric Wilcoxin-Mann-Whitney test was used. Differences were considered significant if the test statistic yielded a p-value less than 0.05.

The dependent variable was whether or not an antibiotic was prescribed – a dichotomous variable. Because the dependent variable is binary I used standard logistic

regression to examine associations in the multivariable analysis. I assessed the appropriateness of the logistic model by evaluating multicollinearity with the variance inflation factor (VIF) and the fit of the model via the c-statistic. The VIF assessment of multicollinearity determines the extent of linear dependencies among the variables and is a product of a linear regression; however, VIF is still frequently used in the logistic setting (166). Due to the size of the data set, some frequently used statistics, such as the Hosmer-Lemeshow test, are inappropriate (167), so I relied on other post-hoc analyses to indicate whether the logistic model was the correct model to use. I also conducted sensitivity analyses using other distributional and link assumptions and compare the estimated coefficients. I used several goodness of fit measures to evaluate model fit.

Analysis 2: assessing the long-term effect of early prescribing

The second objective was to define early prescribing behavior and test its effect on future visits for acute bronchitis and antibiotic prescribing for a subsequent acute bronchitis episode of care.

*Dependent variables*

The primary dependent variable for this analysis was whether or not the child returned for an additional acute bronchitis episode. To be a distinct episode, the child must have had a visit with a primary acute bronchitis diagnosis 14 days or more after the first episode, and an episode is defined as in the first analysis (93). The secondary dependent variable was whether children with a second acute bronchitis episode were prescribed an antibiotic.

*Independent variables*

The main independent variable was the prescribing behavior at the first acute bronchitis episode. This was characterized by six possible behaviors depending on whether the child had more than one acute bronchitis visit in the same encounter (Table 4.1). If a child had one acute bronchitis visit and did not have a repeat visit for the same encounter, the child was either prescribed or not prescribed at that first visit. If the child had a repeat visit within 14 days, they were categorized in one of four ways: the provider "doubled down" on antibiotics, prescribing them for both the index visit and the repeat visit; the provider initially did not prescribe an antibiotic but then "gave in" and prescribed on the repeat visit; the provider was "steadfast" and did not prescribe for either visit; or the prescriber is "one and done," giving an antibiotic the first time but not the second.

**Table 4.1: Prescribing behaviors**

| | Antibiotic, first visit | Antibiotic, repeat visit |
|---|---|---|
| "Double down" | Yes | Yes |
| "Give in" | No | Yes |
| "Steadfast" | No | No |
| "One and done" | Yes | No |
| One visit, prescribed | Yes | - |
| One visit, not prescribed | No | - |

Other independent variables controlled for patient, provider, and practice characteristics and are described in Analysis 1. An additional variable was the length of time, in months, between the first acute bronchitis episode and the second (for those with two). This controlled for the fact that the likelihood of prescribing might differ depending on the last episode – e.g. perhaps providers are less likely to prescribe for a child who was seen just three months ago for the same condition.

*Analysis plan*

I examined the effect of early prescribing behaviors on future acute bronchitis visits and prescribing in two steps: First, I tested the association between the six prescribing behaviors in the first episode of care and whether a child returned for an additional visit for acute bronchitis. Second, among children with a second care episode for acute bronchitis, I evaluated whether the prescribing behavior from the first episode predicted whether or not an antibiotic was prescribed in the second.

I used logistic regression to test the association between early prescribing behaviors and whether a child had a second episode for acute bronchitis (a dichotomous variable). I assessed the multivariable model by evaluating multicollinearity and the fit of the model via the c-statistic and other post-hoc goodness of fit measures. Sensitivity analyses tested other distributional and link assumptions as well as a cross-tabulation analysis between prescribing in the first and second episode.

Similar methods were used to test the association between early prescribing behaviors and whether or not a child was prescribed at the second episode. I used a multivariable logistic model to predict prescribing at the second episode in the subsample of children who returned for a second episode, and performed the goodness of fit measures described above. The distributional and link assumptions were varied in sensitivity analysis and evaluated with the modified Park and Pregibon link tests.

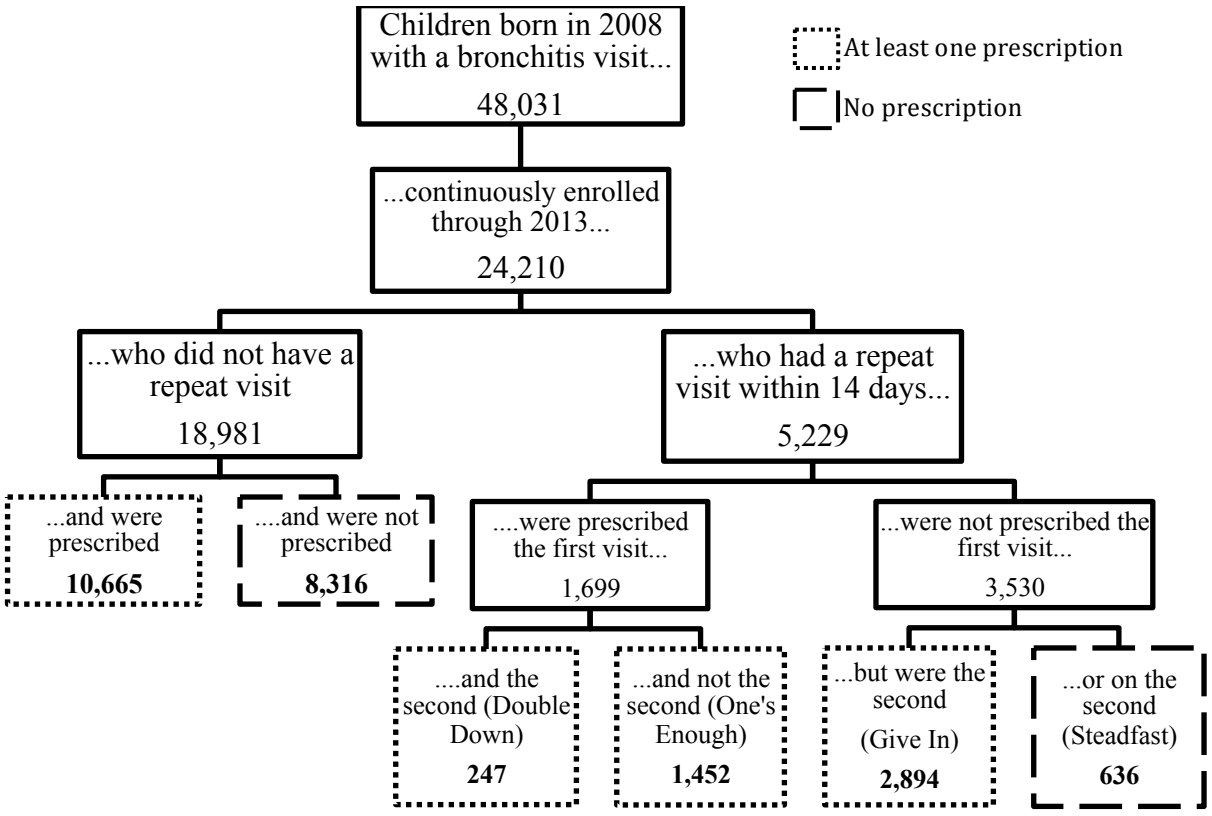
**Results**

Characteristics of the study sample

Figure 4.2 describes the derivation of the analytic sample. From the data, I

identified 48,031 unique children who were born in 2008. Of those, 24,210 were enrolled in the dataset through December 31st 2013, had at least one acute bronchitis episode of care, and had prescription drug coverage through their insurer the entire time. Five thousand, two hundred ninety-nine of these children had a repeat visit for the same episode of care within 14 days of the initial bronchitis diagnosis. 247 of these children were prescribed an antibiotic both times, putting them in the "double down" category; 2,892 had a provider who "gave in" and were prescribed an antibiotic on the repeat visit

**Figure 4.2:** The final analytic sample of the first acute bronchitis episode




after not having one on the first; 636 providers were "steadfast," prescribing neither initially or at the repeat visit, and; 1,452 children were prescribed an antibiotic initially, but "one was enough" and they were not prescribed on the second. 78% (18,981) of

children did not have a repeat visit during their first acute bronchitis episode. Fifty-six percent (10,665 children) of these were prescribed on this first visit, 44% (8,316) were not.

Analysis 1: predicting antibiotic use

The first step of the analysis was to evaluate the differences between children who received an antibiotic during their first episode of care for acute bronchitis and those who did not. Table 4.2 shows the characteristics and bivariate comparisons of children who did and did not receive an antibiotic during their first visit. The unadjusted p-value for the bivariate analysis of each variable is also given in the same table. Overall, 12,364 children received an antibiotic for the first episode of acute bronchitis care – 51% of the total sample. Based on the bivariate analysis, those who were prescribed an antibiotic tended to be almost a year older (2. years vs. 1.2 years, $p<0.001$), more often female (47% of this group was female vs. 42%, $p<0.001$), enrolled in a PPO plan (51% vs. 48%, $p<0.001$), lived in the South and Midwest (45% vs. 42% and 23% vs. 22%, respectively, $p<0.001$), and more often came from a rural area (14% vs 12%, $p<0.001$). Many comorbidities were rare, but the prevalence of several was significantly different between the two groups. Those who received an antibiotic for acute bronchitis less often had a diagnosis of chronic heart disease (2% vs. 3%, $p<0.001$), chronic lung disease (1.0% vs 1.4%), asthma (3.1% vs. 2.7%, $p<0.001$), or disorders relating to low birthweight (9% vs. 11%, $p<0.001$) at the time of the episode compared to those who did not receive an antibiotic. Those who had their appointment during winter (46% vs. 53%, $p<0.001$) were prescribed less often. Children prescribed an antibiotic more often saw a family medicine

provider (13% vs. 7%, p<0.001) and almost always had their appointments in an office setting (91% vs. 86%, p<0.001).

**Table 4.2: Children born in 2008 with at least one bronchitis episode**

| | **Total Sample 24,210** | | **No Antibiotic 11,846** | | **Antibiotic 12,364** | | **Bivariate p-value** |
|---|---|---|---|---|---|---|---|
| | *n* | *% (SD)* | *n* | *% (SD)* | *n* | *% (SD)* | |
| Antibiotic given at first bronchitis episode | 12,264 | 51% | 0 | 0% | 12,364 | 100% | |
| **Patient characteristics** | | | | | | | |
| Age at first visit mean, SD | 1.7 | 1.4 | 1.2 | 1.6 | 2.0 | 1.5 | <0.001 |
| Sex | | | | | | | |
| Male | 13,359 | 55% | 6,452 | 58% | 6,907 | 53% | <0.001 |
| Female | 10,851 | 45% | 4,758 | 42% | 6093 | 47% | |
| Health plan type | | | | | | | |
| PPO | 12,072 | 50% | 5,408 | 48% | 6,664 | 51% | |
| HMO | 6,999 | 29% | 3,449 | 31% | 3,550 | 27% | <0.001 |
| POS | 3,361 | 14% | 1,551 | 14% | 1,810 | 14% | |
| Other | 1,778 | 7% | 802 | 7% | 976 | 8% | |
| Region | | | | | | | |
| Northeast | 2,902 | 12% | 1,498 | 13% | 1,404 | 11% | |
| Midwest | 5,572 | 23% | 2,521 | 22% | 3,051 | 23% | |
| South | 10,562 | 44% | 4,747 | 42% | 5,815 | 45% | <0.001 |
| West | 4,755 | 20% | 2,222 | 20% | 2,533 | 20% | |
| Unknown | 419 | 2% | 222 | 2% | 197 | 2% | |
| Urban area (MSA) | | | | | | | |
| Live in MSA | 21,085 | 87% | 9,898 | 88% | 11,187 | 86% | <0.001 |
| Do not live in MSA | 3,125 | 13% | 1,312 | 12% | 1,813 | 14% | |
| Comorbidities at first episode | | | | | | | |
| Functional or anatomic asplenia | 28 | 0% | 16 | 0% | 12 | 0% | 0.250 |
| HIV** | 1 | 0% | 1 | 0% | 0 | 0% | 0.463 |
| Chronic renal failure | 27 | 0% | 12 | 0% | 15 | 0% | 0.846 |
| Malignant neoplasms | 18 | 0% | 11 | 0% | 7 | 0% | 0.208 |
| Solid organ transplant** | 3 | 0% | 2 | 0% | 1 | 0% | 0.600 |
| Congenital immunodeficiency* | 16 | 0% | 5 | 0% | 11 | 0% | 0.317 |
| Diseases of the white blood cells | 31 | 0% | 14 | 0% | 17 | 0% | 1.000 |
| Cochlear implant** | 1 | 0% | 0 | 0% | 1 | 0% | 1.000 |
| Chronic heart disease | 634 | 3% | 338 | 3% | 296 | 2% | <0.001 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Chronic lung disease | 288 | 1% | 164 | 1% | 124 | 1% | <0.001 |
| Uncomplicated diabetes* | 11 | 0% | 7 | 0% | 4 | 0% | 0.366 |
| Asthma | 706 | 3% | 298 | 3% | 408 | 3% | 0.027 |
| Neurological disorder** | 0 | 0% | 0 | 0% | 0 | 0% | - |
| Chronic liver disease* | 8 | 0% | 6 | 0% | 2 | 0% | 0.156 |
| Trisomy 21 | 37 | 0% | 25 | 0% | 12 | 0% | 0.009 |
| Neuromuscular disorders | 239 | 1% | 109 | 1% | 130 | 1% | 0.828 |
| Disorders relating to low birthweight | 2,414 | 10% | 1,272 | 11% | 1,142 | 9% | <0.001 |
| **Calendar attributes** | | | | | | | |
| Season | | | | | | | |
| Spring | 5,086 | 21% | 2,291 | 20% | 2,795 | 22% | |
| Summer | 1,906 | 8% | 736 | 7% | 1,170 | 9% | <0.001 |
| Fall | 5,249 | 22% | 2,195 | 20% | 3,054 | 23% | |
| Winter | 11,969 | 49% | 5,988 | 53% | 5,981 | 46% | |
| Day of the week | | | | | | | |
| Monday | 5,506 | 23% | 2,471 | 22% | 3,035 | 23% | |
| Tuesday–Thursday | 11,545 | 48% | 5,424 | 48% | 6,121 | 47% | 0.024 |
| Friday | 3,980 | 16% | 1,878 | 17% | 1,996 | 16% | |
| Weekend | 3,179 | 13% | 1,437 | 13% | 1,742 | 13% | |
| **Provider characteristics** | | | | | | | |
| Provider specialty at first bronchitis visit | | | | | | | |
| Pediatrician | 15,890 | 66% | 7,753 | 69% | 8,137 | 63% | |
| Family medicine | 2,472 | 10% | 786 | 7% | 1,686 | 13% | <0.001 |
| ER/Urgent care | 776 | 3% | 413 | 4% | 363 | 3% | |
| Other | 5,072 | 21% | 2,258 | 20% | 2,814 | 22% | |
| **Practice characteristics** | | | | | | | |
| Location of first bronchitis visit | | | | | | | |
| Physician office | 21,550 | 89% | 9,677 | 86% | 11,873 | 91% | |
| Outpatient hospital | 1,607 | 7% | 957 | 9% | 650 | 5% | |
| ER/Urgent care | 607 | 3% | 254 | 2% | 353 | 3% | <0.001 |
| Inpatient | 228 | 1% | 167 | 1% | 61 | 0% | |
| Other | 218 | 1% | 155 | 1% | 63 | 0% | |

Percentage columns for categorical variables display the standard deviation for continuous variables
*Used Fisher's exact test
**Excluded from future analyses due to sample size

Next, I created a predictive model of antibiotic prescribing as a function of patient, provider, and practice characteristics. Table 4.3 presents the results of the logistic

model. I found that older children (OR = 1.60, p<0.001), females (OR = 1.08, p=0.004), and those living in the Midwest (OR = 1.19, p=<0.001), South (OR = 1.31, p<0.001), or West (OR = 1.14, p=0.004) had higher odds of being prescribed while those living in an urban area (OR = 0.89, P<0.001) had lower odds of being prescribed an antibiotic at their first visit compared to the reference group. In general, children with comorbidities were less likely to receive an antibiotic. I found many comorbidities predicted a child to be less likely to be prescribed, included chronic lung disease (OR = 0.73, p=0.004), asthma (OR = 0.76, p=0.002), trisomy 21 (OR = 0.36, p=0.006), and disorders relating to low birthweight (OR = 0.82, p<0.001). In adjusting for season, I found that visits in summer had a higher odds of resulting in a prescription (OR = 1.18, p<0.001) while visits in the winter had lower odds of yielding a prescription (OR = 0.87, p<0.001) compared to visits during fall. Compared to coming in for a visit between Tuesday and Thursday, visits occurring on a Monday or over the weekend had higher odds of ending with a prescription (OR = 1.12, p=0.003 and OR = 1.18, p<0.001, respectively). Relative to being seen by a pediatrician, visits conducted by family medicine providers or by other non-pediatrician and non-ER doctors had higher odds of ending in a prescription (OR = 1.71, p<0.001 and OR = 1.34, p<0.001, respectively). Finally, all visits conducted outside of a physician's office, including visits in an outpatient hospital, an ER or urgent care center, an inpatient admission, or others, had significantly lower odds of resulting in a prescription (OR = 0.48, 0.77, 0.37. and 0.27, respectively, p<0.001 for all).

Several tests indicated the model fit well. The c-statistic (0.70) indicates the model performs reasonably well and the omnibus F-test for significance results in a p-

value < 0.001. Because Hosmer-Lemshow was inappropriate, I evaluated the fit with an alternative suggested in the literature: the standardized Pearson goodness-of-fit test (168). The immense size of the dataset precludes the use of this computationally intensive test as is. However, I was able to run the program using a random sample of my data (10,000 observations), and the resulting standardized Pearson p-value was over 0.05, indicating failure to reject the null of good model fit. Also due to large sample size, the Modified Park and Pregibon link tests failed to identify one of the major distribution or link families as correct. Rather than using uninterpretable link and distribution assumptions in order to perfectly fit the data, I used the most intuitive choice with a binary outcome: the logistic model. The binomial distribution and logit link had the lowest (albeit still significant) test statistics, indicating that among other easily interpretable model specification, logistic was preferred. The VIF was less than three for all variables, and less than two for most, indicating multicollinearity is low and none of our variables were redundant.

**Table 4.3: Multivariable model predicting antibiotic prescribing**

| | Estimate | Odds Ratio | 95% Confidence Interval | p-value |
|---|---|---|---|---|
| **Patient characteristics** | | | | |
| Age at visit | 0.468 | 1.60 | (1.56 – 1.63) | <0.001 |
| Sex | | | | |
| Male | | *Reference group* | | |
| Female | 0.082 | 1.09 | (1.03 – 1.15) | 0.004 |
| Health plan types | | | | |
| PPO | | *Reference group* | | |
| HMO | -0.105 | 0.90 | (0.84 – 0.96) | 0.002 |
| POS | 0.022 | 1.02 | (0.94 – 1.11) | 0.736 |
| Other | 0.005 | 1.01 | (0.90 – 1.12) | 0.920 |
| Regions | | | | |
| Northeast | | *Reference group* | | |
| Midwest | 0.170 | 1.19 | (1.08 – 1.31) | <0.001 |
| South | 0.271 | 1.31 | (1.20 – 1.43) | <0.001 |
| West | 0.131 | 1.14 | (1.03 – 1.26) | 0.004 |
| Unknown | -0.080 | 0.92 | (0.74 – 1.15) | 0.338 |
| Urban area (MSA) | -0.115 | 0.89 | (0.82 – 0.97) | <0.001 |
| Comorbidities at any time | | | | |
| Functional or anatomic asplenia | -0.416 | 0.66 | (0.30 – 1.46) | 0.449 |
| Chronic renal failure | 0.205 | 1.23 | (0.54 – 2.79) | 0.701 |
| Malignant neoplasms | -0.804 | 0.45 | (0.16 – 1.26) | 0.167 |
| Congenital immunodeficiency | 0.583 | 1.79 | (0.56 – 5.75) | 0.270 |
| Diseases of the white blood cells | -0.015 | 0.99 | (0.45 – 2.18) | 0.869 |
| Chronic heart disease | -0.152 | 0.86 | (0.72 – 1.02) | 0.173 |
| Chronic lung disease | -0.310 | 0.73 | (0.56 – 0.95) | 0.004 |
| Uncomplicated diabetes* | -1.186 | 0.31 | (0.08 – 1.16) | 0.109 |
| Asthma | -0.275 | 0.76 | (0.64 – 0.90) | 0.002 |
| Chronic liver disease* | -0.959 | 0.38 | (0.07 – 2.08) | 0.338 |
| Trisomy 21 | -1.011 | 0.36 | (0.17 – 0.77) | 0.006 |
| Neuromuscular disorders | -0.141 | 0.87 | (0.66 – 1.14) | 0.626 |
| Disorders relating to low birthweight | -0.201 | 0.82 | (0.75 – 0.90) | <0.001 |
| **Calendar attributes** | | | | |
| Season | | | | |
| Spring | -0.019 | 0.98 | (0.90 – 1.07) | 0.598 |
| Summer | 0.163 | 1.18 | (1.05 – 1.32) | <0.001 |
| Fall | | *Reference group* | | |
| Winter | -0.134 | 0.87 | (0.82 – 0.94) | <0.001 |

| | | | | |
|---|---|---|---|---|
| Day of the week | | | | |
| Monday | 0.112 | 1.12 | (1.05 – 1.20) | 0.003 |
| Tuesday–Thursday | *Reference group* | | | |
| Friday | 0.037 | 1.04 | (0.96 – 1.12) | 0.411 |
| Weekend | 0.165 | 1.18 | (1.08 – 1.29) | <0.001 |
| **Provider characteristics** | | | | |
| Provider specialty at first bronchitis visit | | | | |
| Pediatrician | *Reference group* | | | |
| Family medicine | 0.537 | 1.71 | (1.55 – 1.89) | <0.001 |
| ER/Urgent care | 0.161 | 1.18 | (0.98 – 1.41) | 0.066 |
| Other | 0.296 | 1.34 | (1.24 – 1.45) | <0.001 |
| **Practice characteristics** | | | | |
| Location of first bronchitis visit | | | | |
| Physician office | *Reference group* | | | |
| Outpatient hospital | -0.735 | 0.48 | (0.42 – 0.55) | <0.001 |
| ER/Urgent care | -0.263 | 0.77 | (0.64 – 0.93) | <0.001 |
| Inpatient | -1.000 | 0.37 | (0.27 – 0.50) | <0.001 |
| Other | -1.308 | 0.27 | (0.20 – 0.37) | <0.001 |

Analysis 2: Predicting long-term outcomes

An overview of the two outcomes stratified by prescribing at the time of the first episode is presented in Table 4.4. The majority (18,981, 78%) of children only had one episode for acute bronchitis, and of those 10,665 (56%) were prescribed an antibiotic and 8,316 (44%) were not. 5,229 children (28%) had a repeat visit for the same episode of care. Of those who had a repeat visit, the majority (2,894, 55%) had a provider who "gave in," and received an antibiotic at the repeat visit. One thousand four-hundred and fifty-two children received an antibiotic initially but not at their repeat visit while 636 children with providers were "steadfast" and did not receive an antibiotic for either the first or repeat visit during the 1$^{st}$ episode of care. 247 children received an antibiotic on both the initial and repeat visit.

**Table 4.4: Prescribing behavior and subsequent acute bronchitis visits and prescribing**

| 1st episode prescribing | *n* | Rx First Visit | Rx Repeat | Returned for 2nd episode | | Prescribed 2nd episode | |
|---|---|---|---|---|---|---|---|
| | | | | n | % (of total) | n | % (of returned) |
| "Double down" | *247* | Yes | Yes | 157 | 64% | 111 | 71% |
| "Give in" | *2,894* | No | Yes | 1,587 | 55% | 695 | 44% |
| "Steadfast" | *636* | No | No | 367 | 58% | 196 | 53% |
| "One's enough" | *1,452* | Yes | No | 834 | 57% | 514 | 62% |
| One visit, prescribed | *10,665* | Yes | - | 4,592 | 43% | 3,415 | 74% |
| One visit, not prescribed | *8,316* | No | - | 3,764 | 45% | 2,005 | 53% |

The proportion of children returning for a second episode of care for acute bronchitis differed across the groups, as did the proportion of those who returned who were prescribed. Those in the "double down" category most often returned for a 2nd episode of care, with 64% of them doing so, followed by "steadfast" (58%), "one's enough" (57%), "give in" (55%), "one visit, not prescribed" (45%), and "one visit, prescribed" (43%). Among those who had a second episode of care, 74% of the "one visit, prescribed" group were given an antibiotic followed by "double down" (71%), "one's enough" (62%), "steadfast" (53%), "one visit, not prescribed" (53%), and "give in" (44%).

To determine the association between prescribing behavior during the first episode of care and experiencing a second acute bronchitis care episode I conducted a multivariable logistic regression controlling for patient, provider, and practice

characteristics (Table 4.5). Compared to children whose first acute bronchitis episode consisted of one visit, which resulted in an antibiotic, those with providers who "doubled down" or thought "one's enough" at the first episode had higher odds of experiencing a second acute bronchitis episode (OR = 2.01, $p<0.001$ and OR = 1.29, $p<0.001$, respectively). Those in "give in" and "one visit, not prescribed" groups had lower odds of a second episode (OR = 0.90, $p=0.022$ and OR = 0.75, $p<0.001$). Having a "steadfast" provider at the first episode was not significantly associated with experiencing a second episode.

Multiple patient, provider, and practice characteristics were also associated with experiencing a second acute bronchitis episode. Children with lower odds of experiencing a second episode were older (OR = 0.61, $p<0.001$), female (OR = 0.94, $p=0.004$), enrolled in an HMO (OR = 0.88, $p<0.001$), lived in an urban area (OR = 0.79, $p<0.001$), and sought care in the spring (OR = 0.80, $p<0.001$) or winter (OR = 0.70, $p<0.001$). Those living in the south or west had higher odds of experiencing a second episode (OR = 1.44, $p<0.001$ and OR = 1.15, $p=0.008$). Several comorbidities are also associated with higher odds of a second episode, namely chronic heart disease (OR = 1.23, $p=0.022$), chronic lung disease (OR=1.79, $p<0.001$), asthma (OR = 1.25, $p=0.009$), and disorders related to low birthweight (OR = 1.20, $p<0.001$).

**Table 4.5: Multivariable model predicting a 2nd acute bronchitis episode**

| | Estimate | Odds Ratio | 95% Confidence Interval | p-value |
|---|---|---|---|---|
| **Patient characteristics** | | | | |
| *Prescribing types (ref one visit, prescribed)* | | | | |
| Double Down | 0.698 | 2.01 | (1.52 – 2.66) | <0.001 |
| Steadfast | 0.098 | 1.10 | (0.93 – 1.31) | 0.257 |
| Give in | -0.107 | 0.90 | (0.82 – 0.99) | 0.022 |
| One's Enough | 0.256 | 1.29 | (1.15 – 1.45) | <0.001 |
| One visit, not prescribed | -0.283 | 0.75 | (0.71 – 0.80) | <0.001 |
| One visit, prescribed | | *Reference group* | | |
| Age at visit | -0.503 | 0.61 | (0.59 – 0.62) | <0.001 |
| Sex | | | | |
| Male | | *Reference group* | | |
| Female | -0.062 | 0.94 | (0.89 – 0.99) | 0.004 |
| Health plan types | | | | |
| PPO | | *Reference group* | | |
| HMO | -0.131 | 0.88 | (0.82 – 0.94) | <0.001 |
| POS | 0.011 | 1.01 | (0.93 – 1.10) | 0.788 |
| Other | 0.010 | 1.01 | (0.91 – 1.12) | 0.854 |
| Regions | | | | |
| Northeast | | *Reference group* | | |
| Midwest | 0.030 | 1.03 | (0.94 – 1.14) | 0.548 |
| South | 0.363 | 1.44 | (1.32 – 1.57) | <0.001 |
| West | 0.137 | 1.15 | (1.04 – 1.27) | 0.008 |
| Unknown | -0.021 | 0.98 | (0.79 – 1.22) | 0.848 |
| Urban area (MSA) | -0.234 | 0.79 | (0.73 – 0.86) | <0.001 |
| Comorbidities at any time | | | | |
| Functional or anatomic asplenia | 0.155 | 1.17 | (0.52 – 2.61) | 0.707 |
| Chronic renal failure | 0.325 | 1.38 | (0.60 – 3.17) | 0.442 |
| Malignant neoplasms | -0.364 | 0.70 | (0.24 – 1.99) | 0.497 |
| Congenital immunodeficiency | -0.570 | 0.57 | (0.18 – 1.83) | 0.341 |
| Diseases of the white blood cells | 0.058 | 1.06 | (0.48 – 2.33) | 0.886 |
| Chronic heart disease | 0.205 | 1.23 | (1.03 – 1.46) | 0.022 |
| Chronic lung disease | 0.580 | 1.79 | (1.37 – 2.33) | <0.001 |
| Uncomplicated diabetes | -0.825 | 0.44 | (0.10 – 1.84) | 0.259 |
| Asthma | 0.224 | 1.25 | (1.06 – 1.48) | 0.009 |
| Chronic liver disease | 1.822 | 6.19 | (0.74 – 51.71) | 0.093 |
| Trisomy 21 | 0.082 | 1.09 | (0.54 – 2.19) | 0.819 |
| Neuromuscular disorders | 0.028 | 1.03 | (0.78 – 1.36) | 0.845 |

| | | | | |
|---|---|---|---|---|
| Disorders relating to low birthweight | 0.180 | 1.20 | (1.09 – 1.31) | <0.001 |
| **Calendar attributes** | | | | |
| Season | | | | |
| Spring | -0.224 | 0.80 | (0.74 – 0.87) | <0.001 |
| Summer | -0.088 | 0.92 | (0.82 – 1.03) | 0.125 |
| Fall | *Reference group* | | | |
| Winter | -0.357 | 0.70 | (0.65 – 0.75) | <0.001 |
| Day of the week | | | | |
| Monday | 0.008 | 1.01 | (0.94 – 1.08) | 0.815 |
| Tuesday–Thursday | *Reference group* | | | |
| Friday | 0.031 | 1.03 | (0.96 – 1.11) | 0.428 |
| Weekend | -0.078 | 0.93 | (0.85 – 1.01) | 0.077 |
| **Provider characteristics** | | | | |
| Provider specialty at first bronchitis visit | | | | |
| Pediatrician | *Reference group* | | | |
| Family medicine | 0.136 | 1.15 | (1.04 – 1.26) | 0.005 |
| ER/Urgent care | 0.039 | 1.04 | (0.87 – 1.25) | 0.676 |
| Other | 0.063 | 1.07 | (0.99 – 1.15) | 0.107 |
| **Practice characteristics** | | | | |
| Location of first bronchitis visit | | | | |
| Physician office | *Reference group* | | | |
| Outpatient hospital | -0.167 | 0.85 | (0.74 – 0.96) | 0.011 |
| ER/Urgent care | -0.228 | 0.80 | (0.66 – 0.96) | 0.018 |
| Inpatient | 0.009 | 1.01 | (0.76 – 1.34) | 0.951 |
| Other | 0.246 | 1.28 | (0.96 – 1.71) | 0.097 |

Next, I used logistic regression to explore the association between prescribing behavior at the first episode of care and whether or not an antibiotic was prescribed during the second episode. Table 4.6 presents the results of this analysis. Children who had only one visit during the first episode and were prescribed during that visit had the highest odds of being prescribed at the second episode. Compared to that group, the "steadfast" (OR = 0.51, $p<0.001$), "give in" (OR = 0.36, $p<0.001$), "one's enough" (OR = 0.66, $p<0.001$), and "one visit, not prescribed" (OR = 0.45, $p<0.001$) categories had significantly lower odds of receiving a prescription at the second acute bronchitis

episode. Children who were in the "double down" category did not have significantly different odds of being prescribed compared to the reference group (p=0.958).

Several other factors predicted whether a child received a prescription at the second acute bronchitis episode. Children who were covered by a HMO insurance plan (OR = 0.90, p=0.046) or who lived in an urban area (OR = 0.87, p=0.026) were less likely to be prescribed at the second episode, while those living in the south (OR = 1.17, p=0.028) or west (OR = 1.19, p=0.039) had higher odds of being prescribed. Three chronic conditions were associated with being prescribed, with a diagnosis of malignant neoplasms (OR = 0.13, p=0.030) and chronic heart disease (OR = 0.75, p=0.016) associated with lower odds of receiving a prescription and a diagnosis of chronic lung disease (OR = 1.26, p=0.003) associated with higher odds. Seeking care during the winter was associated with lower odds of a prescription compared to the fall (OR = 0.82, p<0.001) and children were more likely to be prescribed if they sought care on a Monday compared to mid-week (OR = 1.22, p<0.001). Provider and practice characteristics were also associated with whether or not a child was prescribed. Children seen by family medicine (OR = 1.42, p<0.001) and other providers (OR = 1.13, p=0.049) had higher odds of being prescribed compared to children seen by pediatricians, and being seen outside of a physician's office was associated with lower odds of being prescribed. This included being seen in an outpatient hospital (OR = 0.53, p<0.001), an ER or urgent care center (OR = 0.71, p=0.002), an inpatient facility (OR = 0.24, p<0.001), or some other non-office based location (OR = 0.23, p<0.001).

**Table 4.6: Multivariable model predicting prescribing at the 2nd acute bronchitis episode**

| | Estimate | Odds Ratio | 95% Confidence Interval | p-value |
|---|---|---|---|---|
| **Patient characteristics** | | | | |
| *Prescribing types (ref one visit, prescribed)* | | | | |
| Double Down | -0.010 | 0.99 | (0.69 – 1.43) | 0.958 |
| Steadfast | -0.666 | 0.51 | (0.41 – 0.65) | <0.001 |
| Give in | -1.021 | 0.36 | (0.32 – 0.41) | <0.001 |
| One's Enough | -0.410 | 0.66 | (0.56 – 0.78) | <0.001 |
| One visit, not prescribed | -0.803 | 0.45 | (0.41 – 0.50) | <0.001 |
| One visit, prescribed | | *Reference group* | | |
| Months since 1st episode | 0.018 | 1.02 | (1.01 – 1.02) | <0.001 |
| Age at visit | 0.232 | 1.26 | (1.21 – 1.32) | <0.001 |
| Sex | | | | |
| Male | | *Reference group* | | |
| Female | 0.051 | 1.05 | (0.97 – 1.14) | 0.233 |
| Health plan types | | | | |
| PPO | | *Reference group* | | |
| HMO | -0.101 | 0.90 | (0.82 – 1.00) | 0.046 |
| POS | 0.062 | 1.06 | (0.94 – 1.21) | 0.337 |
| Other | 0.011 | 1.01 | (0.86 – 1.19) | 0.896 |
| Regions | | | | |
| Northeast | | *Reference group* | | |
| Midwest | 0.099 | 1.10 | (0.95 – 1.29) | 0.210 |
| South | 0.155 | 1.17 | (1.02 – 1.34) | 0.028 |
| West | 0.170 | 1.19 | (1.01 – 1.39) | 0.039 |
| Unknown | -1.259 | 0.28 | (0.13 – 0.65) | 0.003 |
| Urban area (MSA) | -0.138 | 0.87 | (0.77 – 0.98) | 0.026 |
| Comorbidities at any time | | | | |
| Functional or anatomic asplenia | 0.007 | 1.01 | (0.38 – 2.70) | 0.989 |
| Chronic renal failure | 0.257 | 1.29 | (0.41 – 4.09) | 0.662 |
| Malignant neoplasms | -2.036 | 0.13 | (0.02 – 0.82) | 0.030 |
| Congenital immunodeficiency | 1.134 | 3.11 | (0.77 – 12.50) | 0.110 |
| Diseases of the white blood cells | 1.337 | 3.81 | (0.97 – 15.02) | 0.056 |
| Chronic heart disease | -0.289 | 0.75 | (0.59 – 0.95) | 0.016 |
| Chronic lung disease | 0.231 | 1.26 | (1.08 – 1.47) | 0.003 |
| Uncomplicated diabetes* | - | - | - - - | - |
| Asthma | -0.131 | 0.88 | (0.76 – 1.02) | 0.081 |
| Chronic liver disease | -0.647 | 0.52 | (0.09 – 3.07) | 0.474 |
| Trisomy 21 | 0.527 | 1.69 | (0.66 – 4.33) | 0.271 |

| | | | | |
|---|---|---|---|---|
| Neuromuscular disorders | -0.139 | 0.87 | (0.61 – 1.24) | 0.435 |
| Disorders relating to low birthweight | -0.043 | 0.96 | (0.84 – 1.09) | 0.524 |
| **Calendar attributes** | | | | |
| Season | | | | |
| Spring | -0.110 | 0.90 | (0.80 – 1.01) | 0.071 |
| Summer | 0.040 | 1.04 | (0.89 – 1.22) | 0.624 |
| Fall | *Reference group* | | | |
| Winter | -0.196 | 0.82 | (0.74 – 0.92) | <0.001 |
| Day of the week | | | | |
| Monday | 0.199 | 1.22 | (1.10 – 1.36) | <0.001 |
| Tuesday–Thursday | *Reference group* | | | |
| Friday | -0.097 | 0.91 | (0.81 – 1.02) | 0.101 |
| Weekend | 0.132 | 1.14 | (1.00 – 1.31) | 0.056 |
| **Provider characteristics** | | | | |
| Provider specialty at first bronchitis visit | | | | |
| Pediatrician | *Reference group* | | | |
| Family medicine | 0.352 | 1.42 | (1.23 – 1.65) | <0.001 |
| ER/Urgent care | 0.173 | 1.19 | (0.81 – 1.75) | 0.379 |
| Other | 0.125 | 1.13 | (1.00 – 1.28) | 0.049 |
| **Practice characteristics** | | | | |
| Location of first bronchitis visit | | | | |
| Physician office | *Reference group* | | | |
| Outpatient hospital | -0.628 | 0.53 | (0.44 – 0.65) | <0.001 |
| ER/Urgent care | -0.344 | 0.71 | (0.57 – 0.89) | 0.002 |
| Inpatient | -1.443 | 0.24 | (0.16 – 0.34) | <0.001 |
| Other | -1.458 | 0.23 | (0.19 – 0.29) | <0.001 |

*Inestimable due to small sample size

Goodness-of-fit and sensitivity analyses indicated the model fit well. Both models had a good c-statistic: 0.68 for the prediction of the second episode and 0.74 predicting an antibiotic prescription at the second visit. The omnibus F-test was significant for both models as well with $p<0.001$, and the Pearson test using a subsample of the data failed to reject the null of a good fitting model in both cases. Both models were also free of serious multicollinearity issues with inflations factors under three in the VIF analysis. As in the first analysis, I selected the most intuitive distribution and link assumptions for the data –

the logit distribution with log link. Cross-tabulation of the prescribing behavior is available in Appendix C.

**Discussion**

In this chapter I created a predictive model of antibiotic prescribing for acute bronchitis in children and assessed how early prescribing experience affected later resource use related to acute bronchitis and antibiotics. In this first analysis, I determined what factors predicted an antibiotic prescription at the time of the initial visit, and next examined how the initial encounter predicted subsequent visits and prescribing.

In the first analysis predicting prescribing for the first episode of acute bronchitis care, the results underscored the importance of including characteristics from the child, the doctor, and the health care setting when modeling antibiotic prescribing. First, the characteristics of the children significantly affected their odds of being prescribed. Similar to other studies of patient factors and prescribing, I found that sex and geography were significantly associated with the odds of being prescribed, with females and those from the south and west more likely to receive an antibiotic (60, 71) and those from urban areas were less likely. Each additional year of life was significantly predictive of being prescribed with one of the largest estimated coefficients, which is consistent with past literature (56), despite the fact that symptom expression is often similar across age groups and guidelines are often the same (59, 169). This could be because older children may be able to more clearly communicate symptoms, which the provider uses to justify antibiotics. It also may be that providers are less worried about some of the negative effects of prescribing (such as diarrhea) in older children (21).

Next, the current health state of the child was also an important factor determining whether or not he or she was prescribed. The association between comorbidities and prescribing was found to be different from some previous studies, and may be related to the way that comorbidities were included in the study. While other research has indicated that antibiotics and asthma medication are often prescribed together as a "just in case" measure (78), my results suggest that asthma is protective against an antibiotic prescription. In the multivariable analysis, I measured the effect of having a confirmed comorbidity *before* the acute bronchitis episode. In this case, it may be that doctors who are aware of a comorbid condition both see the patient more often to manage the chronic condition and attribute some of the symptoms to the conditions (especially for respiratory conditions such as asthma and chronic lung disease) instead of to a possible bacterial infection requiring an antibiotic. Additionally, because the observed episodes are for children with a primary diagnosis of acute bronchitis, it is possible that prescribing for asthma is occurring in visits with a primary asthma diagnosis, and this offsets the "protective" effect I observe. More research to understand why these conditions are protective against prescribing for acute bronchitis would be valuable.

I also found that provider and practice characteristics were significantly associated with prescribing at the first episode. The results show that pediatricians are significantly less likely to prescribe antibiotics for acute bronchitis than family medicine providers. This phenomenon of elevated antibiotic prescribing practices in family medicine has been observed in other research (24) and future interventions may benefit from exploring what in the family medicine setting is so different from pediatrics or

general internal medicine and may be related to overprescribing. The site of care is also important in the prescribing decision, and has implications for where interventions might most productively be placed. While the doctor's office was where most visits occurred, every other location of care resulted in lower odds of prescribing. This could be because other locations may be differently structured (perhaps the office environment is more relaxed when it comes to prescribing whereas an urgent care center may have a rigid guideline concordant standard operating procedure) or may simply have different priorities regarding stewardship. This may suggest promoting stewardship across a medical care setting could be important for promoting proper antibiotic use.

In my novel analysis of early prescribing behaviors I found that a child's first interaction with the health care system for acute bronchitis affects whether that child returns for a subsequent episode and whether he or she is prescribed. Children who received one or two antibiotics for their first acute bronchitis episode were more likely to have a visit for a second episode, even after controlling for the health of the child and other confounders. Those with two prescriptions at the first visit had more than twice the odds of experiencing a second episode compared to those in the "one visit, prescribed" category while those who had just one visit and were not prescribed had 0.75 times the odds. This could reflect parenting styles – parents who brought a child in more than once within 14 days for acute bronchitis may have be more likely to interact with the health care system overall. However, other children with two visits in the first episode – those in the "steadfast" and "give in" categories – did not have elevated odds of returning for a second episode, suggesting that the type of prescribing during the first episode is

important for predicting future behavior. However, among those with a second episode, most prescribing categories, with the exception of the "double down" category, were associated with a lower odds of prescribing at that second episode compared to those in the "one visit, prescribed" category. It could be that a patient with multiple visits for their first episode of acute bronchitis raised a red flag for providers as possible antibiotic seeking patients or it could be that patients who were prescribed an antibiotic with just one visit in the first episode of care were more likely to be prescribed in the future if they felt the prescribed antibiotic "worked."

The characteristics of the child, his or her comorbidities, and provider and practice characteristics were all associated with experiencing a second acute bronchitis episode and being prescribed at that second episode. Being insured by an HMO was associated with lower odds of experiencing a second episode and being prescribed at that episode. Other studies have found that among commercial plans, HMOs are associated with lower medical costs which can be due in part to fewer visits and fewer prescriptions (170). Those who lived in the south and west were also more likely to experience a second acute bronchitis episode and be prescribed at that episode, while those in urban areas were less likely. Regional variation has been a topic of study for some time in health services research (62), and it is possible the differences I observed could be due to patient health literacy, which tends to be lower in the Southeast (75), or simply due to differences in local practice which have evolved over time.

All statistically significant comorbidities were associated with increased odds of experiencing a second acute bronchitis episode. It could be that children with comorbid

conditions are more connected with the health care system overall, so are more likely to seek care for all symptoms. The two comorbidities that predicted a second episode most strongly were chronic lung disease and asthma, which could indicate children with a history of respiratory diagnoses may be more likely to seek care for respiratory symptoms. Chronic lung disease was also associated with higher odds of receiving an antibiotic at the second episode, which could be related to clinician uncertainty of whether to attribute the symptoms to acute bronchitis or another more serious condition associated with chronic lung disease (171).

Provider and practice characteristics of the first episode affected the probability of experiencing a second episode and may be related to the experience or education a patient receives at a visit. For example, family medicine providers may allocate limited appointment time differently than pediatricians and emphasize antibiotic stewardship less, which may in turn affect whether or not a parent brings in a child with acute bronchitis symptoms. During the second episode, the provider and practice factors predicting prescribing are similar to those factors predicting prescribing for the first episode. As in previous literature, family medicine providers are most likely to prescribe (24) and there is substantial heterogeneity in prescribing based on location of care.

This study has several limitations. While MarketScan is a large cohort that allows for longitudinal observation, only children covered by private insurance are included in the dataset. Previous research has found that overprescribing does not vary between public and private insurance (24, 25), but early prescribing experience may be different among those covered by public insurance such as Medicaid. While the sample may not be

representative of the entire population, other research has shown MarketScan to be a fairly good representation of the U.S. privately insured population (172). Additionally, the data did not contain information on race/ethnicity which Chapter 1 of this dissertation suggested was important in the prescribing decision. The analysis was also constrained by the amount of follow-up. First, this study would have benefitted from longer follow-up to examine how childhood prescribing experiences translated to adult behavior, although data of this type are extraordinarily rare. Next, administrative claims do not allow me to know exactly why the provider was prescribing the antibiotic. I only included visits where acute bronchitis was the primary diagnosis to reduce this bias as much as possible, but it is possible that the provider was acting on a different diagnosis when he or she wrote the prescription. Finally, I only included children fully enrolled from birth through the end of 2013, and children who were not enrolled during the whole period may be different. It is possible that this loss to follow-up was differential – e.g. perhaps the parents move often so frequently change insurance, and this frequent change of settings affects the relationship with the medical system and thus prescribing outcomes. While future research into patterns of care for children who come in and out of insurance coverage is important to understand that population, it was beyond the scope of this research, which was a detailed exploration into how early experiences affect subsequent health care visits and prescribing.

Overprescribing is persistent and difficult to combat. A major challenge is that the prescribing process is poorly understood, and that there has been little research into how early prescribing can affect a patient's "antibiotic trajectory." The goal of this study was

to explore whether early antibiotic prescribing affected future visits for acute bronchitis and prescribing. I found that early prescribing behaviors are significantly associated with future episodes of acute bronchitis care and future prescribing. This novel study into the effect of early prescribing serves both as a way to better understand the prescribing and to caution potential prescribers of the consequences a simple antibiotic prescription can have. Future research should compare this result to an adult population to investigate which population's future utilization is more strongly predicted by prior utilization. The unintended effect on future prescribing and health care visits (including the risks associated with future elevated exposure to antibiotics) is another compelling piece of evidence for stakeholders to leverage in the fight against unnecessary antibiotic use.

# CHAPTER FIVE: CONCLUSION

In 2015, President Obama issued the National Action Plan for Combating Antibiotic-Resistant Bacteria (173) in order to "ris[e] to the challenge of antibiotic resistance and potentially sav[e] thousands of lives" (174). However, even as concerns about the threat of resistance reach the highest levels of political power, overprescribing remains woefully common. To rise to the challenge of resistance, it is critical that researchers investigate prescribing and stewardship with innovative methods and measures and from perspectives not considered before. The goals of this dissertation were to understand the prescribing process in a more comprehensive way in order to promote judicious antibiotic use and to better understand how stewardship functions by soliciting the attitudes of current infectious disease fellows. Throughout this dissertation, the factors I found to be most relevant to prescribing, such as race concordance and how children are prescribed following their first acute bronchitis diagnosis, are often absent from the literature and thus absent from discussions on crafting policy and interventions.

Qualitative interviews with infectious disease fellows revealed that there are many different ways stewardship works "on the ground." While these future stewards appreciated the importance of stewardship, they considered some stewardship tasks, such as carrying an antibiotic pager, to be less effective forms of stewardship compared to consulting one-on-one with other providers. This is an important insight into crafting effective interventions. Successfully implementing an intervention requires buy-in from those who will carry out the intervention. For example, infectious disease fellows are often strong advocates of stewardship, but have to balance any intervention to improve

stewardship with existing responsibilities. Non-physicians, such as clinical pharmacists, may help manage stewardship responsibilities, and the group of fellows I interviewed identified pharmacists as critical members of the team. This existing system of support, already well integrated in the stewardship process, is a potential resource to promote stewardship. The fellows I spoke with were often drawn to infectious disease as a "cerebral" specialty, and many thought educating other providers and working together to promote proper use of antibiotics was one of the most satisfying and effective stewardship activities. Harnessing this enthusiasm by creating interventions that work with stewards and emphasize the types of stewardship they know to be most effective is an approach that warrants additional study.

My in-depth study of adult patients diagnosed with acute bronchitis at a large academic medical center found that racial concordance between the patient and provider plays an important role in whether or not antibiotics are prescribed for acute bronchitis, typically a viral RTI where antibiotics are not indicated. After controlling for other patient, provider, practice, and clinical factors, whether or not patients and providers were race concordant was one of the strongest predictors of whether or not an antibiotic would be prescribed. Innovative measure such as race and gender concordance are often left out of similar analyses, and this analysis suggests that exclusion is detrimental, and the persistence of high rates of overprescribing indicates that there is a need for innovative explanatory models to better understand prescribing. Prescribing is the result of a meeting between provider and patient, and new measures of how patients and providers interact provide much needed insight into overprescribing. The importance of racial concordance

may reflect the role of cross-cultural communication and the patient-provider relationship. The role of cross-cultural communication in prescribing is rarely described in the literature, and may provide an opportunity to promote the judicious use of antibiotics. Patient centered care emphasizes understanding patients in the "context of their own social worlds" (175) and educating providers in the best ways to communicate the importance of stewardship may be an important tool in combating overprescribing.

Finally, I found that the first interaction a child has with the health care system for a diagnosis for acute bronchitis has long-lasting impacts. Unnecessary prescribing lingers, with children who received antibiotics during their first acute bronchitis episode more likely to return for a second episode over five years compared to children not prescribed. Examining repeat visits for the same acute bronchitis complaint allowed me to further investigate the effect of the decision whether or not to prescribe following the first acute bronchitis diagnosis on long-term use, where, for example, children who have repeat visits for their first episode are often more likely to return for a second episode but are also less likely to be prescribed at the second episode. This suggests that increased patient-provider interaction may affect future interactions and may provide an opportunity to encourage proper antibiotic use. This study illustrated that whether or not a provider prescribes an antibiotic may affect the likelihood that a child receives a future prescription for the same complaint, and providers in all settings should be made aware that an antibiotic "just this once" can have lasting influence.

There is an urgent need to slow the spread of antimicrobial resistance and to encourage more judicious use of antibiotics. The recent White House National Action

Plan states that the only way to achieve this goal is through cooperation between providers, health care leaders, patients, and other antibiotic stakeholders (173). This dissertation supports this assessment. Engaging in more comprehensive research that includes novel measures of the patient-provider relationship is an important first step in understanding the prescribing process. That same comprehensiveness should then carry over into interventions, where taking into account the "whole picture" of prescribing and engaging patients, providers, and other stakeholders can inform better, more effective interventions.

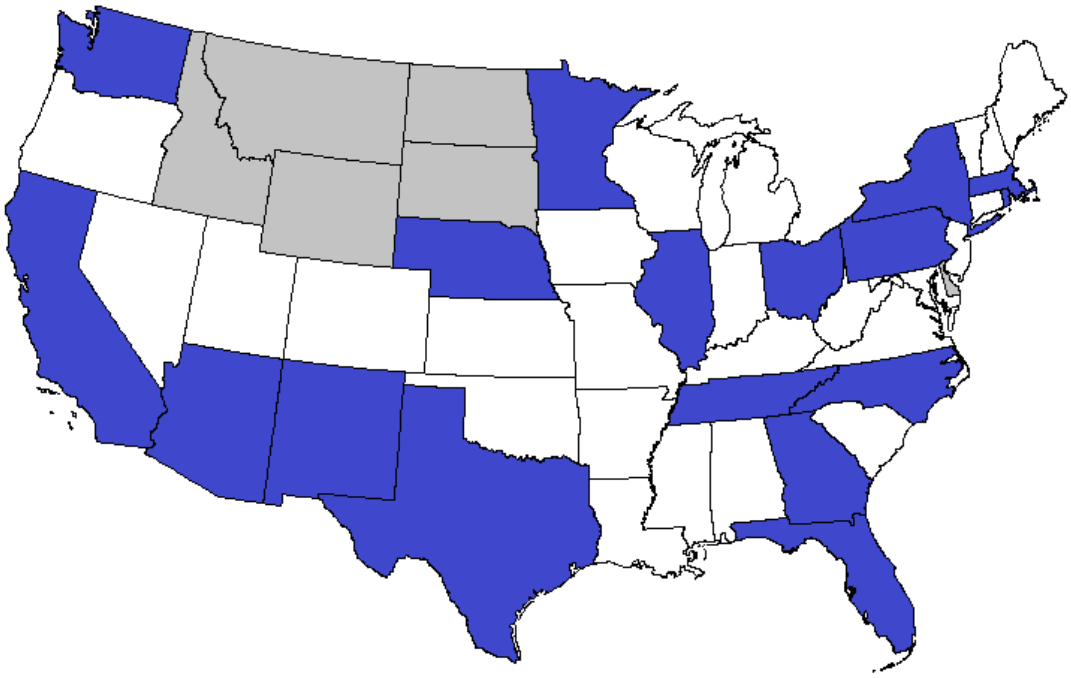
This dissertation opens the door for several important areas of future research. From my first study, it is clear that more work is needed to understand how fellowship programs can continue to attract high quality physicians while promoting stewardship in a way that is effective, engaging, and encouraging. Specifically, long-term prospective analyses could follow individual providers over time to compare fellowship program characteristics' effects on providers, and more near term analyses could see how programmatic changes, such as who carries the pager and when, affected the quality of life of fellows. From the second study, I found a strong association between racial concordance and appropriateness of prescribing. While I have hypothesized the reasons for this association, such as patient education or cross-cultural communication skills, a qualitative interview of patient-provider dyads would be better equipped to explore the mechanisms behind this effect. Long-term effects of prescribing on behavior is a rich area to explore further with longer running longitudinal cohorts. My third study offers important results into the first five years of life, but more research covering a longer

period, e.g. the first 20 years, would be highly insightful. It is also important to see how subsequent prescribing affects behavior among an adult population. This would inform researchers thinking of designing interventions as to what kind of "dose-response" to expect: in other words, how many times must it be implemented before an intervention behavior "sticks" either among patients or providers. The future areas of research prompted by this dissertation are critical to developing better and more effective interventions in order to curb the overuse of antibiotics.

This dissertation is a response to the crisis of antibiotic overprescribing and increasing antimicrobial resistance. The three studies described trace prescribing from its origin with how providers think about antibiotics through the long-term effects in patients. Corresponding to increased focus on patient centered care, each study highlights the importance of communication and a willingness to listen, whether it be surgeons and infectious disease fellows, patients and providers, or parents and children. Progress in the fight against antibiotic resistance will hinge on the ability of researchers to explore creative and innovative interventions and on how well we – providers, patients, researchers, decision makers – can present a united front against antibiotic overprescribing.

# APPENDIX A: CHAPTER 2 SUPPLEMENTAL MATERIALS

**States where infectious disease fellows were interviewed.**



Participating fellows were enrolled in an infectious disease fellowship program in one of the blue states. White states have at least one fellowship program, but no fellows were interviewed from these states. Grey states, including Alaska and Hawaii, represent states where no infectious disease fellowship programs existed as of 2014.

**Semi-structured qualitative interview guide**

PRIMARY RESEARCH QUESTION: What is the role of stewardship in your fellowship programs and how does it influence your attitudes and beliefs about antibiotic prescribing.

Questions (bullet points are examples of possible probes):

1. Tell me about how you came to be in your fellowship
    - Did you seek out stewardship from residency?
    - How interested are you in stewardship-related fellowship activities?
    - What is your main interest?

2. How does stewardship fit in to your fellowship?
    - How has the stewardship component affected your practice?
    - As you think of going out into practice, how will you use the stewardship information from your fellowship?

3. Tell me about your involvement with stewardship in your fellowship
    - Follow with program-specific probes – understand how the program teaches/emphasizes stewardship
        - Formal vs. informal

4. What can be improved around antibiotic stewardship in your fellowship program?

5. Why did you do this interview?

6. Is there anything else you think I should know?

7. Demographics

**Demographic Data Collection:**

1) What is your gender? …… 1☐ Male 2☐ Female 3☐ Other

2) What year are you in the fellowship program? _____

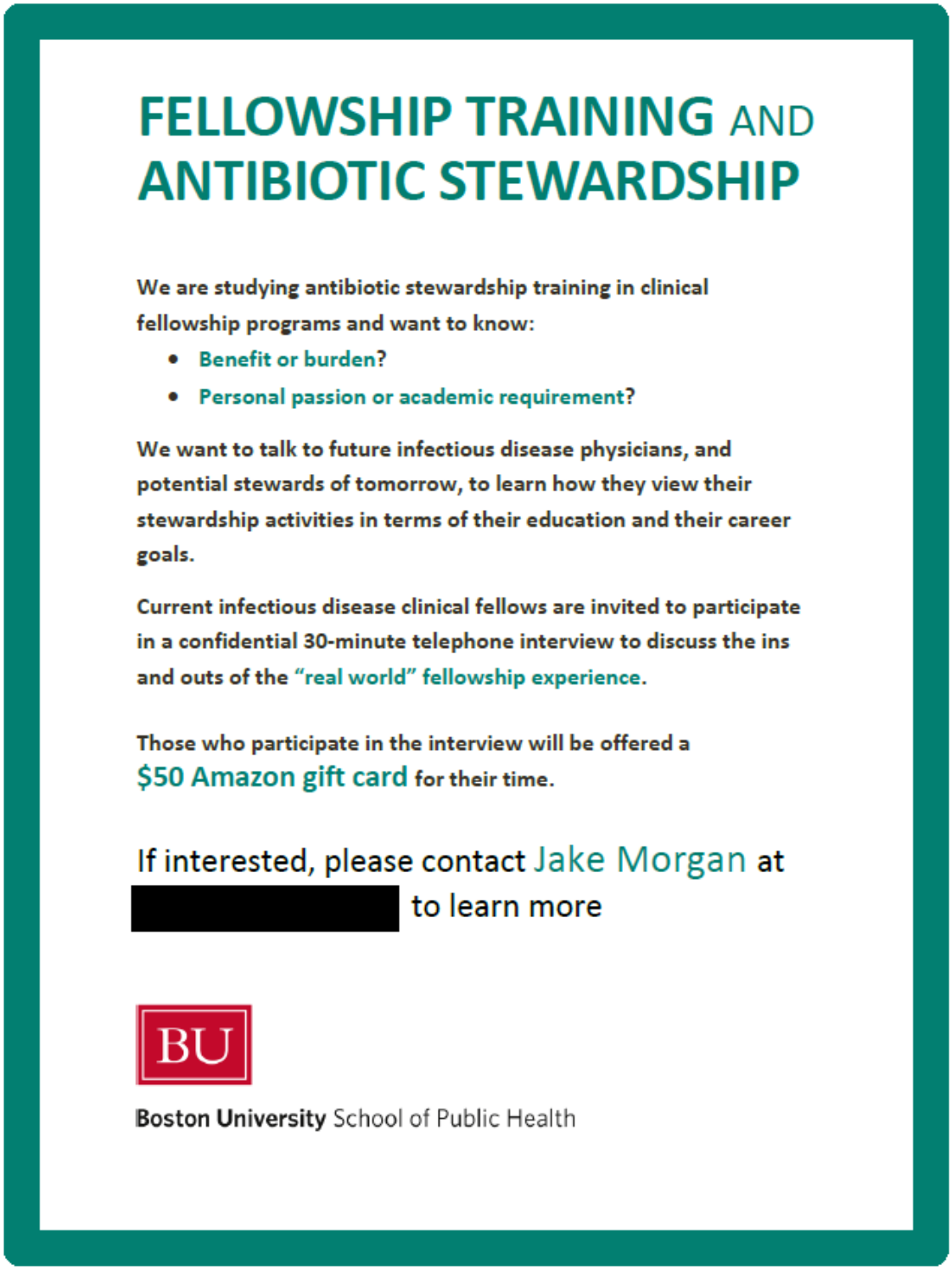
3) How would you describe your race? _____

4) In what state do you practice? _____

5) In what other settings have you practiced? For how long?

_____

**Recruitment flyer**



# FELLOWSHIP TRAINING AND ANTIBIOTIC STEWARDSHIP

We are studying antibiotic stewardship training in clinical fellowship programs and want to know:

- Benefit or burden?
- Personal passion or academic requirement?

We want to talk to future infectious disease physicians, and potential stewards of tomorrow, to learn how they view their stewardship activities in terms of their education and their career goals.

Current infectious disease clinical fellows are invited to participate in a confidential 30-minute telephone interview to discuss the ins and outs of the "real world" fellowship experience.

Those who participate in the interview will be offered a $50 Amazon gift card for their time.

If interested, please contact Jake Morgan at [redacted] to learn more

BU

Boston University School of Public Health

# APPENDIX B: CHAPTER 3 SUPPLEMENTAL MATERIALS

## Marginal effects after cloglog model

Marginal effects after cloglog
y = Pr(overprescribed) (predict)
= 0.71440143

| Variable | dy/dx | S.E. | z | p | 95% CI | | X (mean) |
|---|---|---|---|---|---|---|---|
| race concordant | -0.159 | 0.040 | -4.010 | 0.000 | -0.237 | -0.081 | 0.386 |
| sex concordant | -0.021 | 0.030 | -0.710 | 0.478 | -0.079 | 0.037 | 0.616 |
| provider white | -0.059 | 0.035 | -1.680 | 0.093 | -0.129 | 0.010 | 0.698 |
| provider > 45 | -0.015 | 0.035 | -0.420 | 0.674 | -0.083 | 0.054 | 0.603 |
| South Res. | 0.103 | 0.085 | 1.220 | 0.224 | -0.063 | 0.269 | 0.032 |
| Midwest Res. | -0.195 | 0.063 | -3.080 | 0.002 | -0.319 | -0.071 | 0.065 |
| West Res. | 0.214 | 0.079 | 2.690 | 0.007 | 0.058 | 0.369 | 0.014 |
| Family Medicine | 0.137 | 0.036 | 3.830 | 0.000 | 0.067 | 0.208 | 0.227 |
| Male Patient | -0.105 | 0.030 | -3.470 | 0.001 | -0.165 | -0.046 | 0.380 |
| White Patient | 0.101 | 0.037 | 2.720 | 0.007 | 0.028 | 0.173 | 0.468 |
| Medicare | 0.059 | 0.041 | 1.420 | 0.155 | -0.022 | 0.140 | 0.260 |
| Medicaid | -0.027 | 0.039 | -0.710 | 0.478 | -0.103 | 0.048 | 0.235 |
| Other Insurance | 0.011 | 0.066 | 0.160 | 0.874 | -0.119 | 0.140 | 0.046 |
| Provider Male | -0.051 | 0.035 | -1.460 | 0.144 | -0.120 | 0.018 | 0.499 |
| Uninsured | -0.072 | 0.076 | -0.950 | 0.342 | -0.220 | 0.076 | 0.042 |
| MI/CHF | 0.059 | 0.048 | 1.230 | 0.219 | -0.035 | 0.152 | 0.093 |
| Patient>65 | -0.116 | 0.043 | -2.670 | 0.008 | -0.201 | -0.031 | 0.197 |
| Chronic Lung Disease | 0.088 | 0.028 | 3.100 | 0.002 | 0.032 | 0.144 | 0.467 |

(*) dy/dx is for discrete change of dummy from 0 to 1

## Predicted probabilities

| | | Race | | | |
|---|---|---|---|---|---|
| Gender | Patient/ Provider | White/ White | Non-White /Non-White | Non-White/ White | White/ Non-White |
| | Male/ Male | 0.551 | 0.510 | 0.609 | 0.771 |
| | Male/ Female | 0.624 | 0.582 | 0.683 | 0.836 |
| | Female/ Female | 0.710 | 0.668 | 0.766 | 0.898 |
| | Female/ Male | 0.679 | 0.637 | 0.737 | 0.877 |

# APPENDIX C: CHAPTER 4 SUPPLEMENTAL MATERIALS

## List of included antibiotics

The table below provides details on the included antibiotics by RedBook-defined therapeutic class.

| Therapeutic class and description | |
|---|---|
| **4** | Antibiotics, aminoglycosides |
| **6** | Antibiotics, cephalosporin and related |
| **7** | Antibiotics, B-lactam Antibiotics |
| **9** | Antibiotics, erythromycin & macrolide |
| **10** | Antibiotics, penicillins |
| **11** | Antibiotics, tetracyclines |
| **16** | Quinolones |
| **17** | Sulfonamides |
| **19** | Urinary Anti-infectives (only nitrofurantoin) |
| **20** | Anti-infectives (only metronidazole) |

**Definition of health plan types**

| Variable | Plan type | Description |
|---|---|---|
| PPO | Preferred Provider Organization | Patients are incentivized to use preferred providers. Specialists can be seen without primary care referral and services are not capitated. Patients may seek care outside of the network but will incur a financial penalty |
| HMO | Health Maintenance Organization | Patients are limited to a list of providers for all non-emergency care. Referral from a primary care provider is required to see a specialists. All or some services are capitated |
| POS | Point-of-Service | Patients are incentivized to use preferred providers with low copays or deductibles. Referral from a primary care provider is required to see a specialists. Services can be fully, partially, or not capitated and patients can see out of network providers with a financial penalty |
| Other | Basic/Major Medical | No preferred providers. The basic policy handles the first set of charges such as hospital admission with no out of pocket charges, after which the major medical plan assumes coverage and is associated with a deductible and coinsurance |
| | Comprehensive | Patient can choose any provider and the plan is associated with a deductible and coinsurance |
| | Exclusive Provider Organization | Patients choose from a list of providers and choose a primary care physician. Referral is required for specialist care and plan payment is not capitated |
| | Consumer-Driven Health Plan | PPO with a Health Reimbursement Arrangement (HRA). HRA is funded by the employer and ay be used for drug coverage or other designated expenses |
| | High Deductible Health Plan | Features a Health Savings Account (HSA). Employee is 100% vested in HSA which may be funded by employee or employer. HSA is tax advantaged and portable. |

Adapted from the MarketScan User Guide published by Truven Health Analytics (176)

**Identifying chronic conditions in children**

The ICD-9 diagnosis and procedural codes and CPT codes were used to identify each chronic condition. To be considered chronically infected, children needed evidence of one of the following in the medical record: (1) ICD-9 codes listed at two or more outpatient visits at least seven days apart; (2) one CPT procedure code, or; (3) any code listed at an inpatient visit (165).

| | ICD-9 Diagnosis Code | ICD-9 Procedure Code | CPT Code | | Notes |
|---|---|---|---|---|---|
| Asplenia | 282.4 | 41.5 | 38100 | 38120 | |
| | 282.5 | | 38102 | | |
| | 282.6 | | | | |
| | 282.7 | | | | |
| | 284 | | | | |
| | 289.4 | | | | |
| | 289.5 | | | | |
| | 759.0 | | | | |
| | 759.3 | | | | |
| HIV | 42 | | | | |
| | V08 | | | | |
| Renal Failure | 403 | 39.27 | 36800 | 90989 | |
| | 404 | 39.42 | 36810 | 90993 | |
| | 581 | 39.43 | 36815 | 90997 | |
| | 582 | 39.95 | 36818–36821 | 90999 | |
| | 583 | 54.98 | 90935 | 93990 | |
| | 585 | | 90937 | 90918 | |
| | 586 | | 90940 | 90919–90921 | *valid 2006–2008* |
| | 753 | | 90945 | 90951–90962 | *valid after 2009* |
| | V42.0 | | 90947 | | |
| | V45.1 | | 90951–90970 | | |
| | V56 | | | | |
| Immunosuppressive conditions | 140–172 | 92.2 | | | |
| | 174–208 | 99.25 | | | |
| Neoplasms | V58.0 | | | | |
| | V58.1 | | | | |
| | V67.1 | | | | |

| | | | |
|---|---|---|---|
| | V67.2 | | |
| Solid organ trans. | V42.81 | 41.0 | 38240 |
| | V42.82 | 37.5 | 38241 |
| | V42.0 | 33.6 | 33945 |
| | V42.1 | 46.97 | 33935 |
| | V42.84 | 50.59 | 44135 |
| | V42.7 | 33.5 | 44136 |
| | V42.6 | 33.51 | 47135 |
| | V42.83 | 33.52 | 50360 |
| | V42.89 | 55.69 | 50365 |
| | V42.9 | 41.94 | 38999 |
| | | 52.8 | |
| Congenital immunodeficiency | 279 | | |
| Diseases of WBCs | 288.0 | | |
| | 288.1 | | |
| Cochlear | | 20.96 | 69930 |
| | | 20.97 | |
| | | 20.98 | |
| Heart Disease | 393–398 | 36.0 | 33510–33514 |
| | 402 | 36.1 | 33516–33519 |
| | 404 | 36.2 | 33521–33523 |
| | 410–414 | 36.3 | 33530 |
| | 416 | | 33533–36 |
| | 424 | | 92980–82 |
| | 425 | | 92982 |
| | 428 | | 92984 |
| | 429.7 | | 92995 |
| | 745 | | 92996 |
| | 746 | | |
| | 747.1 | | |
| Chronic Lung | 277.0 | | |
| | 416.8 | | |
| | 416.9 | | |
| | 490 | | |
| | 491 | | |
| | 492 | | |
| | 494 | | |
| | 496 | | |
| | 500–505 | | |

| | | | | |
|---|---|---|---|---|
| | 506.4 | | | |
| | 515 | | | |
| | 516 | | | |
| | 518.83 | | | |
| | 518.84 | | | |
| | 770.7 | | | |
| Asthma | 493 | | | |
| Diabetes | 249 | | | |
| | 250 | | | |
| | 357.2 | | | |
| | 362.0 | | | |
| | 366.41 | | | |
| | 648.0 | | | |
| | E932.3 | | | |
| Chronic Liver | 571 | 39.1 | 37140 | 37183 |
| | 572 | 42.91 | 37145 | 43204 |
| | 573.0 | | 37160 | 43205 |
| | 456.0 | | 37180 | 43243 |
| | 456.1 | | 37181 | 43244 |
| | 456.2 | | 37182 | 43400 |
| Trisomy 21 | 758.0 | | | |
| Neuromuscular | 333.7 | | | |
| | 343 | | | |
| | 345 | | | |
| | 779.0 | | | |
| | 780.39 | | | |
| | 359 | | | |
| Low birthweight | 765.0 | | | |
| | 765.1 | | | |

**Cross tabulation of prescribing in first and second episode**

| First Episode | | Second Episode: Double down | Steadfast | Give in | One's enough | One visit, prescribed | One visit, not prescribed |
|---|---|---|---|---|---|---|---|
| **Double down** | n | 3 | 2 | 7 | 8 | 98 | 39 |
| | Total % | 0.03 | 0.02 | 0.06 | 0.07 | 0.87 | 0.35 |
| | Row % | 1.91 | 1.27 | 4.46 | 5.1 | 62.42 | 24.84 |
| | Column % | 2.24 | 0.88 | 1.09 | 1.46 | 1.63 | 1.05 |
| **Steadfast** | n | 3 | 8 | 27 | 19 | 166 | 144 |
| | Total % | 0.03 | 0.07 | 0.24 | 0.17 | 1.47 | 1.27 |
| | Row % | 0.82 | 2.18 | 7.36 | 5.18 | 45.23 | 39.24 |
| | Column % | 2.24 | 3.51 | 4.22 | 3.47 | 2.75 | 3.87 |
| **Give in** | n | 15 | 35 | 182 | 100 | 545 | 710 |
| | Total % | 0.13 | 0.31 | 1.61 | 0.88 | 4.82 | 6.28 |
| | Row % | 0.95 | 2.21 | 11.47 | 6.3 | 34.34 | 44.74 |
| | Column % | 11.19 | 15.35 | 28.44 | 18.25 | 9.04 | 19.06 |
| **One's enough** | n | 14 | 23 | 53 | 61 | 416 | 267 |
| | Total % | 0.12 | 0.2 | 0.47 | 0.54 | 3.68 | 2.36 |
| | Row % | 1.68 | 2.76 | 6.35 | 7.31 | 49.88 | 32.01 |
| | Column % | 10.45 | 10.09 | 8.28 | 11.13 | 6.9 | 7.17 |
| **One visit, prescribed** | n | 66 | 63 | 118 | 204 | 3082 | 1059 |
| | Total % | 0.58 | 0.56 | 1.04 | 1.81 | 27.27 | 9.37 |
| | Row % | 1.44 | 1.37 | 2.57 | 4.44 | 67.12 | 23.06 |
| | Column % | 49.25 | 27.63 | 18.44 | 37.23 | 51.15 | 28.43 |
| **One visit, not prescribed** | n | 33 | 97 | 253 | 156 | 1719 | 1506 |
| | Total % | 0.29 | 0.86 | 2.24 | 1.38 | 15.21 | 13.33 |
| | Row % | 0.88 | 2.58 | 6.72 | 4.14 | 45.67 | 40.01 |
| | Column % | 24.63 | 42.54 | 39.53 | 28.47 | 28.53 | 40.43 |

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# CURRICULUM VITAE

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## EDUCATION

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- Major specialization in Health Economics
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- Thesis Title: *Tracking the Little Black 'Rain' Clouds: An Enviro-Economic Analysis of Ambient Air Pollution Effects on Pediatric Asthma*

**2007–2010 Hillsdale College, Hillsdale, MI**
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## PROFESSIONAL EXPERIENCE

**July 2014–Present Boston Medical Center, Boston, MA**
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- Contributed to the design and implementation of cost-effectiveness models for the screening and treatment of Hepatitis C (HCV) infected individuals.
- Leveraged Bayesian methods to predict HCV prevalence in subpopulations such as intravenous drug users, those born in the birth cohort, and publically insured persons.

**August 2012–July 2014 Boston University School of Public Health, Boston, MA**
*Research Coordinator & Student Researcher, Department of Health Policy and Management*

- Studied the outpatient practices at Boston Medical Center to identify predictors of inappropriate prescribing in response to growing antimicrobial resistance. Determined the effectiveness of retention and quality interventions for HIV and STD patients.

- Lead clinicians and public health researchers in appropriate statistical model design and empirical analysis for government and industry sponsored research.

**March 2012 – August 2012 Montana Department of Public Health, Helena, MT**
*Research Consultant, Montana Asthma Control Program*

- Working with the Department of Public Health and Human Services to track and model the health effects of weather inversion events on asthma outcomes in Montana.

**October 2010 – August 2012 Montana State University, Bozeman, MT**
*Graduate Research Assistant, Dept. of Agricultural Economics and Economics*

- Collected, organized, and cleaned data for economic papers in the pre-publication stage. Research efforts focused on Health and Labor economics, and were primarily concerned with education and healthcare.

**June 2011 – Sept. 2011 Centers for Disease Control and Prevention, Atlanta, GA**
*Contractor, Air Pollution and Respiratory Health Branch National Center for Environmental Health*

- Coordinated with the Public Health Surveillance Program to investigate the effect of ambient air pollution on pediatric asthma aggravation and the influence on human capital development.

PEER-REVIEWED PUBLICATIONS

- Perkins RB, **Morgan JR**, Awosogba TP, Ramanadham S, Paasche-Orlow, MK. Gynecologic Outcomes after Hysteroscopic and Laparoscopic Sterilization Procedures. *Obstetrics and Gynecology*. 2016;128(4) [in press]
- Thakarar K, **Morgan JR**, Gaeta JM, Hohl C, Drainoni M. Homelessness, HIV, and Incomplete Viral Suppression. *Journal of Health Care for the Poor and Underserved*. 2016;27(1):145–156
- **Morgan JR**, Drainoni M, Sequeira S, Sullivan M, Hsu K. Getting What You Pay For: The Economics of Quality Care for Sexually Transmitted Infections. *Sexually Transmitted Diseases*. 2016;43(1):18–22
- Sequeira S, **Morgan JR**, Fagan M, Hsu K, Drainoni M. Evaluating Quality of Care for Sexually Transmitted Infections in Different Clinical Settings. *Sexually Transmitted Diseases*. 2015;42(12):717–24
- Drainoni M, Carey KM, **Morgan JR**, Christiansen CL, McDoom MM, Sullivan M. An Interrupted Continuum of Care? What are the Risk Factors and Comorbidities Related to Long-Term Engagement and Retention in HIV Care? *Journal of AIDS & Clinical Research* 2015;6(6):468
- Linas BP, Barter DM, **Morgan JR**, Pho MT, Leff JA, Schackman BR, Horsburgh CR, Assoumou SA, Salomon JA, Weinstein MC, Freedberg KA, Kim AY. The

cost-effectiveness of sofosbuvir-based regimens for treatment of hepatitis C virus genotype 2 or 3 infection. *Annals of Internal Medicine*. 2015;162(9):619–29

- Thakarar K, **Morgan JR**, Gaeta JM, Hohl C, Drainoni ML. Predictors of Frequent Emergency Room Visits among a Homeless Population. *PLoS One*. 2015;10(4):e0124552
- Horný M, **Morgan JR**, Merker VL. Using Medical Claims for Policy Effectiveness Surveillance: Reimbursement and Utilization of Abdomen/Pelvis Computed Tomography Scans. *Health Services Research.* 2015; 50(6):1910–26
- Burgess JF Jr., Jones EA, **Morgan JR**. Capsule commentary on Tannenbaum et al., nudging physician prescription decisions by partitioning the order set: results of a vignette-based study. *Journal of General Internal Medicine.* 2015;30(3):343
- Barlam TF, **Morgan JR**, Wetzler LM, Christiansen CL, Drainoni ML. Comparison of Antibiotic Prescribing for Respiratory Infections in an Outpatient Setting. *Infection Control & Hospital Epidemiology*. 2015;36(02):153–159
- Schechter-Perkins EM, Koppelman E, Mitchell PM, **Morgan JR**, Kutzen R, Drainoni ML. Characteristics of Patients Who Accept and Decline ED Rapid HIV Testing. *The American Journal of Emergency Medicine*. 2014;32(9):1109–12.
- Bekkerman A and **Morgan JR**. Coal Power Plant Emission Exposure and Its Effect on Education Access. *Journal of Public Health.* 2014;22(4): 313–21.

## CONFERENCE PRESENTATIONS

- **Annual Meeting of the Society for Medical Decision Making** 2015. (Lee B. Lusted Prize winner) "A Bayesian Approach to Epidemiologic Estimation for Policy models in the Presence of Sparse Data: the Example of Hepatitis C Prevalence among Injection Drug Users"
- **International Health Economics Association International Congress** 2014. (Dublin) "Antibiotics as Perceived Service: Stewardship through the Disparity Lens"
- **CCCC Tandem Lecture Series** 2014. (Keynote) "Using What We Know: Hospitals, Providers, and Patients in the Battle Against Bloodborne Pathogens"
- **Alderson Broaddus Leadership, Religion, and Ethics Conference**. 2013. (Keynote) "Comparative Ethics and Medical Intervention: Decision-Making from Circumcision to Colonoscopy"
- **National Environmental Health Association Annual Conference.** 2013 "Smog in the Classroom: Power Plant Emissions, Pediatric Asthma, and School Attendance – A New Strategy."
- **Society for Epidemiologic Research Annual Meeting.** 2013. "Underprescribing among Upper Respiratory Infections."

- **Council of State and Territorial Epidemiologists Annual Conference.** 2013. "Factors Influencing Physician Antimicrobial Prescribing At Boston Medical Center Outpatient Facilities."
- **International Society for Environmental Epidemiology Annual Conference.** 2012. "Pollution Effects on Asthma Outcomes During Inversion Events."

  **Morgan, J**., K Loveland, J Frazier. (2012) "Pollution Effects on Asthma Outcomes During Inversion Events." *Epidemiology*, 23(5S) 2012.
- **National Environmental Health Association Annual Conference.** 2012. "Exacerbation of Respiratory Response to $P.M._{2.5}$ During Inversion Events."
- **Montana Chronic Disease Prevention Conference.** 2012. "Weather Inversions and Asthma Outcomes: Environmental Public Health in Montana."
- **Centers for Disease Control and Prevention Asthma Analysis Group**. 2011. "Air Pollution, Asthma Aggravation and Spatial Variation."