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## Nudging Guideline-Concordant Antibiotic Prescribing:

### A Randomized Clinical Trial

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### Abstract

**IMPORTANCE**—“Nudges” that influence decision making through subtle cognitive mechanisms have been shown to be highly effective in a wide range of applications, but there have been few experiments to improve clinical practice.

**OBJECTIVE**—To investigate the use of a behavioral “nudge” based on the principle of public commitment in encouraging the judicious use of antibiotics for acute respiratory infections (ARIs).

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**Author Contributions:** Drs Meeker and Doctor had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

*Study concept and design:* Meeker, Friedberg, Linder, Goldstein, Fox, Doctor.

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*Recruitment and implementation logistics:* Rothfeld, Diaz.

*Programmed electronic health record data feed:* Meeker.

**DESIGN, SETTING, AND PARTICIPANTS**—Randomized clinical trial in 5 outpatient primary care clinics. A total of 954 adults had ARI visits during the study timeframe: 449 patients were treated by clinicians randomized to the posted commitment letter (335 in the baseline period, 114 in the intervention period); 505 patients were treated by clinicians randomized to standard practice control (384 baseline, 121 intervention).

**INTERVENTIONS**—The intervention consisted of displaying poster-sized commitment letters in examination rooms for 12 weeks. These letters, featuring clinician photographs and signatures, stated their commitment to avoid inappropriate antibiotic prescribing for ARIs.

**MAIN OUTCOMES AND MEASURES**—Antibiotic prescribing rates for antibiotic-inappropriate ARI diagnoses in baseline and intervention periods, adjusted for patient age, sex, and insurance status.

**RESULTS**—Baseline rates were 43.5% and 42.8% for control and poster, respectively. During the intervention period, inappropriate prescribing rates increased to 52.7% for controls but decreased to 33.7% in the posted commitment letter condition. Controlling for baseline prescribing rates, we found that the posted commitment letter resulted in a 19.7 absolute percentage reduction in inappropriate antibiotic prescribing rate relative to control ( $P = .02$ ). There was no evidence of diagnostic coding shift, and rates of appropriate antibiotic prescriptions did not diminish over time.

**CONCLUSIONS AND RELEVANCE**—Displaying poster-sized commitment letters in examination rooms decreased inappropriate antibiotic prescribing for ARIs. The effect of this simple, low-cost intervention is comparable in magnitude to costlier, more intensive quality-improvement efforts.

**TRIAL REGISTRATION**—clinicaltrials.gov identifier: NCT01767064

Systems that depend on trusted professionals typically rely on rational models of human decision making. In health care, for example, we assume that the decisions of clinicians are based on scientific knowledge about best practices appropriately applied to each individual patient's needs; we refer to this as the *rational model* of clinician decision making. However, clinician decisions often diverge from the rational model of decision making, even when practice guidelines exist and are widely accepted. An alternative model suggests that clinician decisions are influenced by psychosocial factors such as perceived demand from patients, desire to conform to behavior of peers, concern over the opinion or approval of one's associates, and—importantly—the need to act in ways that are consistent with one's previous public commitments.<sup>1–5</sup> Some of these factors may contribute to overuse of medical care; others may be leveraged to reverse this tendency.

Despite published clinical guidelines for diagnosis<sup>6</sup> and treatment<sup>7,8</sup> of acute respiratory infections (ARIs) and decades of admonitions and clinical interventions, inappropriate antibiotic prescribing for ARIs persists.<sup>9–11</sup> Each year, adults in the United States receive 41.2 million antibiotic prescriptions for ARIs at a cost of \$1.1 billion.<sup>12</sup> Half of these prescriptions are inappropriate, since they are prescribed to treat ARIs for which there is no evidence of benefit.<sup>13</sup> There are multiple reasons for this inappropriate antibiotic prescribing behavior, including “defensive prescribing,” unawareness of diagnostic guidelines (eg, those

allowing clinicians to accurately distinguish between pneumonia and acute bronchitis),<sup>8</sup> patient demand, and workplace culture. None of these common rationalizations constitutes a valid justification for revising prevailing prescription guidelines.<sup>14–16</sup> Inappropriate antibiotic prescribing increases costs of care, causes adverse drug reactions, and, most distressingly, accelerates the evolution of antibiotic-resistant bacteria.<sup>17</sup>

To encourage more judicious use of antibiotics, we designed an intervention that takes advantage of clinicians' desire to be consistent with their public commitments. We developed a simple, low-cost behavioral “nudge”<sup>18</sup> in the form of a public commitment device: a poster-sized letter signed by clinicians and posted in their examination rooms indicating their commitment to reducing inappropriate antibiotic use for ARIs.

## Methods

The randomized trial involved patient and clinician dyads from 5 Los Angeles community clinics. All study procedures were reviewed and approved by the University of Southern California institutional review board prior to study commencement. Participating clinicians provided informed consent; patient informed consent was waived. Clinicians were identified as potential study participants if they met the following eligibility requirements: (1) they were medical professionals licensed to prescribe medications (including antibiotics), and (2) they treated adult patients (age =18 years). Eligible clinicians were given an overview of the study and offered participation during a standard monthly clinic meeting. Interested clinicians were informed (1) that they would be randomly assigned to 1 of 2 groups, a signed-commitment-poster intervention group or a no-poster control group and (2) that all clinicians, regardless of group, would have their baseline and intervention antibiotic prescribing data analyzed as part of the study. We observed patients who met the following inclusion criteria during the study timeframe: (1) they were 18 years or older, and (2) they experienced a visit encounter with a study clinician involving an ARI diagnosis for which antibiotics might or might not have been appropriate (Table 1).<sup>7</sup>

The study timeframe included a complete 1-year flu cycle. This included a three-quarter baseline period followed by poster implementation during peak cold and flu season. Randomization was initiated in February 2012. Using clinic records from a 12-month period (September 2010 to August 2011), we classified clinicians as low or high prescribers of antibiotics. We calculated the number of visits needed for an 80% chance to detect a clinically meaningful difference in antibiotic prescribing (10%), adjusting for intraclinician correlations of 0.010<sup>19,20</sup>; by this calculation, 522 visits were required for a 1-sided  $\alpha$  of 0.05. Randomization was achieved using the statistical programming language R, blocking on above- and below-median (median split) prescribing rates in the 12-month period,<sup>21</sup> with 7 clinicians randomized to each of the 2 conditions: (1) the intervention of a posted commitment letter or (2) the standard practice control. The commitment poster condition required clinician photographs and signatures as endorsement on a poster-sized commitment letter (18 × 24 inches) displayed in their examination rooms for a 12-week period beginning in mid February 2012. All clinicians in our sample used their own examination rooms, limiting the potential of cross-contamination across conditions.

The posted commitment letter, written at the eighth grade reading level and displayed in English and Spanish, emphasized clinician commitment to guidelines for appropriate antibiotic prescribing and explained why antibiotics were not appropriate in many cases. The letter read as follows:

We want to give you some important information about antibiotics.

Antibiotics, like penicillin, fight infections due to bacteria that can cause some serious illnesses. But these medicines can cause side effects like skin rashes, diarrhea, or yeast infections. If your symptoms are from a virus and not from bacteria, you won't get better with an antibiotic, and you could still get these bad side effects.

Antibiotics also make bacteria more resistant to them. This can make future infections harder to treat. This means that antibiotics might not work when you really need them. Because of this, it is important that you only use an antibiotic when it is necessary to treat your illness.

How can you help? Carefully follow your doctor's instructions. He or she will tell you if you should or should not take antibiotics.

When you have a cough, sore throat, or other illness, your doctor will help you select the best possible treatments. If an antibiotic would do more harm than good, your doctor will explain this to you, and may offer other treatments that are better for you.

Your health is very important to us. As your doctors, we promise to treat your illness in the best way possible. We are also dedicated to avoid prescribing antibiotics when they are likely to do more harm than good.

If you have any questions, please feel free to ask your doctor, nurse, or pharmacist.

Analysis was based on a 1-year extract from the clinic electronic health record system. We calculated the relative frequency of patients receiving antibiotic prescriptions for antibiotic-inappropriate ARI diagnoses (Table 1).<sup>7</sup> To control for temporal trends in antibiotic prescribing and provider fixed effects, we fit a logistic mixed effects model that predicted inappropriate antibiotic prescribing as a function of study arm and an indicator for baseline vs intervention period (a difference-in-differences regression), adjusting for age, sex, and insurance status. We also calculated 95% CIs around these estimates. When random assignment is used, variance in group assignment is completely determined by chance, and any difference in groups on covariates is by design, type I error. Therefore, removal of variance in the dependent variable associated with covariates is appropriate with random assignment because it removes only random variance and nothing substantive.<sup>22</sup> The range of values in each CI bracketing these rates was determined through a bootstrapping procedure in R that allows for estimation of the sampling distribution of the adjusted rates.

To investigate the possibility of diagnostic shift (ie, a shift in use of diagnostic codes to conditions that are more antibiotic appropriate) as a result of the posted commitment letter, we compared frequency of proportion of antibiotic appropriate diagnoses for both poster and control conditions in baseline and intervention periods using a logistic mixed effects model.

We also separately tested for evidence that the poster impact decreased over exposure time in the treatment group by regressing inappropriate prescribing rates on time points. Main analyses were conducted using Stata software, version 12.0 (StataCorp LP).

## Results

The Figure shows the flow of study participants. We recruited a total of 15 clinicians; 14 consented to participate, yielding a 93% participation rate. Consenting clinicians included 11 physicians and 3 nurse practitioners; most were women (79%;  $n = 11$ ) with a mean age of 54 years and an average of 17.6 years since medical licensure. We observed 954 adult patients with ARI visits during the study timeframe; 449 were treated by clinicians in the posted-commitment-letter condition (335 in the baseline period, 114 in the intervention period), and 505 were treated by clinicians in the standard practice control condition (384 baseline, 121 intervention). Most patients were women (77%) with a mean age of 48.4 years; 43% were uninsured. Table 2 lists the baseline characteristics of patients and clinicians by condition. Specific ARIs for visit encounters included acute nasopharyngitis (12 visits), acute laryngitis without obstruction (4 visits), acute laryngopharyngitis (3 visits), acute bronchitis (125 visits), acute upper respiratory tract infections of other multiple sites (10 visits), acute upper respiratory tract infections not otherwise specified (448 visits), bronchitis not specified as acute or chronic (181 visits), nonstreptococcal pharyngitis (161 visits), and influenza with other respiratory manifestations (10 visits).

Table 3 lists the prescribing rates during different baseline intervals and the treatment interval for each of the groups. Appropriate prescribing rates varied over time, but the 2 groups varied together throughout the baseline period and diverged after the intervention.

Rates of inappropriate prescribing in the baseline and intervention periods by study arm are listed in Table 4.<sup>21</sup> The adjusted baseline-inappropriate prescribing rate was 43.5% for patients seeing clinicians in the commitment-poster condition and 42.8% for the control condition (the difference was not statistically significant). During the intervention period, the inappropriate prescribing rate was 33.7% (9.8 absolute percentage reduction) for patients seeing clinicians in the poster condition and 52.7% (9.9 absolute percentage increase) for controls. Relative to control, the posted commitment letter resulted in a 19.7 absolute percentage reduction in inappropriate antibiotic prescribing for ARIs ( $P = .02$  for the interaction).

Importantly, there was no evidence of diagnostic shift away from antibiotic-inappropriate diagnosis codes. The odds of selecting an antibiotic-appropriate diagnosis vs an inappropriate diagnosis for patient encounters where antibiotics were prescribed did not change significantly between the baseline and intervention period for either the treatment (odds ratio [OR], 1.09; 95% CI, 0.41–2.90) ( $P = .86$ ) or control group (OR, 0.77; 95% CI, 0.37–1.59) ( $P = .48$ ). The rate of appropriate antibiotic prescribing (based on the presence of diagnosis codes for which antibiotics are warranted [Table 1]) within the poster condition did not decrease during the intervention period. Furthermore, there was a nonsignificant trend toward decreasing inappropriate prescribing during each additional month of poster exposure (OR, 0.50; 95% CI, 0.19–1.32) ( $P = .16$ ).

## Discussion

The most prevalent models for quality improvement have been *audit with feedback* and *pay for performance*, informed by HE-DIS (Healthcare Effectiveness Data and Information Set) and other quality measures. Audit with feedback assumes that knowledge of poor performance either by administrators or clinicians themselves will result in changes to delivery or new behaviors that improve performance. Pay for performance assumes that incentive payments (or penalties) can be used to overcome practices that do not improve quality of care, and changes in measured performance are often the result of coding practices rather than improved quality.<sup>23,24</sup> These models rely largely on the assumption that clinicians, as rational actors, respond to incentives or simple feedback that performance needs improvement while neglecting psychosocial and professional factors that may affect clinical decisions. Findings from the present study support an alternative model suggesting that clinicians are influenced by interpersonal factors within the context of patient care—in particular, a desire to remain consistent with a prior public commitment. To our knowledge, the present intervention is the first attempt to apply the principle of commitment and consistency to the domain of clinician prescribing behavior.

Relative to standard-practice control, we found a significant decrease in unnecessary antibiotic prescribing rates for patients treated by clinicians who signed and posted a letter in their examination rooms emphasizing a commitment to avoid inappropriate antibiotic prescribing for ARIs. The present study moves beyond other randomized trials that relied on examination room posters in the absence of intensive educational interventions. Studies using posters alone to target antibiotic prescribing,<sup>25</sup> and colorectal cancer screening have had weak or negative results.<sup>26,27</sup> Furthermore, unlike quality-improvement interventions based on financial incentives,<sup>24,28,29</sup> we found no evidence that these improvements were driven by changes in clinician coding practices, and we observed no tendency for the intervention to decrease prescribing for appropriate conditions over the 12-week exposure period. Furthermore, the intervention had a sustained effect during each month of the intervention period. Prior systematic reviews have found that passive methods to improve quality of care were less effective than approaches that involved active engagement such as educational efforts; but active engagement is typically expensive and has lower uptake.<sup>30</sup> Our results show that active engagement in the form of public commitment need not involve extensive demands on provider time.

The results here are consistent with results in other applied research areas using public commitments to change behavior. Social psychology research suggests that individuals who make public commitments to specific behaviors are more likely to follow through with these expressed intentions.<sup>2,4,31</sup> For example, in a classic study,<sup>8</sup> participants more successfully resisted pressure to agree with a group in providing an incorrect answer to an easy test question if the participants had publicly provided the correct answer before hearing from the other group members than if they had not done so. Public commitment has been shown to increase recycling,<sup>32–34</sup> heighten participation in hotel towel reuse programs,<sup>35</sup> boost monetary contributions to organizations serving the disabled,<sup>36</sup> and enhance the likelihood of voting in an upcoming election.<sup>37</sup> Indeed, public commitment has been found to be more

effective than education as a tool for prompting greater personal motivation to perform a behavior.<sup>1-3</sup>

Two psychological factors seem to drive the effectiveness of public commitments. First, people place a high value on consistency and follow through with their public commitments to avoid disapproval by their peers.<sup>5</sup> Second, publicly committing to a behavior prompts people to later justify that behavior and identify the behavior with their self-image, which may enhance personal dedication to performing that behavior.<sup>35,38,39</sup>

In recent decades, the fields of psychology and behavioral economics have steadily accumulated evidence contradicting the rational model of clinician behavior. In spite of this evidence, interventions continue to be grounded largely in the rational model, with most clinical interventions focusing on education, awareness training, electronic alerts or reminders, and financial incentives. For example, basic alerts and reminders assume that the clinician will make optimal choices if he or she remembers what constitutes optimal behavior at the time a decision is made. Unfortunately, rationally grounded interventions have not been particularly effective.<sup>40</sup> Thus, investigation of novel approaches is warranted<sup>41</sup> as part of a larger strategy to better understand and favorably influence clinician behavior.<sup>42,43</sup>

In an era of shared decision making, health care interventions that engage patients are critical in changing behavior. Patient responses to the posted commitment letters may also have played a role in the success of our intervention. Previous studies have suggested that patient demand for antibiotics influences clinician prescribing decisions.<sup>14,44</sup> Thus, patients treated in examination rooms displaying the commitment letter may have become better informed about the issues surrounding antibiotic use for ARIs or wished to support their provider's commitment and may have been less likely to expect or demand antibiotics from their clinician. Likewise, it is possible that some clinicians perceived the patients as less demanding (even if this was not the case) due to expectations that the posted commitment letter would be effective. From an implementation standpoint, the possibility of patient-driven effects does not diminish the practical utility of the result.

Our study had several limitations, including limited geographic range, small number of clinicians, and a limited length of observation. Although the study was randomized and stratified on inappropriate prescribing rate, stratification was based only on average prescribing rate, not temporal patterns; there may have been unobserved differences between groups that resulted in different patterns of prescribing over time. Coded electronic health record data have limitations. More detailed assessment with chart abstraction or prospective patient evaluation could reveal clinical detail or diagnostic uncertainty that might justify antibiotic prescribing in individual cases. The target antibiotic prescribing rate for these coded conditions is not necessarily 0.<sup>45</sup> The validity of our results relies on our use of randomization, which is designed to ensure exceptions occur with equal frequency in the control and intervention groups. Similarly, randomization allows for identification of causal effects of the intervention in the presence of variability in prescribing over time.



Although the decrease in inappropriate prescribing in the commitment-poster condition is notable, the rate of inappropriate antibiotic use following the intervention remains high, suggesting a persistent need for additional interventions to encourage judicious use of antibiotics.<sup>46</sup> Future evaluation of the mechanism of the reduction, including the impact on patient behavior, as well as the persistence of effects following poster removal will be important to understand the effect of public commitment in improving long-term prescribing behavior.

## Conclusions

This simple, low-cost, and easily scalable intervention shows great promise in reducing inappropriate antibiotic prescribing and is comparable to prior quality-improvement efforts involving more intensive and costlier designs.<sup>40</sup> When extrapolated to the entire United States, the posted-commitment-letter intervention could eliminate 2.6 million unnecessary antibiotic prescriptions and save \$70.4 million annually on drug costs alone.<sup>12</sup>

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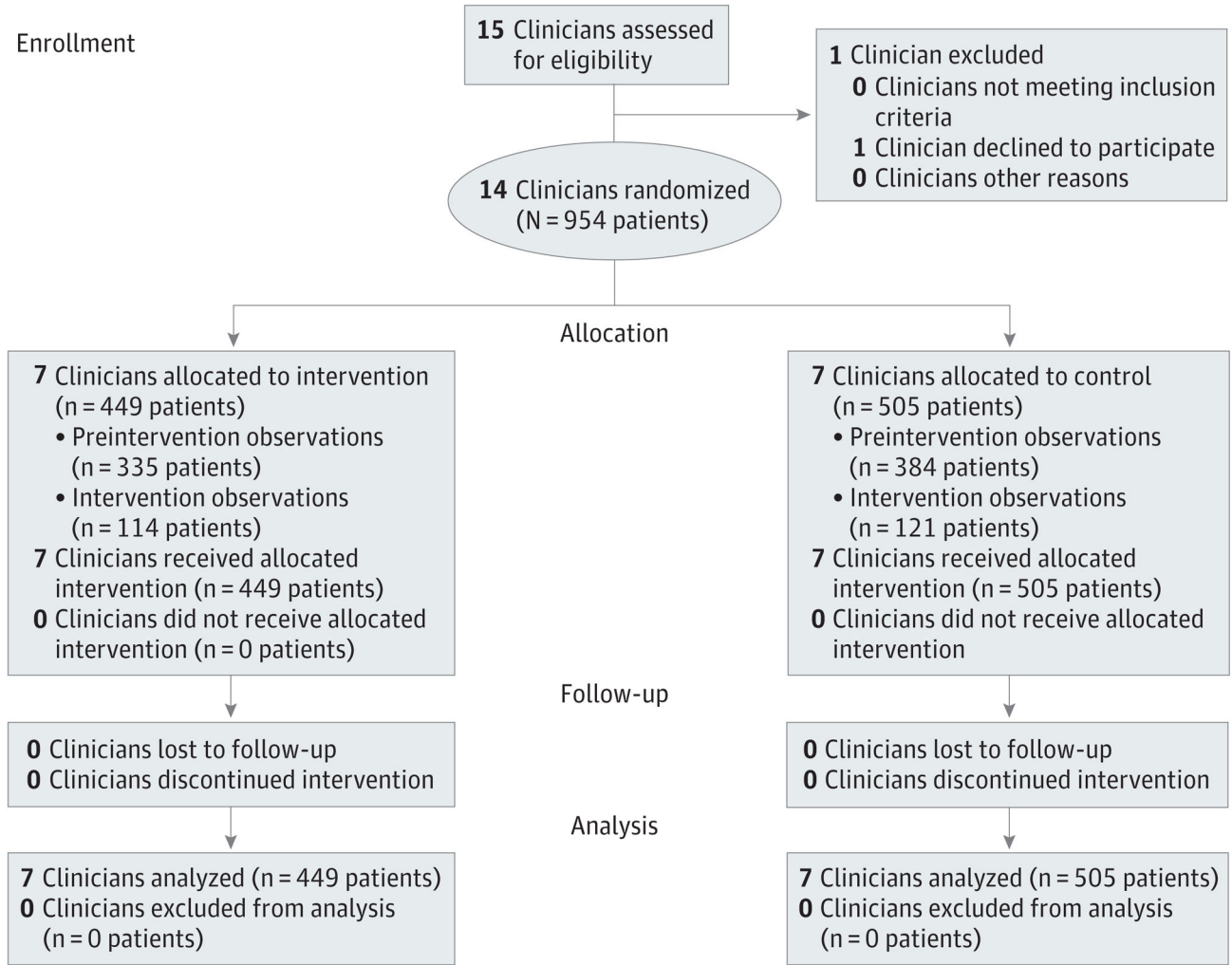
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**Figure. Flow Diagram**  
 A total of 14 clinicians completed the study, treating 954 patients.

**Table 1**Study Diagnosis Codes for Antibiotic-Inappropriate and Antibiotic-Appropriate ARI Diagnoses<sup>a</sup>

ICD-9 Code	Diagnosis
Inappropriate <sup>b</sup>	
460.x	Acute nasopharyngitis
465.8	Acute laryngitis without obstruction
465.0	Acute laryngopharyngitis
466.x	Acute bronchitis
465.8	Acute upper respiratory tract infections of other multiple sites
465.9	Acute upper respiratory tract infections not otherwise specified
490.x	Bronchitis not specified as acute or chronic
462.xx	Nonstreptococcal pharyngitis
487.1	Influenza with other respiratory manifestations
Appropriate <sup>c</sup>	
786.2	Cough
486	Pneumonia, organism not otherwise specified
461.9	Acute sinusitis not otherwise specified
382.9	Otitis media not otherwise specified
473.9	Chronic sinusitis not otherwise specified
463	Acute tonsillitis
034.0	Streptococcal sore throat
382.01	Acute suppurative otitis media with spontaneous rupture of eardrum
491.21	Obstructive chronic bronchitis with (acute) exacerbation
382.00	Acute suppurative otitis media without spontaneous rupture of eardrum
461	Acute sinusitis
491.9	Chronic bronchitis not otherwise specified
472.1	Chronic pharyngitis
381.4	Nonsuppurative otitis media, not specified as acute or chronic
475	Peritonsillar abscess
382.4	Unspecified suppurative otitis media

Abbreviations: ARI, acute respiratory infection; ICD-9, *International Classification of Diseases, Ninth Revision*.

<sup>a</sup>Classifications of diagnoses as appropriate/inappropriate are based on the principles of antibiotic use in the treatment of ARIs.

<sup>b</sup>Diagnoses for which antibiotics are not recommended, used to calculate inappropriate prescribing rates.

<sup>c</sup>Diagnoses for which antibiotics are appropriate, or possibly appropriate (as in cough), used to assess diagnostic shift in coding practices as a result of the commitment-poster intervention.

**Table 2**

## Baseline Characteristics of Patients and Clinicians

Characteristic	Total	Poster Intervention	Control	P Value <sup>a</sup>
<b>Patients</b>				
Sample size	954	449	505	
Men, %	22.6	25	20	.22
Age, mean (SD), y	48.4 (14.9)	45.8 (15.8)	50.7 (13.8)	.02
Insured, %	43.1	48	38	.11
<b>Clinicians</b>				
Sample size	14	7	7	
Age, mean (SD), y	54.3 (10.64)	53 (12.9)	55 (9.5)	.63
Men, No. (%)	3 (21)	2 (29)	1 (14)	.51
Years since licensure, mean (SD)	17.64 (8.41)	18.0 (9.5)	17.2 (9.2)	.88

<sup>a</sup> $\chi^2$  Wald test after adjusting for provider fixed effects.

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**Table 3**Time Trends<sup>a</sup> in Inappropriate Prescribing Rates by Group

Inappropriate Prescribing Rate, %				
Group	6 to 10 Months Prior to Intervention	3 to 6 Months Prior to Intervention	0 to 3 Months Prior to Intervention	Intervention Period
Control	46.2	44.9	37.3	48.8
Intervention	46.4	50.6	40.4	36.0
Difference	0.2	5.7	3.1	12.8

<sup>a</sup>Intervals selected to ensure a minimum of 85 visits contributing to each cell.

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**Table 4**Changes in Adjusted Rates<sup>a</sup> of Inappropriate Antibiotic Prescribing for ARIs

Characteristic	Poster Condition		Control Condition	
	Baseline	Final Measurement	Baseline	Final Measurement
Inappropriate prescribing rate, % (95% CI)	43.5 (38.5 to 49.0)	33.7 (25.1 to 43.1)	42.8 (38.1 to 48.1)	52.7 (44.2 to 61.9)
Absolute percentage change, baseline to final measurement (95% CI)	-9.8 (0.0 to -19.3)		9.9 (0.0 to 20.2)	
Difference in differences between poster condition and control (95% CI)	-19.7 (-5.8 to -33.04) <sup>b</sup>			

Abbreviation: ARI, acute respiratory infection.

<sup>a</sup> Adjusted for demographic characteristics and insurance status.<sup>b</sup>  $P = .02$  for the difference.

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