Title

Scope-of-Practice for Nurse Practitioners and Adherence to Medications for Chronic Illness in Primary Care

Journal

Journal of General Internal Medicine, 36(2)

ISSN

0884-8734

Authors

Muench, Ulrike
Whaley, Christopher
Coffman, Janet
et al.

Publication Date

2021-02-01

DOI

10.1007/s11606-020-05963-3

Peer reviewed

Scope-of-Practice for Nurse Practitioners and Adherence to Medications for Chronic Illness in Primary Care

Ulrike Muench, PhD RN[1,2], *Christopher Whaley, PhD*[3], *Janet Coffman, PhD*[2], *and Joanne Spetz, PhD*[2]

[1]Department of Social and Behavioral Sciences, School of Nursing, University of California, San Francisco, San Francisco, CA, USA; [2]Philip R. Lee Institute for Health Policy Studies, Department of Community and Family Medicine, School of Medicine, University of California, San Francisco, San Francisco, CA, USA; [3]RAND Corporation and School of Public Health, University of California, Berkeley, Berkeley, CA, USA.

BACKGROUND: Nonadherence to medications is costly and improving adherence is difficult, requiring multifactorial solutions, including policy solutions.

OBJECTIVE: The purpose of this study is to evaluate the effect of one policy strategy on medication adherence. Specifically, we examine the effect on adherence of expanding scope-of-practice regulations for nurse practitioners (NPs) to practice and prescribe without physician supervision.

DESIGN: We conducted three difference-in-difference multivariable analyses of commercial insurance claims.

PARTICIPANTS: Patients who filled at least two prescriptions in one of three chronic therapeutic medications: anti-diabetics ($n = 514{,}255$), renin angiotensin system antagonists (RASA) ($n = 1{,}679{,}957$), and anti-lipidemics ($n = 1{,}613{,}692$).

MAIN MEASURES: Medication adherence was measured as the proportion of days covered (PDC). We used one continuous (PDC 0–1) and one binary outcome (PDC of > .8), the latter indicating good adherence.

KEY RESULTS: Patients taking anti-diabetic medications had a 1.9 percentage point higher medication adherence rate ($p < 0.05$) and a 2.7 percentage point higher probability of good adherence ($p < 0.001$) in states that expanded NP scope-of-practice. Medication adherence for patients taking RASA was higher by 2.3 percentage points ($p < 0.001$) and 3.4 percentage points ($p < 0.01$) for both measures, respectively. Patients taking anti-lipidemics saw a smaller, but statistically insignificant, improvement in adherence.

CONCLUSIONS: Results indicate that scope-of-practice regulations that allow NPs to practice and prescribe without physician oversight are associated with improved medication adherence. We postulate that the mechanism for this effect is increased access to health care services, which in turn increases access to prescriptions. Our results suggest that policies allowing NPs to maximally use their skills can be beneficial to patients.

KEY WORDS: medication adherence; nurse practitioners; scope-of-practice; policy evaluation; administrative claims data.

Electronic supplementary material *The online version of this article (https://doi.org/10.1007/s11606-020-05963-3) contains supplementary material, which is available to authorized users.*

Received September 18, 2019
Accepted June 5, 2020
Published online June 24, 2020

J Gen Intern Med 36(2):478–86
DOI: 10.1007/s11606-020-05963-3

INTRODUCTION

The role of medication adherence in managing clinical conditions, especially for patients with chronic illness, is well documented.[1, 2] Yet, over half of US adults are nonadherent to their medications and the health care costs associated with nonadherence are estimated to be in the billions of dollars annually.[3] These costs could increase due to the aging of the Baby Boom generation and anticipated growth in the number of Americans with chronic conditions.[4] Barriers to medication adherence are numerous and a multifactorial intervention approach, including patient, provider, system, and policy strategies, has been suggested.[5] This paper examines the impact of one policy option—expanding scope-of-practice for nurse practitioners (NPs)—on medication adherence. Although this policy was not specifically designed to improve medication adherence, it could improve adherence by improving access to care from qualified clinicians, which could improve access to medications.

Projected shortfalls in the number of primary care physicians[6, 7] have led policymakers and health care leaders to advocate for enabling non-physician providers, such as NPs, to practice without physician supervision. Twenty-eight states and the District of Columbia have enacted scope-of-practice laws that allow NPs to practice and prescribe without physician supervision.[8] Despite a large number of studies affirming NP care to be equivalent to physician care across a range of primary care outcomes,[9–13] including medication adherence,[14] many states continue to have restrictive scope-of-practice laws. These laws typically require NPs to work under supervision or in collaboration with a physician for two components of their care: practice and prescribing. This can entail chart reviews, co-signatures on procedures and prescriptions, limits on days' supply and refills, and other requirements.[15, 16]

The Effect of Expanded Nurse Practitioner Scope-of-Practice Laws

Ongoing debates about whether states should limit the level of NP autonomy have spurred research that assesses the associations between quality of NP care and scope-of-practice. Studies have generally found no statistically significant differences in NP quality measures, and these outcomes were not affected by scope-of-practice.[17–19] Other studies have assessed the causal effects of scope-of-practice changes on economic, market, and utilization measures such as wages,[20] provider supply,[21–24] prices,[20, 25, 26] spending,[25–27] access to care,[24, 26, 28] inpatient admissions,[23] avoidable hospitalizations, and emergency department visits.[24, 28] Despite mixed results on access, prices for services, and overall patient spending, studies have provided evidence that expanded scope-of-practice does not compromise the quality of care,[20, 24] may lead to reorganization of the delivery of care services,[25, 26] and may be an effective tool to improve health and utilization outcomes for some populations.[26, 28–30] The effect on the use of medications was the focus of a recent study that analyzed access to behavioral health medications for Medicaid patients in underserved areas. Findings showed increased access to prescriptions, suggesting that independent scope-of-practice may particularly benefit disadvantaged populations.[31] Another recent paper found that Medicare patients who moved from restricted states to independent states had increased prescription spending and an increase in the number of prescriptions, although the latter was not statistically significant.[26] Proposed mechanisms for these effects include that an increase in the supply of primary care providers and associated increases in primary care services improve access to care and medications, reduce acute care services, and improve overall health.

The Relationship between NP Scope-of-Practice Laws and Medication Adherence

To date, no studies of the relationship between NP scope-of-practice laws and patient outcomes have considered medication adherence. Adherence is an important quality measure because of its role in reducing health care costs and utilization and because of its contribution in improving individual and population-level health outcomes.[32–35] It is one component in Medicare's Part D Star Rating system, highlighting its contribution to health care quality.[36]

Medication adherence consists of three phases: initiation, implementation, and persistence. Nonadherence can occur at any stage, through late or non-initiation of the prescribed treatment, sub-optimal implementation of the dosing regimen, or early discontinuation of the treatment.[37] We hypothesize that expanded scope-of-practice for NPs can improve medication adherence at any stage through several potential mechanisms. First, NPs may foster medication adherence more effectively than physicians because they are formally trained in patient-centered holistic care and communication,[38] which in turn could affect prescribing practices, provider communication, trust, and the ability to educate the patient on the medication and its side effects, all of which are key elements to achieving good adherence.[39–44] Evidence supports differences in practice styles between NPs and physicians; patients who received care from NPs had longer patient visits[45, 46] and received more educational services.[17] Research has found that NPs prescribed medications for shorter days' supply than physicians but with higher refill rates, leading to a greater number of days supplied overall.[47] Second, expanded NP scope-of-practice could increase access to medications through greater availability of providers. Research has found that there are a greater number of NPs in states with expanded scope-of-practice,[21, 23] which could increase health care access in general and medication access in particular. In fact, studies have documented a link between independent NP scope-of-practice and increases in the aggregate number of medications prescribed.[17, 26, 31] Thus, it is plausible that improvements could occur during each of the adherence phases.

This paper makes two contributions to the literature. First, adherence is a common and costly problem, and expanding NP scope-of-practice might be one policy that can facilitate improvement in adherence. Second, and more broadly, our study evaluates the relationship of NP scope-of-practice on a clinical quality outcome at the patient level, which is an important and neglected component in the literature on the potential impact of removing physician oversight requirements for NPs.

METHODS

Study Design and Data Sources

Most research on the relationship between NP scope-of-practice laws and patient outcomes have used population-level data or cross-sectional patient-level data. This study used longitudinal individual-level patient data, which enables us to implement a retrospective quasi-experimental study using a difference-in-difference design. With the difference-in-difference design, we are able to control for differences between patients and trends over time, which improves the precision of our estimates of the association between expanding scope-of-practice regulations and adherence. We analyzed commercial insurance claims for the years 2008–2012 from the Health Care Cost Institute (HCCI). The HCCI data contained data from three contributors—Aetna, Humana, and UnitedHealthcare—for approximately 50 million individuals located in every US state and metropolitan region. We also used the publicly available Area Health Resources File (AHRF), years 2008–2012, to obtain state-level control variables which were merged to the HCCI data at the state-year level.

The adherence measure used in this study (described in detail below) is a National Quality Forum (NQF) measure endorsed by the Pharmacy Quality Alliance[48] and is used by the Center for Medicare and Medicaid Services as a quality

indicator in their Star Ratings.[49, 50] We identified medications from data available from the Pharmacy Quality Alliance,[51] which include National Drug Identification Codes (NDC) for both brand and generic pharmaceuticals. NDC codes were merged with the HCCI pharmacy claims to identify patients taking the medications of interest. Data on NP scope-of-practice regulations came from the annual Pearson Report.[52, 53] Information was cross-checked with state statutes and state Boards of Nursing. Where there were inconsistencies between these data sources, we used information from statutes.

Sample

We defined our study population as patients with a chronic condition, identified from National Quality Forum Adherence Measure 0541 - *Proportion of Days Covered (PDC): 3 Rates by Therapeutic Category.*[54] This measure includes patients who were using medications in at least one of three major therapeutic categories: anti-diabetics ($n = 514{,}256$), renin angiotensin system antagonists (RASA) ($n = 1{,}679{,}958$), and anti-lipidemics ($n = 1{,}613{,}692$). To be included in the sample, patients were required to have at least two medication fills within a drug class, be continuously enrolled in a health plan during the study period, and reside in the same state in all 5 years. For the anti-diabetic therapeutic group, we excluded patients with one or more prescriptions for insulin as suggested in the measure specifications (see Table 1 Supplementary Material). (For a list of medications in each therapeutic class, see Table 2 Supplementary Material.)

Outcome Measures

Adherence. We calculated the annual proportion of days covered (PDC) for patients on anti-diabetics, RASAs, or anti-lipidemics following the NQF algorithm for measure 0541.[54] This measure uses the fills observed and does not measure whether medications were taken. Note that this measure of adherence includes only two of the three phases of adherence: implementation and persistence/non-persistence. Initiation, the process of taking the first medication, cannot be examined in claims data since we only observe medication fills. The PDC was calculated as the number of days in the measurement period for which a patient had filled prescriptions in a therapeutic class divided by the number of days in the measurement period. The measurement period began with a patient's first fill in one of the drug classes and ended on the last day of each calendar year or the patient's date of death. For example, for a February 1st start date and a 300-day supply in the same year, the medication adherence rate is 0.9 or 90% (300 divided by 333, which is the number of days remaining in the year after February 1). We excluded from our PDC calculations prescriptions for which the first observed fill occurred after the end of March to have a measurement period long enough to capture any nonadherence. Thus, for a November 1 start date and 90 days' supply, the PDC would not be calculated until the following year (starting January 1), with 29 days counting towards the measurement period. The shortest measurement period for a patient was therefore 9 months and the longest was 5 years. Per the measurement algorithm, we accounted for generic ingredient overlap of medications. (For additional details on measurement adjustments, see Table 3 in the Supplementary Material.)

The NQF 0541 measure recognizes high or good adherence as a PDC level of at least 0.80 with the rationale that medications have the greatest potential clinical benefit at or above 0.80.[54] While this is an arbitrary cutpoint and studies have shown that significant reductions in health service use can be seen at PDC levels below 80%,[55] we opted to uphold the 0.80 threshold according to the measure specifications to allow standardization and comparability across studies. However, we also used the annual PDC rate as a continuous adherence measure (0–1) as recommended elsewhere.[55] To avoid overestimation, we truncated days' supply on the last day of the measurement period, December 31, 2012.

Independent Variable

Scope-of-Practice. Our independent variable of interest was a binary measure indicating whether a state allowed NPs to both practice and prescribe without physician oversight (1 = full independence, 0 = restricted). Five states switched to allowing NP practice without physician supervision between 2008 and 2012—Maryland (2011), Colorado (2010), Hawaii (2009), North Dakota (2011), and Vermont (2011)—constituting the treatment group; other states served as the comparison group.[52, 56] In the treatment states, the changes in state law permitted NPs to establish a practice without any physician involvement and prescribe medications without physician review or co-signature.

Control Variables

We controlled for time-varying patient characteristics that might affect medication adherence, including patient's age, mean out-of-pocket share, and type of insurance plan. State-level time-varying variables included median annual per capita income and annual unemployment rate from the AHRF. Our analysis also included patient fixed effects, which control for time-invariant characteristics such as race/ethnicity, gender, and chronic comorbidities.

Analysis

Difference-in-difference estimation was used to measure the associations between removing requirements for physician oversight of NPs on medication adherence (continuous outcome) and on good medication adherence (> 0.8; binary outcome). For both adherence outcomes, we estimated regressions for each drug class cohort at the person and year level using the following general specification:

$$y_{ist} = \alpha + \delta_{DD}\text{scope}_{st} + \text{year}_t + \text{patient}_i + X_{ist} + \varepsilon_{ist}.$$

Table 1 Descriptive Statistics for the Three Drug Class Cohorts by NP Scope-of-Practice

	Anti-diabetics ($n = 514,255$)			RASA ($n = 1,679,957$)			Anti-lipidemics ($n = 1,613,692$)		
	Treatment %	Control %	*p* value	Treatment %	Control %	*p* value	Treatment %	Control %	*p* value
Age groups [%]			< 0.001			< 0.001			< 0.001
0–17	0.28	0.34		0.16	0.16		0.04	0.04	
18–24	0.76	0.71		0.28	0.28		0.12	0.11	
25–34	3.92	3.75		2.28	2.44		1.34	1.35	
35–44	11.03	10.07		10.87	10.01		8.87	7.86	
45–54	25.05	22.28		27.51	24.15		26.80	23.08	
55–64	32.48	29.67		32.97	30.42		36.26	33.11	
65–74	18.10	21.36		16.64	19.70		17.60	21.31	
75–84	6.85	9.62		7.17	9.83		7.17	10.42	
> 85	1.53	2.20		2.12	3.01		1.82	2.72	
Year [%]			< 0.001			< 0.001			< 0.001
2008	15.76	14.37		17.22	16.00		16.46	15.17	
2009	19.65	21.13		20.12	21.37		20.32	21.16	
2010	21.58	21.80		20.88	20.86		21.07	20.96	
2011	21.85	21.22		20.83	20.46		21.20	20.85	
2012	21.16	21.49		20.95	21.31		20.94	21.86	
Insurance type [%]			< 0.001			< 0.001			< 0.001
EPO	7.70	4.95		7.50	4.75		7.78	4.35	
HMO	35.99	27.69		34.33	26.51		30.20	26.55	
IND	3.83	3.48		4.45	4.05		4.60	4.52	
OTH	–	0.02		–	0.02		–	0.03	
PFF	4.13	5.86		4.03	5.47		3.80	5.44	
POS	35.36	38.16		36.51	38.65		40.00	38.80	
PPO	12.98	19.84		13.17	20.55		13.62	20.31	
Out of pocket share	0.56 (0.0003)	0.54 (0.0003)	< 0.001	0.56 (0.0002)	0.54 (0.0002)	< 0.001	0.56 (0.0002)	0.53 (0.0002)	< 0.001
Median household income	63,795.84 (18.164)	49,503.38 (11.371)	< 0.001	63,525.84 (9.940)	49,538.67 (6.363)	< 0.001	62,916.85 (9.967)	49,777.37 (6.583)	< 0.001
Unemployment	7 (0.0035)	8.48 (0.0032)	< 0.001	6.97 (0.0019)	8.42 (0.0018)	< 0.001	7.05 (0.0019)	8.44 (0.0019)	< 0.001
N	155,683	358,572		526,553	1,153,404		523,478	1,090,214	

Continuous variables tested with t test [mean (SD), categorical variables [%] tested with Pearson chi-squared test

In this expression, y_{ist} measures the outcomes of adherence for patient i who lives in state s during year t. The scope_{st} variable indicates if physician oversight was required in each state and year and equals to 1 if no oversight was in place. X_{ist} controls for time-varying patient characteristics. The patient and year fixed effects negate the need for the mean treatment and post-period indicators. The fixed effects also control for time-invariant differences between patients and for time trends across the study period. The final model included control variables for insurance plan type, average patient out-of-pocket share, state unemployment rate, and median household income.

We used ordinary least squares regression to estimate this association on continuous adherence and a linear probability model to estimate the association on the binary variable of good adherence. Standard errors were clustered at the state level in all models.

Drawing causal inferences from difference-in-difference regressions require two assumptions.[57, 58] First, there must be no differences in pre-implementation trends between the states with and without physician oversight of NPs. Second, there must not be any contemporaneous policies or programs that might change medication adherence. While the latter assumption is inherently untestable, we estimated event study models to examine pre- and post-implementation adherence trends.

RESULTS

In 2008, 13 states had no restrictions on NP SOP. By 2012, this number had increased to 18 states. Table 1 shows descriptive characteristics for patients in states that lifted scope-of-practice restrictions during the study period (treatment group) and patients in all other states (control group). There were statistically significant differences between the treatment and control groups on all study variables due to the large sample sizes. Noteworthy differences consistent across all drug classes were that patients aged 55–64 were more likely to reside in states that lifted restrictions on scope-of-practice ($p < 0.001$) and that median income was significantly higher in states that lifted restrictions ($p < 0.001$).

Table 2 displays the effect of expanded NP scope-of-practice on the rate of medication adherence and good adherence for unadjusted and adjusted models. Adjusted models showed that following the implementation of expanded NP scope-of-practice, medication adherence increased by 1.9 percentage points (95% CI, 0.6 to 3.1 percentage points, $p < 0.05$) for patients taking anti-diabetes medications and 2.3 percentage points (95% CI, 0.4 to 4.1 percentage points, $p < 0.001$) for patients taking RASA medications. The increase for statin medications was 1.2 percentage points but was not statistically significant (95% CI, −1.4 to 3.8 percentage points). The

Table 2 The Effect of Independent Scope-of-Practice on Adherence

	Anti-diabetics				RASA					Anti-lipidemics		
	PDC 0–1		PDC > .8		PDC 0–1		PDC > .8			PDC 0–1	PDC > .8	
Indep. SOP	0.0172*	0.0185***	0.0247*	0.0266***	0.0217*	0.0227**	0.0324*	0.0336**	0.0119	0.0121	0.0167	0.0169
	(0.0087)	(0.0063)	(0.0128)	(0.0094)	(0.0112)	(0.00891)	(0.0173)	(0.0137)	(0.0128)	(0.00937)	(0.0193)	(0.0139)
Year (ref. 2008)												
2009	–	–	–	–	–	–	–	–	–	–	–	−0.0226***
	0.0268***	0.0092***	0.0402***	0.0126***	0.0465***	0.0286***	0.0781***	0.0509***	0.0339***	0.0133***	0.0557***	
	(0.006)	(0.008)	(0.01)	(0.015)	(0.007)	(0.011)	(0.012)	(0.018)	(0.006)	(0.009)	(0.009)	(0.014)
2010	−0.043***	–	−0.063***	−0.0312***	–	−0.052***	–	–	–	–	–	−0.0515***
		0.0226***			0.0728***		0.1222***	0.0905***	0.0563***	0.0316***	0.0911***	
	(0.006)	(0.009)	(0.01)	(0.017)	(0.006)	(0.01)	(0.01)	(0.017)	(0.005)	(0.01)	(0.008)	(0.015)
2011	–	–	–	–	–	–	–	–	–	–	–	−0.0844***
	0.0517***	0.0352***	0.0748***	0.0497***	0.0848***	0.0684***	0.1421***	0.1172***	0.0699***	0.0503***	0.1158***	
	(0.006)	(0.007)	(0.009)	(0.012)	(0.006)	(0.009)	(0.011)	(0.014)	(0.005)	(0.008)	(0.009)	(0.012)
2012	–	−0.057***	–	–	–	−0.087***	–	–	–	−0.07***	–	−0.1153***
	0.0672***		0.0981***	0.0833***	0.0966***		0.1621***	0.1479***	0.0816***		0.1338***	
	(0.008)	(0.008)	(0.012)	(0.012)	(0.008)	(0.01)	(0.014)	(0.016)	(0.007)	(0.008)	(0.011)	(0.013)
Age group (ref. 0–17)												
18–24		−0.109***		−0.156*		–		−0.0857*		−0.0167		−0.0119
						0.0716***						
		(0.0362)		(0.0829)		(0.0235)		(0.0508)		(0.0392)		(0.103)
25–34		−0.240***		−0.354***		−0.132***		−0.158**		−0.102**		−0.121
		(0.0501)		(0.106)		(0.0325)		(0.0630)		(0.0481)		(0.108)
35–44		−0.256***		−0.379***		−0.146***		−0.171***		−0.127**		−0.159
		(0.0490)		(0.107)		(0.0313)		(0.0635)		(0.0475)		(0.108)
45–54		−0.249***		−0.362***		−0.145***		−0.164**		−0.129***		−0.156
		(0.0476)		(0.104)		(0.0329)		(0.0644)		(0.0470)		(0.110)
55–64		−0.243***		−0.349***		−0.140***		−0.156**		−0.126***		−0.148
		(0.0500)		(0.108)		(0.0345)		(0.0654)		(0.0462)		(0.107)
65–74		−0.251***		−0.361***		−0.142***		−0.161**		−0.131***		−0.156
		(0.0478)		(0.102)		(0.0356)		(0.0680)		(0.0448)		(0.103)
75–84		−0.240***		−0.346***		−0.125***		−0.133**		−0.109**		−0.119
		(0.0514)		(0.108)		(0.0316)		(0.0636)		(0.0470)		(0.109)
> 85		−0.251***		−0.364***		−0.131***		−0.149**		−0.111**		−0.120
		(0.0546)		(0.110)		(0.0268)		(0.0620)		(0.0498)		(0.112)
Insurance type (ref. EPO)												
HMO		0.0130		0.0265		0.0116		0.0304		0.0143		0.0351*
		(0.0154)		(0.0306)		(0.0142)		(0.0292)		(0.0108)		(0.0197)
IND		0.0207		0.0412		0.0529***		0.0924***		0.0459***		0.0791***
		(0.0139)		(0.0252)		(0.0103)		(0.0180)		(0.00722)		(0.0166)
OTH		−0.0121		−0.0622		−0.00879		0.0155		0.0329*		0.0704**
		(0.104)		(0.268)		(0.0237)		(0.0426)		(0.0203)		(0.0348)
PFF		−0.0253**		−0.0391*		−0.0184		−0.0216		−0.0177*		−0.0192
		(0.00966)		(0.0212)		(0.0118)		(0.0233)		(0.00964)		(0.0171)
POS		0.0138		0.0293*		0.0201		0.0410*		0.0173**		0.0347**
		(0.00901)		(0.0164)		(0.0121)		(0.0218)		(0.00792)		(0.0159)
PPO		−0.0102		−0.00819		−0.00339		0.00250		0.000534		0.00917
		(0.00664)		(0.0158)		(0.00956)		(0.0192)		(0.00872)		(0.0156)
Out of pocket share		−0.059**		−0.0801*		−0.0575***		−0.0926***		−0.0759***		−0.131***
		(0.0259)		(0.0415)		(0.0191)		(0.0344)		(0.0251)		(0.0451)
Median household income		2.07e-06		3.67e-06		2.62e-06		4.52e-06		3.87e-06*		6.12e-06*

(*continued on next page*)

Table 2. (continued)

	Anti-diabetics			RASA			Anti-lipidemics		
	PDC 0–1	PDC > .8		PDC 0–1	PDC > .8		PDC 0–1	PDC > .8	
		(2.24e-06)	(3.66e-06)		(2.73e-06)	(4.56e-06)	(2.18e-06)		(3.56e-06)
Unemployment rate		–	−0.00652*		–	–	–		–
		0.00424**			0.00411**	0.00609**	0.00462**		0.00704***
		(0.00179)	(0.00331)		(0.00154)	(0.00258)	(0.00188)		(0.00275)
Constant	0.860***	1.037***	0.731***	0.946***	0.878***	0.915***	0.769***	0.735***	0.850***	0.825***	0.716***	0.6435***
	(0.00607)	(0.122)	(0.00934)	(0.192)	(0.0693)	(0.159)	(0.0114)	(0.254)	(0.00629)	(0.122)	(0.00983)	(0.198)
Observations	514,255	514,255	514,255	514,255	1,679,957	1,679,957	1,679,957	1,679,957	1,613,692	1,613,692	1,613,692	1,613,692
R-squared	0.759	0.759	0.714	0.714	0.727	0.727	0.680	0.680	0.739	0.739	0.682	0.682

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

results for analyses of effects on good adherence were similar with slightly larger effect sizes for both the anti-diabetics cohort with a 2.7 percentage point increase (95% CI, 0.7 to 4.6 percentage points, $p < 0.001$) and for patients taking RASA medications with a 3.4 percentage point increase (95% CI, 0.5 to 6.2 percentage points, $p < 0.01$). Unadjusted and adjusted results were quantitatively comparable suggesting that omitted variables are unlikely to bias our results.

We examined pre-implementation trends for both adherence measures by estimating event study models and found no evidence of improvements in adherence prior to law implementation. However, following the expansion of scope-of-practice, adherence increased each year. Figures 1 and 2 show the regression-adjusted trends of continuous and good adherence for the years prior to the implementation of the law (t–2 and t-3) and post implementation (t1, t2, t3, t4) for the three drug classes combined.

DISCUSSION

This study evaluated the association between expanding NP SOP and medication adherence and found that giving NPs autonomy to practice and prescribe without physician oversight has a small positive effect on medication adherence. Given the many barriers associated with improving medication adherence,[5] the 1.8–3.4 percentage point increase observed in our data is meaningful.

The literature on the quality of NP care is robust.[9, 59–61] Prescribing outcomes, however, have been largely absent in this literature until recently,[47, 62, 63] and previous studies have not evaluated the impact of expanding NP scope-of-practice on a patient-level prescribing measure such as adherence. Muench and colleagues examined prescribing patterns of NPs and physicians across a wide range of drug classes, including the number of prescriptions, days supplied, and refill patterns, finding that NPs provided more prescriptions and shorter days' supply, while physicians provided fewer prescriptions and longer days' supply.[47] Jiao and colleagues reported prescribing quality indicators using patient visit information, including aspirin and beta-blocker use for coronary artery disease and did not find that outcomes favored one clinician type over another.[62] One study examined medication adherence by clinician type in Medicare beneficiaries, reporting comparable medication adherence rates for NP and physician patients.[14] This suggests that the increase in medication adherence observed in our study may not be driven by changes in NP patient management but rather by factors that help promote medication adherence, such as increased access to medications. In addition, the mechanisms by which expansion of NP scope-of-practice affects medication adherence among Medicare patients versus commercially insured patients may differ.[26]

One possible explanation for our findings is that patients in treatment and control states filled or took medications at

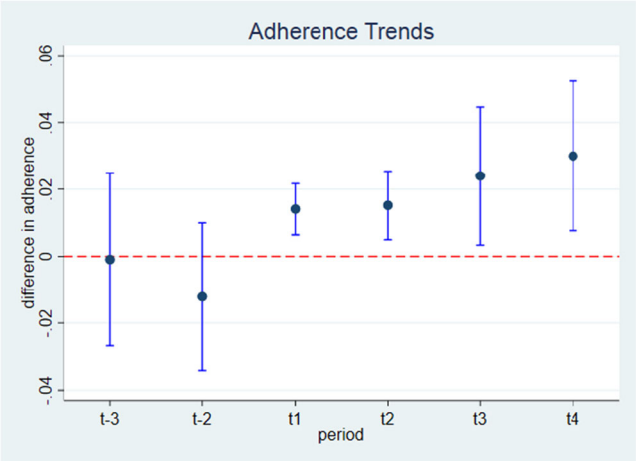

Figure 1 Pre- and post-SOP implementation adherence trends (continuous measure).

systematically different rates during the implementation and persistence phases of adherence. While we cannot rule this out, we are unaware of evidence that would support this inference. One study using the same adherence measure reported that only 9–25% of patients were lacking medication fills for 1 year of data over a 4-year time period.[64] Finally, the quasi-experimental difference-in-difference design accounts for differences in provider practice or patient characteristics at baseline between treatment and control states.

Limitations

This study has a number of limitations. First, we used data from three commercial insurers. The effects of scope-of-practice laws may be different among the populations covered by Medicare, Medicaid, or other insurers. Second, we examined adherence in three chronic drug classes and the results may not apply to other medications. Third, our difference-in-difference design identified changes based on five states that changed to independent scope-of-practice, which might not be generalizable to all states. Fourth, it is important to note that measuring adherence with fills in claims data does not equate to patients taking the medications. Fifth, our model included patient fixed effects to control for time-invariant comorbidities, but did not adjust for acute illness or comorbidities that could have varied during the study period. It is possible that this could have biased our results if patient health is correlated with the implementation of scope-of-practice laws and if these health shocks occurred at different proportions in treatment and control states, but such a correlation seems unlikely. Finally, we do not have information about the extent to which NPs practice closely with physicians, which can occur regardless of legal requirements. Thus, the results should be interpreted as assessing the effect of changes in regulations, not of practice and relationships between providers.

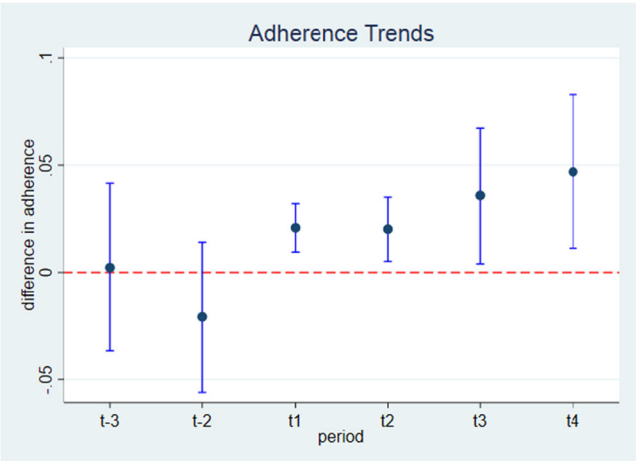

Figure 2 Pre- and post-SOP implementation adherence trends (binary measure).

CONCLUSION

This study aimed to examine the relationship between nurse practitioner scope-of-practice regulations and the important patient-level outcome of medication adherence using a quasi-experimental design. Our results support a growing body of evidence that allowing NPs to practice and prescribe without physician oversight benefits patients.

Corresponding Author: *Ulrike Muench, PhD RN; Department of Social and Behavioral Sciences, School of Nursing, University of California, San Francisco, San Francisco, CA, USA (e-mail: Ulrike.muench@ucsf.edu).*

Funding Information *This study was in part funded by the Laura and John Arnold Foundation through a grant from the Health Care Cost Institute and National Academy for State Health Policy.*

Compliance with Ethical Standards:

Conflict of Interest: *The authors declare that they do not have a conflict of interest.*

REFERENCES

1. **Luga AO**, **McGuire MJ**. Adherence and health care costs. Risk Manag Healthc Policy 2014;7:35-44. doi:https://doi.org/10.2147/RMHP.S19801
2. **Osterberg L**, **Blaschke T**. Adherence to Medication. N Engl J Med 2005;353(5):487-497. doi:https://doi.org/10.1056/NEJMra050100
3. **Aitken M**, **Valkova S**. The $200 Billion Opportunity from Using Medicines More Responsibly. Parsippany: IMS Institute for Healthcare Informatics; 2013.
4. Medicare Payment Advisory Commission. A Databook: Healthcare Spending and the Medicare Program. Washington, DC: Medicare Payment Advisory Commission; 2016. http://www.medpac.gov/docs/default-source/data-book/june-2016-data-book-health-care-spending-and-the-medicare-program.pdf.
5. **Zullig LL**, **Granger BB**, **Bosworth HB**. A renewed Medication Adherence Alliance call to action: harnessing momentum to address medication nonadherence in the United States. Patient Prefer Adherence 2016;10:1189-1195. doi:https://doi.org/10.2147/PPA.S100844
6. U.S. Department of Health and Human Services, Health Resources and Services Administration (HRSA), National Center for Health Workforce

Analysis. Projecting the Supply and Demand for Primary Care Practitioners Through 2020. Rockville, Maryland: U.S. Department of Health and Human Services; 2013. https://bhw.hrsa.gov/sites/default/files/bhw/nchwa/projectingprimarycare.pdf. Accessed 9 Feb 2016.
7. AAMC. The Complexities of Physician Supply and Demand: Projections from 2013 to 2025. Prepared for the Association of American Medical Colleges. Washington, DC: Association of American Medical Colleges; 2015.; 2015. https://www.aamc.org/download/426242/data/ihsreportdownload.pdf?cm_mmc=AAMC-_-ScientificAffairs-_-PDF-_-ihsreport. Accessed 9 June 2016.
8. **Spetz J** Expanding the Role of Nurse Practitioners in California. Physician Oversight in Other States. California Health Care Foundation; 2019. https://www.chcf.org/wp-content/uploads/2019/05/ExpandingNPOversightStates.pdf.
9. **Buerhaus P**, **Perloff J**, **Clarke S**, **O'Reilly-Jacob M**, **Zolotusky G**, **DesRoches CM**. Quality of Primary Care Provided to Medicare Beneficiaries by Nurse Practitioners and Physicians. Med Care 2018. doi:https://doi.org/10.1097/MLR.0000000000000908
10. **Kurtzman ET**, **Barnow BS**. A Comparison of Nurse Practitioners, Physician Assistants, and Primary Care Physicians' Patterns of Practice and Quality of Care in Health Centers. Med Care 2017;55(6):615-622. doi:https://doi.org/10.1097/MLR.0000000000000689
11. **Lenz ER**, **Mundinger MO**, **Kane RL**, **Hopkins SC**, **Lin SX**. Primary Care Outcomes in Patients treated by Nurse Practitioners or Physicians: Two-Year Follow-Up. Med Care Res Rev 2004;61(3):332-351. doi:https://doi.org/10.1177/1077558704266821
12. **Newhouse RP**, **Stanik-Hutt J**, **White KM**, **et al.** Advanced Practice Nurse Outcomes 1990-2008: A Systematic Review. Nurs Econ 2011;29(5):1.
13. **Stanik-Hutt J**, **Newhouse RP**, **White KM**, **et al.** The Quality and Effectiveness of Care Provided by Nurse Practitioners. Jnp-J Nurse Pract. 2013;9(8):492-+. doi:https://doi.org/10.1016/j.nurpra.2013.07.004
14. **Muench U**, **Guo C**, **Thomas CP**, **Perloff J**. **Adherence, ER** Visits and Costs of Nurse Practitioner and Primary Care Physician Patients: Evidence from Three Cohorts of Medicare Beneficaries. Forthcom Health Serv Res. 2018.
15. **Park J**, **Athey E**, **Pericak A**, **Pulcini J**, **Greene J**. To What Extent Are State Scope of Practice Laws Related to Nurse Practitioners' Day-to-Day Practice Autonomy? Med Care Res Rev 2018;75(1):66-87. doi:https://doi.org/10.1177/1077558716677826
16. American Medical Association. State Law Chart: Nurse Practitioner Prescriptive Authority.; 2017. https://www.ama-assn.org/sites/ama-assn.org/files/corp/media-browser/specialty%20group/arc/ama-chart-np-prescriptive-authority.pdf.
17. **Kurtzman ET**, **Barnow BS**, **Johnson JE**, **Simmens SJ**, **Infeld DL**, **Mullan F**. Does the Regulatory Environment Affect Nurse Practitioners' Patterns of Practice or Quality of Care in Health Centers? Health Serv Res 2017;52:437-458. doi:https://doi.org/10.1111/1475-6773.12643
18. **Ortiz J**, **Hofler R**, **Bushy A**, **Lin Y-L**, **Khanijahani A**, **Bitney A**. Impact of Nurse Practitioner Practice Regulations on Rural Population Health Outcomes. Healthcare. 2018;6(65). doi:https://doi.org/10.3390/healthcare6020065
19. **Perloff J**, **Clarke S**, **DesRoches CM**, **O'Reilly-Jacob M**, **Buerhaus P**. Association of State-Level Restrictions in Nurse Practitioner Scope of Practice With the Quality of Primary Care Provided to Medicare Beneficiaries. Med Care Res Rev 2017:1077558717732402. doi:https://doi.org/10.1177/1077558717732402
20. **Kleiner MM**, **Marier A**, **Park KW**, **Wing C**. Relaxing Occupational Licensing Requirements: Analyzing Wages and Prices for a Medical Service. J Law Econ 2016;59(2):261-291. doi:https://doi.org/10.1086/688093
21. **Graves JA**, **Mishra P**, **Dittus RS**, **Parikh R**, **Perloff J**, **Buerhaus PI**. Role of Geography and Nurse Practitioner Scope-of-Practice in Efforts to Expand Primary Care System Capacity: Health Reform and the Primary Care Workforce. Med Care 2016;54(1):81-89. doi:https://doi.org/10.1097/MLR.0000000000000454
22. **Kalist DE**, **Spurr SJ**. The effect of state laws on the supply of advanced practice nurses. Int J Health Care Finance Econ 2004;4(4):271–281.
23. **Kuo Y-F**, **Loresto FL**, **Rounds LR**, **Goodwin JS**. States with the least restrictive regulations experienced the largest increase in patients seen by nurse practitioners. Health Aff (Millwood) 2013;32(7):1236-1243. doi:https://doi.org/10.1377/hlthaff.2013.0072
24. **Stange K.** How does provider supply and regulation influence health care markets? Evidence from nurse practitioners and physician assistants. J Health Econ 2014;33:1-27. doi:https://doi.org/10.1016/j.jhealeco.2013.10.009
25. **Whaley C**, **Muench U**, **Spetz J**. The Effects of Nurse Practitioner Scope of Practice Laws on Healthcare Spending, Prices, and Access. RR Med Care Res Rev 2018.
26. **Koch T**, **Petek N**. The Effect of Nurse Practitioner Scope of Practice Laws on Health Care Utilization and Health: Evidence from Law Changes and Patient Moves. Fed Trade Comm Work Pap 2019.
27. **Spetz J**, **Parente ST**, **Town RJ**, **Bazarko D**. Scope-Of-Practice Laws For Nurse Practitioners Limit Cost Savings That Can Be Achieved In Retail Clinics. Health Aff (Millwood) 2013;32(11):1977-1984. doi:https://doi.org/10.1377/hlthaff.2013.0544
28. **Traczynski J**, **Udalova V**. Nurse practitioner independence, health care utilization, and health outcomes. J Health Econ 2018;58:90-109. doi:https://doi.org/10.1016/j.jhealeco.2018.01.001
29. **Alexander D**, **Schnell M**. Just What the Nurse Practitioner Ordered: Independent Prescriptive Authority and Population Mental Health. Rochester: Social Science Research Network; 2018. https://papers.ssrn.com/abstract=2985991. Accessed September 3, 2018.
30. **Hamilton MR**. Three Essays in Health Economics. Univeristy of Michigan; 2017. https://deepblue.lib.umich.edu/bitstream/handle/2027.42/138556/hamiltmr_1.pdf?sequence=1&isAllowed=y. Accessed 2 June 2018.
31. **Alexander D**, **Schnell M**. Just what the nurse practitioner ordered: Independent prescriptive authority and population mental health. J Health Econ 2019;66:145-162. doi:https://doi.org/10.1016/j.jhealeco.2019.04.004
32. **Balkrishnan R**, **Rajagopalan R**, **Camacho FT**, **Huston SA**, **Murray FT**, **Anderson RT**. Predictors of medication adherence and associated health care costs in an older population with type 2 diabetes mellitus: a longitudinal cohort study. Clin Ther 2003;25(11):2958-2971.
33. **Karve S**, **Markowitz M**, **Fu D-J**, et al. Assessing Medication Adherence and Healthcare Utilization and Cost Patterns Among Hospital-Discharged Patients with Schizoaffective Disorder. Appl Health Econ Health Policy 2014;12(3):335-346. doi:https://doi.org/10.1007/s40258-014-0095-8
34. **Pittman DG**, **Tao Z**, **Chen W**, **Stettin GD**. Antihypertensive medication adherence and subsequent healthcare utilization and costs. Am J Manag Care 2010;16(8):568-576.
35. **Roebuck MC**, **Liberman JN**, **Gemmill-Toyama M**, **Brennan TA**. Medication adherence leads to lower health care use and costs despite increased drug spending. Health Aff (Millwood) 2011;30(1):91-99. doi:https://doi.org/10.1377/hlthaff.2009.1087
36. **Lau DT**, **Briesacher BA**, **Touchette DR**, **Stubbings J**, **Ng JH**. Medicare Part D and Quality of Prescription Medication Use. Drugs Aging 2011;28(10):797-807. doi:https://doi.org/10.2165/11595250-000000000-00000
37. **Vrijens B**, **De Geest S**, **Hughes DA**, et al. A new taxonomy for describing and defining adherence to medications. Br J Clin Pharmacol 2012;73(5):691-705. doi:https://doi.org/10.1111/j.1365-2125.2012.04167.x
38. American Association of Nurse Practitioners. What's an NP? https://www.aanp.org/all-about-nps/what-is-an-np#unique-approach. Published 2018. Accessed 30 Aug 2018.
39. **Wroth TH**, **Pathman DE**. Primary Medication Adherence in a Rural Population: The Role of the Patient-Physician Relationship and Satisfaction with Care. J Am Board Fam Med 2006;19(5):478-486. doi:https://doi.org/10.3122/jabfm.19.5.478
40. **Schoenthaler A**, **Chaplin WF**, **Allegrante JP**, et al. Provider communication effects medication adherence in hypertensive African Americans. Patient Educ Couns 2009;75(2):185-191. doi:https://doi.org/10.1016/j.pec.2008.09.018
41. **Harmon G**, **Lefante J**, **Krousel-Wood M**. Overcoming barriers: the role of providers in improving patient adherence to antihypertensive medications. Curr Opin Cardiol 2006;21(4):310–315. doi:https://doi.org/10.1097/01.hco.0000231400.10104.e2
42. **Viswanathan M**, **Golin CE**, **Jones CD**, et al. Interventions to improve adherence to self-administered medications for chronic diseases in the United States: a systematic review. Ann Intern Med 2012;157(11):785-795. doi:https://doi.org/10.7326/0003-4819-157-11-201212040-00538
43. **Piette JD**, **Heisler M**, **Krein S**, **Kerr EA**. The Role of Patient-Physician Trust in Moderating Medication Nonadherence Due to Cost Pressures. Arch Intern Med 2005;165(15):1749-1755. doi:https://doi.org/10.1001/archinte.165.15.1749
44. **Martin LR**, **Williams SL**, **Haskard KB**, **DiMatteo MR**. The challenge of patient adherence. Ther Clin Risk Manag 2005;1(3):189-199.
45. **Horrocks S**, **Anderson E**, **Salisbury C**. Systematic review of whether nurse practitioners working in primary care can provide equivalent care

to doctors. BMJ. 2002;324(7341):819-823. doi:https://doi.org/10.1136/bmj.324.7341.819
46. **Kinnersley P**, **Anderson E**, **Parry K**, et al. Randomised controlled trial of nurse practitioner versus general practitioner care for patients requesting "same day" consultations in primary care. BMJ. 2000;320(7241):1043-1048. doi:https://doi.org/10.1136/bmj.320.7241.1043
47. **Muench U**, **Perloff J**, **Thomas CP**, **Buerhaus PI**. Prescribing Practices by Nurse Practitioners and Primary Care Physicians: A Descriptive Analysis of Medicare Beneficiaries. J Nurs Regul 2017;8(1):21-30.
48. Pharmacy Quality Allience. PQA Measure Overview. Virginia: PQA Alliance; 2019. https://www.pqaalliance.org/assets/Measures/2019_PQA_Measure_Overview.pdf.
49. Centers for Medicare & Medicaid Services (CMS). Medicare 2018 Part C & D Star Ratings Technical Notes.; 2017. https://www.cms.gov/Medicare/Prescription-Drug-Coverage/PrescriptionDrugCovGenIn/Downloads/2018-Star-Ratings-Technical-Notes-2017_09_06.pdf.
50. Pharmacy Quality Allience. PQA Measures Used By CMS in the Star Ratings & As Display Ratings Program. http://pqaalliance.org/measures/cms.asp. Published 2017. Accessed 5 Oct 2017.
51. Pharmacy Quality Alliance. Measure Licensing & Use. https://pqa.memberclicks.net/measure-licensing-use. Published 2018. Accessed 15 March 2020
52. **Pearson L.** The Pearson Report. Am J Nurse Pract 2009;13(2):8-82.
53. **Pearson L.** 24th Annual Legislative Update. Nurs Pract 2012;37(1):22–45.
54. National Quality Forum. Proportion of Days Covered (PDC): 3 Rates by Therapeutic Category. http://goo.gl/MjyDAC. Published 2014. Accessed 1 Nov 2014.
55. **Roebuck MC**, **Kaestner RJ**, **Dougherty JS**. Impact of Medication Adherence on Health Services Utilization in Medicaid. Med Care 2018;56(3):266-273.
56. **Phillips SJ**. 25th Annual Legislative Update. Nurs Pract 2013;38(1):18–42.
57. **Dimick JB**, **Ryan AM**. Methods for Evaluating Changes in Health Care Policy: The Difference-in-Differences Approach. JAMA. 2014;312(22):2401-2402. doi:https://doi.org/10.1001/jama.2014.16153
58. **Imbens GW**, **Wooldridge JM**. Recent Developments in the Econometrics of Program Evaluation. J Econ Lit 2009;47(1):5-86. doi:https://doi.org/10.1257/jel.47.1.5
59. **Laurant M**, **Harmsen M**, **Wollersheim H**, **Grol R**, **Faber M**, **Sibbald B**. The Impact of Nonphysician Clinicians. Med Care Res Rev. 2009;66(6_suppl):36S-89S. doi:https://doi.org/10.1177/1077558709346277
60. **Naylor MD**, **Kurtzman ET**. The Role Of Nurse Practitioners In Reinventing Primary Care. Health Aff (Millwood). 2010;29(5):893-899. doi:https://doi.org/10.1377/hlthaff.2010.0440
61. **Swan M**, **Ferguson S**, **Chang A**, **Larson E**, **Smaldone A**. Quality of primary care by advanced practice nurses: a systematic review. Int J Qual Health Care 2015;27(5):396-404. doi:https://doi.org/10.1093/intqhc/mzv054
62. **Jiao S**, **Murimi IB**, **Stafford RS**, **Mojtabai R**, **Alexander GC**. Quality of Prescribing by Physicians, Nurse Practitioners, and Physician Assistants in the United States. Pharmacotherapy. 2018. doi:https://doi.org/10.1002/phar.2095
63. **Ladd E**, **Sweeney CF**, **Guarino A**, **Hoyt A**. Opioid Prescribing by Nurse Practitioners in Medicare Part D: Impact of State Scope of Practice Legislation. Med Care Res Rev 2017. doi:https://doi.org/10.1177/1077558717725604
64. **Muench U**, **Guo C**, **Thomas C**, **Perloff J**. Medication adherence, costs, and ER visits of nurse practitioner and primary care physician patients: Evidence from three cohorts of Medicare beneficiaries. Health Serv Res 2019;54(1):187-197. doi:https://doi.org/10.1111/1475-6773.13059