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Scope-of-Practice Laws and Patient Safety: Evidence from the Opioid Crisis

Benjamin J. McMichael*

Abstract

Scope-of-practice laws that restrict Nurse Practitioners' (NPs) ability to deliver healthcare are justified as necessary to promote patient safety and protect patients from providers with less training than physicians. Analyzing a dataset of over 1.3 billion opioid prescriptions at the individual-provider level, I evaluate this justification in the context of the ongoing opioid crisis. I examine whether allowing NPs to practice independently of physicians increases opioid prescriptions. Granting NPs independence increases NP opioid prescriptions but decreases physician opioid prescriptions across three different measures of prescriptions. The net effect is an overall decrease of about 1.2 percent in morphine milligram equivalents prescribed across all providers. The results suggest that restrictive scope-of-practice laws are not necessary to protect patients from the overuse of dangerous drugs and that these laws may increase the use of these medications and undermine patient safety.

Keywords: opioid, nurse practitioner, scope of practice, healthcare workforce

JEL codes: I11, I18, J44, K10

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1. Introduction

Access to healthcare continues to dominate the national health policy debate, even almost a decade after the passage of the Affordable Care Act. This debate has largely centered on ways to improve access via demand-side policies, i.e., policies that increase the availability and decrease the cost of health insurance, while de-emphasizing supply-side policies, i.e., policies that affect the supply of providers willing and able to supply healthcare. However, at least as important as the availability of health insurance is the availability of a healthcare workforce to deliver the care demanded by individuals. And recent work suggests that many areas of the country currently lack an adequate supply of providers and that this dearth of supply will only become more acute over the next decade (Pettersen et al. 2012; Association of American Medical Colleges 2018; Skinner et al. 2018).

One policy option that has the potential to mitigate provider shortages is the increased use of Nurse Practitioners (NPs) to provide care alongside physicians. NPs are registered nurses who have undergone additional training to provide healthcare services historically provided by physicians. In general, NPs may evaluate patients, provide diagnoses, offer treatment, and prescribe medications. The Bureau of Labor Statistics estimates that, in 2017, approximately 166,000 NPs were practicing (Bureau of Labor Statistics 2018). NPs are the principle source of care in many geographic areas (Auerbach 2012) and are more likely than physicians to practice in rural and underserved communities (Larson et al. 2003; Grumbach et al. 2003; Everett et al. 2009).

While NPs provide healthcare services across the country, their ability to do so is not equal in all areas. State scope-of-practice (SOP) laws—a subset of the occupational licensing laws that govern NPs and many other professionals—determine what services NPs may provide and the conditions under which they may provide those services. Two specific types of SOP laws are

particularly important for NPs. First, physician supervision laws determine the degree of physician supervision required for an NP. Second, prescriptive authority laws determine the medications that NPs may prescribe. When NPs can practice without any physician supervision *and* prescribe a full range of medications, they can practice independently. Prior work has shown that granting NPs more autonomy can facilitate access to care (Graves et al 2016; McMichael 2018; Traczynski and Udalova 2018), improve the quality of care (Traczynski and Udalova 2018), reduce the use of intensive medical procedures (Markowitz et al. 2017), and reduce the price of some healthcare services (Kleiner et al. 2016).

Based on this type of evidence, reports by the National Academy of Medicine¹ and staff at the Federal Trade Commission, among others, recommend that NPs be granted more autonomy (IOM 2011; Gilman and Koslov 2014). However, only a minority of states have followed these recommendations. One of the reasons states may have chosen to maintain restrictive SOP laws for NPs is the opposition to the relaxation of these laws by physician groups. The American Medical Association adopted a resolution in 2017 to “[e]ffectively oppose the continual, nationwide efforts to grant independent practice . . . to non-physician practitioners [including NPs]” (AMA 2017). While the debate over SOP laws does not break down along partisan lines,² previous work has demonstrated that opposition by physician interest groups can successfully deter states from allowing NPs to practice independently (McMichael 2017). When opposing NP independence, physician groups often emphasize the greater training physicians are required to complete relative to NPs and argue that requiring physician supervision promotes patient safety and the delivery of

¹ The National Academy of Medicine was formerly known as the Institute of Medicine (IOM).

² In 2018, both the right-leaning American Enterprise Institute and the left-leaning Brookings Institution issued reports calling for the relaxation of NP SOP laws (Buerhaus 2018; Adams and Markowitz 2018).

high-quality care (American Academy of Family Physicians 2017). In contrast to these claims, clinical evidence suggests that the care delivered by NPs generally results in healthcare outcomes that equal or exceed the outcomes achieved by physicians (IOM 2011; Schiff 2012; Dunker, Krofah, and Isasi 2014; Gilman and Koslov 2014; Newhouse et al. 2011; Naylor and Kurtzman 2010). Additionally, prior work has noted that physician opposition to relaxing NP SOP laws may stem from anticompetitive concerns and the desire to protect their market power (Markowitz et al. 2017; Kleiner et al. 2016).

This paper contributes to the ongoing debate over NP SOP laws by providing direct evidence of the role of these laws in patient safety. While prior work has evaluated the quality and safety of care delivered by NPs relative to physicians (see, e.g., Dunker, Krofah, and Isasi 2014; Gilman and Koslov 2014; Newhouse et al. 2011), evidence on the effect of NP SOP laws on safety and quality is more limited. For example, Traczynski and Udalova (2018) examine the effect of NP SOP laws on patient-reported quality of healthcare visits, and Markowitz et al. (2017) evaluate the effect of these laws on certain birth outcomes, including some that implicate safety concerns. The analysis presented here takes a broader view and examines the role of NP SOP laws in the ongoing opioid crisis, where patient safety concerns have assumed a central role.

In 2017, the Centers for Disease Control and Prevention estimated that over 40 Americans died each day from a drug overdose involving a prescription opioid (Mattson 2017). Between 2000 and 2014, the use of prescription opioids increased by a factor of four, prompting the declaration of an opioid crisis (Dart et al. 2015; Rudd et al. 2016). This increase in opioid use has led to an increase in drug overdoses, emergency room visits, and admissions for treatment of drug dependence (Schnell and Currie 2018). Within the ongoing crisis, individual providers, and the prescriptive authority they possess, play a key role in determining individuals' access to

prescription opioids. For example, Barnett et al. (2017) examine patients receiving emergency care within the same hospital and find that those patients treated by physicians who prescribe, on average, more opioids were more likely to develop a dependence on opioids than similar patients who were treated by physicians who prescribe fewer opioids on average. Relatedly, Schnell and Currie (2018) investigate the role of provider education and find that physicians who attended lower ranked medical schools prescribe significantly more opioids than physicians who attended higher ranked medical schools.

Given the clear ability of opioid use to cause harm and the important role that individual providers play in determining access to prescription opioids, the ongoing opioid crisis provides a nearly ideal setting in which to test whether relaxing SOP laws results in harm, specifically, an increase in opioid prescriptions. In this study, I analyze a dataset of over 1.3 billion individual opioid prescriptions, which represent approximately 90 percent of all opioid prescriptions filled at outpatient pharmacies between 2011 and 2017, to examine the impact NP SOP laws have on the quantity of opioids prescribed by both physicians and NPs. Aggregating these prescription data to the individual provider level and examining three highly specific measures of opioid prescriptions, including morphine milligram equivalents (MMEs), I analyze the effect of relaxing SOP laws on the quantity of opioids prescribed by physicians and NPs.

In general, I find that relaxing NP SOP laws reduces the quantity of opioids prescribed across all physicians and NPs. Allowing NPs to practice independently has a negative, statistically significant effect on the quantity of opioids prescribed by physicians and a positive, statistically significant effect on the quantity of opioids prescribed by NPs. For example, with respect to MMEs—the most specific measure of opioids—I find that the number of MMEs prescribed by physicians decreases by 2.5 percent while the number of MMEs prescribed by NPs increases by 6

percent. Because physicians outnumber NPs and prescribe more opioids than NPs, the net effect of this decrease and increase is an overall reduction in the number of MMEs prescribed by all physicians and NPs of 1.2 percent, suggesting that relaxing NP SOP laws reduces the use of prescription opioids. I find a similar pattern of effects for two other measures of prescription opioid use—total days supply of opioids and number of unique patients receiving opioids. Extending the analysis, I examine the effect of allowing NPs to practice independently on the quantity of opioids prescribed by specific sets of specialties—emergency medicine, internal medicine, primary care, and surgery.

Overall, the results suggest that granting NPs independence does not result in increased harm to patients. Conversely, the results suggest that allowing NPs to practice independently decreases the use of prescription opioids, which can improve patient safety and reduce the negative side effects associated with opioid use. Beyond demonstrating that SOP laws do not generally protect patient safety, these results suggest that relaxing SOP laws could play a role in ameliorating the ongoing opioid crisis.

2. Background and Institutional Framework

2.1 The Opioid Crisis

Opioids are used to treat both chronic and acute pain; however, they are generally not effective at treating chronic pain (with the possible exception of cancer pain) (Boudreau et al., 2009; Chou et al., 2015, 2009). Starting in 2000 and continuing for the next fifteen years, providers increasingly recognized pain as a “fifth vital sign” and began to treat it more aggressively. This led to an increase in the use of opioids and may have contributed to the development of the opioid crisis (Dart et al. 2015; Merboth and Barnason 2000; Rudd et al. 2016; Tompkins et al. 2017; Von

Korff and Franklin 2016). As opioid use increased, so did opioid-related mortality (Mattson et al. 2017; Pacula and Powell 2018) and several other negative effects, such as increased emergency room visits for opioid-related harms (Braden et al. 2010).

Recognizing the severity of the opioid crisis, state and federal policymakers have begun to search for potential solutions. At the federal level, the Centers for Disease Control and Prevention (CDC) have issued guidelines concerning the use of opioids (Dowell et al. 2016). At the state level, various policies have shown potential to ameliorate the effects of the opioid crisis. While prescription drug monitoring programs (PDMPs), which provide a central repository of prescription information to healthcare practitioners and others, have proved popular, the evidence on their effectiveness is mixed. Buchmueller and Carey (2018) find that PDMPs that require providers to access them reduce opioid misuse among Medicare beneficiaries (see also Dowell et al. 2016; Dave et al. 2017), and Patrick et al. (2016) find some evidence that PDMPs can reduce opioid-related overdose deaths. However, other research suggests that PDMPs have little effect in general (Paulozzi, Kilbourne, and Desai 2011; Reifler et al. 2012; Haegerich et al. 2014; Meara et al. 2016).

Beyond PDMPs, recent work suggests that laws facilitating access to cannabis can reduce opioid use and the harms associated with this use. For example, Bradford et al. (2018) examine Medicare beneficiaries and find that laws allowing access to cannabis for medical reasons reduce opioid use (as measured by the number of daily doses) among six different types of opioids by between 8 and 21 percent. Wen and Hockenberry (2018) consider Medicaid beneficiaries and find that laws allowing access to medical cannabis reduce the number of opioid prescriptions by 5.88 percent and that laws allowing access to recreational cannabis reduce opioid prescriptions by 6.38 percent. Examining the general population, Ozluk (2017) finds that medical cannabis laws

decrease annual spending on prescription opioids per person by \$2.47. Similarly examining the general population, McMichael et al. (2018) find that recreational and medical cannabis access laws reduce the number of MMEs prescribed each year by 6.9 and 6.1 percent, respectively. Consistent with this evidence, other work has found that cannabis access laws can mitigate the negative effects of opioid use. For example, Powell et al. (2018) find that medical cannabis laws reduce both opioid-related deaths and admissions to treatment facilities for opioid abuse. Similarly, Shi (2017) finds that these laws reduce hospital admissions for opioid use disorder by 23 percent and admissions related to prescription-opioid use by 13 percent.

While much of the work on policies targeting opioid use has focused on PDMPs and cannabis access laws, the role of providers has received less attention. Schnell (2017) examines how both patient and physician behavior have contributed to the opioid crisis. Developing a model of physician behavior when patients can search over physicians in the legal opioid market and the illegal opioid market, Schnell (2017) estimates that physicians overprescribe opioids by at least 20 percent. Schnell and Currie (2018) focus more specifically on physicians, examining the relationship between the ranking of a physician's medical school and that physician's propensity to prescribe opioids. They find an inverse relationship between medical school rank and opioid prescriptions, suggesting a possible role for physician education in reducing opioid prescriptions.

This study extends the existing literature on the opioid crisis in two salient ways. First, it expands on recent work that has focused on the role of individual providers by analyzing the prescribing behaviors of both physicians and NPs. Second, it combines the provider-focused research with the policy-focused studies by explicitly examining how the regulation of the healthcare workforce—through NP SOP laws—impacts the prescribing behavior of individual

providers. In doing so, it suggests a new link between provider regulation and opioid prescriptions that could be used as an additional tool to address the opioid crisis.

2.2 Nurse Practitioners and Scope-of-Practice Laws

NPs are registered nurses who have undergone additional training—typically completing between 1.5 and 3 years of graduate-level training resulting in either a masters or professional doctoral degree—to provide services traditionally reserved to physicians. While NPs do not provide all of the care delivered by physicians, they provide care in a wide variety of settings and may diagnose and treat patients, order and interpret tests, and prescribe medication. And clinical evidence has demonstrated that NPs perform as well or better than physicians in delivering care within their education and training (Newhouse et al. 2011; Naylor and Kurtzman 2010; Stanik-Hutt et al. 2013; Mafi et al. 2016; Conlon 2010; Venning et al. 2000; Jiao et al. 2018; Kuo et al. 2015). Relative to physicians, NPs are more likely to practice in primary care specialties, to provide care to Medicaid beneficiaries, and to provide care for rural and underserved populations (McMichael 2018; Stange 2014; DesRoches 2017; 2013; Larson et al. 2003; Grumbach et al. 2003; Everett et al. 2009).

Though NPs can provide care comparable to physicians, particularly in primary care settings, and are more likely to deliver care to rural and underserved populations, state SOP laws often prevent NPs from providing this care (Gilman and Koslov 2014). While prior work has classified the SOP laws governing NPs in slightly different ways (see, e.g., Markowitz et al. 2017; Kleiner et al. 2016), I follow a version of the classification scheme used by McMichael (2017;

2018), which is similar to that used by Kleiner et al. (2016).³ An important advantage of this classification scheme is that it is based on actual statutes and regulations instead of secondary sources, which minimizes problems of inconsistent legal interpretations across multiple sources.

Under this approach, a state may be categorized as either allowing independent NP practice or restricting NP practice. To fit within the first category, a state must allow NPs to practice without physician oversight and allow NPs to prescribe the same range of medications as physicians. If a state either requires some form of physician supervision (or collaboration) as a condition of practicing or prohibits NPs from prescribing certain medications that physicians can prescribe, it fits within the restricted practice category.⁴ Figure 1 provides an overview of the number of states falling into each legal category between 2011 and 2017 and demonstrates the state variation in NP SOP laws that contributes to the identification of the empirical models discussed below.⁵

Many studies have investigated the justifications for and effects of restrictive occupational licensing laws in healthcare and related fields. For example, Kleiner and Kudrle (2010) find that restrictive laws in dentistry raise the prices paid by consumers without an increase in the quality of care. Thornton and Timmons (2013) find that restrictive laws limit the number of massage therapists at the expense of consumers.

³ This is not to suggest that any particular classification scheme is correct or incorrect. In general, though different schemes tend to focus on slightly different aspects of SOP laws, the resulting classifications are correlated with one another.

⁴ If a state imposes certain requirements on a particular set of medications but imposes those requirements on both physicians and NPs, then that state is categorized as allowing NP independence as long as it does not impose any physician supervision requirements on NPs.

⁵ Seventeen states allowed NPs to practice independently throughout the entire study period of 2011–2017: Alaska, Arizona, Colorado, the District of Columbia (which is treated as a state throughout the analysis), Hawaii, Idaho, Iowa, Maine, Montana, New Hampshire, New Mexico, North Dakota, Oregon, Utah, Vermont, Washington, and Wyoming. Seven states changed their laws during the study period (with years of change in parentheses): Maryland (2012), Nevada (2013), Connecticut (2014), Rhode Island (2014), Minnesota (2015), Delaware (2016), and Nebraska (2016). The remaining states prohibited NPs from practicing independently throughout the study period.

Similarly, prior work has shown that granting NPs more autonomy can result in lower healthcare prices, increased access to care, and improved quality of care. With respect to the price of care, multiple studies demonstrate that granting NPs greater authority leads to reduced prices and lower healthcare expenditures. In particular, the price of a common medical examination decreases by 3–16 percent when NPs gain greater independence (Kleiner et al. 2016), the savings achieved by using retail health clinics instead of emergency departments are higher when NPs have more independence (Spetz et al. 2013), and Medicaid costs either decrease or remain flat when NPs are granted more authority (Timmons 2016). Stange (2014) finds that a greater supply of NPs has relatively little impact on the office-based healthcare market, but he concludes that healthcare markets are more responsive to changes in NP supply when these providers possess more autonomy, suggesting that restrictive SOP laws may blunt the effect NPs can have on the provision of healthcare. Consistent with this evidence, Traczynski and Udalova (2018) determine that relaxing NP SOP laws reduces healthcare costs by up to 1.3 percent.

With respect to access to care, McMichael (2018) finds that relaxing SOP laws increases access to healthcare most in the counties that have the least access to care. Similarly, Graves et al. (2016) find that states with relaxed SOP laws have up to 40 percent more primary care NPs in some areas. Kuo et al. (2013) demonstrate that NPs treat more Medicare patients in states with less restrictive SOP laws. Analyzing different measures of healthcare utilization, Traczynski and Udalova (2018) find that granting NPs more autonomy increases access to care, lowers barriers to care, increases the use of medical care in underserved populations, and reduces the use of emergency departments for primary care.

Fewer studies have investigated the effect of SOP laws on healthcare quality. Traczynski and Udalova (2018) find that granting NPs more autonomy increases the self-reported quality of

care. Markowitz et al. (2017) find that relaxing SOP laws reduces rates of labor inductions and C-sections, which is consistent with an improvement in quality given the high rates of C-sections in the United States. Markowitz et al. (2017) also investigate other measures of healthcare quality, including whether an infant suffers an injury during birth, and find that relaxing SOP laws either has no effect on or improves these measures. Two prior published studies have investigated how SOP laws impact providers' opioid-prescribing behavior. Ladd et al. (2017) conduct a cross-sectional, state-level analysis of a single year of data from Medicare and find that granting NPs greater autonomy is associated with more opioid prescriptions written by both NPs and physicians. Examining a larger dataset of approximately 259 million opioid prescriptions in 2012, Schirle and McCabe (2015) conclude that opioid prescription rates are higher in states that do not allow NPs to practice independently. While this study includes a richer dataset, the authors are nevertheless unable to examine opioid prescriptions over time.

This study extends the existing literature and contributes directly to the ongoing debate over the relaxation of SOP laws across the country by investigating whether allowing NPs to practice independently endangers patients. Specifically, the analysis uses the ongoing opioid crisis as a backdrop against which to examine whether granting NPs independence results in higher levels of opioid prescriptions. As noted above, overuse of opioids has led to, among other negative effects, increased mortality, higher levels of drug dependence, and increased hospital admissions. Thus, higher levels of opioid use by providers following the relaxation of NP SOP laws would suggest that this relaxation may decrease the quality of care delivered (and provide support for the standard justification that legal restrictions are necessary to ensure the delivery of high-quality care). Conversely, lower levels of opioid use would suggest an increase in quality and patient safety (and undermine the case for the imposition of restrictions via SOP laws). The evidence

developed here speaks directly to whether allowing NPs to practice independently creates a greater risk of harm for patients.

2.3 Mechanisms of Change

Relaxing SOP laws to allow NPs to practice independently may have a number of different effects which contribute to changes in the quantity of opioids prescribed by both NPs and physicians. NP independence may alter how care is delivered in several ways. First, on the extensive margin, allowing NPs to practice independently can increase the number of practicing NPs, facilitating access to care (McMichael 2018).⁶ Second, on the intensive margin, with less oversight and the ability to provide more services, independent NPs may be able to satisfy more demand for care (Gilman and Koslov 2014).⁷ Third, patient demand for NP-delivered care may increase, as NPs can provide care in more convenient locations and provide more of the services demanded by patients than they can when their practices are restricted by SOP laws (Markowitz et al. 2017; Gilman and Koslov 2014). Collectively, these three effects may result in both a shift from physician-supplied care to NP-supplied care and the delivery of more care in general.

While allowing NPs to practice independently may induce changes in how healthcare is delivered, the effects of these changes on opioid prescriptions are not obvious. To the extent that patients substitute NP-delivered care for physician-delivered care, NPs will prescribe more opioids and physicians will prescribe fewer opioids. If NPs and physicians prescribe opioids in exactly the

⁶ Prior work notes that, while allowing NPs to practice independently generally increases the number of practicing NPs in areas with few physicians, these laws have no statistically significant effect on the number of practicing physicians (McMichael 2018).

⁷ In general, complying with oversight laws requires both NPs and physicians to expend time and resources that could be devoted to patient care.

same way and patients simply shift from physicians to NPs, then allowing NPs to practice independently will have a zero net effect on opioid prescriptions. A patient cared for by an NP will receive the same opioid prescription as if she had been cared for by a physician. If—in addition to shifting some patients from physicians to NPs—allowing NPs to practice independently allows more patients to receive care in general and NPs and physicians prescribe opioids in the same way, then NP opioid prescriptions will increase and physician opioid prescriptions may remain fairly stable.

However, NPs and physicians may not prescribe opioids in the same way. Markowitz et al. (2017) find that patients cared for by certified nurse midwives (CNMs)⁸ are less likely to receive medically intensive interventions than patients cared for by physicians. Similarly, Perloff et al. (2015) conclude that NPs expend fewer resources treating patients than do physicians, and Groover (2018) finds that relaxing NP SOP laws reduces the number of prescriptions filled per year by 8 percent. Markowitz et al. (2017) note that the nursing model of care generally emphasizes less use of medically intensive treatments, and prior work has suggested that NPs often spend more time with their patients instead of offering intensive medical interventions (Kutney-Lee et al. 2009; Naylor and Kurtzman 2010).

In the context of opioid prescriptions, this emphasis on less intensive intervention suggests that a shift toward NP independence will result in a decline in opioid use as NPs, while still prescribing more opioids generally, will not prescribe opioids to some patients who would have received opioids from physicians. On the other hand, if physician groups are correct, NPs and

⁸ CNMs and NPs are different types of advanced practice registered nurses (APRNs). While CNMs and NPs are technically different types of APRNs, they are regulated very similarly and CNMs essentially function as NPs with a specialty in women's care and obstetrics.

physicians will not prescribe opioids in the same way, and a shift toward NP independence may result in an increase in opioid use, as unsupervised NPs overuse opioids. The analysis below provides insight into these issues using a dataset that is uniquely well suited to the task.

3. Data

3.1 Prescription Opioid Data

Data on individual opioid prescriptions filled by patients at outpatient pharmacies between 2011 and 2017 come from Symphony Health's IDV® (Integrated Dataverse) dataset. The data were collected from health insurance claims (from both private and public payers) and from non-retail invoices and point-of-sale information obtained from individual pharmacies. The dataset includes approximately 1.3 billion individual opioid prescriptions, which represent approximately 90 percent of all opioid prescriptions filled at outpatient pharmacies in the United States over the relevant time frame. Prescription data are available regardless of payer—prescriptions for patients covered by private insurance, Medicaid, and Medicare are included as well as prescriptions paid for in cash.

Each observation in the dataset represents an individual prescription and includes the following information: the year the prescription was filled, the eleven-digit national drug code (NDC) for the prescription, the total days supply for the prescription, the quantity of drugs, an encrypted patient identifier, and an encrypted healthcare provider identifier. While the provider identifier is encrypted, it includes the provider's state of practice and the provider's taxonomy from the National Plan and Provider Enumeration System (NPPES). I assign providers to different SOP laws based on the listed state of practice in the NPPES.

From these raw data, I construct the following variables, which are all defined at the provider-year level: (1) the total number of MMEs prescribed by each provider, (2) the total days supply prescribed by each provider, and (3) the number of unique patients to whom each provider prescribed opioids. The first variable, total annual MMEs, is the sum of the MMEs of all opioids prescribed by each provider in each year, and the MME of each individual opioid prescription is defined as:

$$MME = \frac{(Drug\ Strength) \cdot (Drug\ Quantity) \cdot (MME\ Conversion\ Factor)}{Days\ Supply}.$$

Drug quantity and days supply come from the IDV® dataset. The MME conversion factor and drug strength come from a dataset compiled by the Prescription Drug Monitoring Program Training and Technical Assistance Center (PDMPTTAC). The PDMPTTAC dataset is organized by 11-digit NDCs. Using the NDCs in the IDV® and PDMPTTAC datasets, I match the strength per unit and conversion factor information for all prescription opioids appearing in the IDV® dataset and calculate the MME for each opioid prescription.⁹ Using the provider identifiers associated with each prescription, I then calculate the total number of MMEs prescribed by each provider in each year. I apply a logarithmic transformation to the total annual MMEs for each provider in each year.

To calculate the total days supply prescribed by each provider in each year, I sum the days supply for all opioid prescriptions associated with each provider in each year. To calculate the total number of unique opioid patients associated with each provider in each year, I count the number

⁹ While buprenorphine/naloxone does, technically, have an MME conversion factor, the PDMPTTAC dataset codes this conversion factor as zero. I maintain this coding throughout my analysis because this drug is used in the treatment of opioid addiction.

of different patient identifiers associated with each provider's identifier in each year.¹⁰ I apply a logarithmic transformation to both the total days supply and total number of unique opioid patients variables. Collectively, the three main variables of interest represent the most specific measures of opioid prescribing available, and past work on the opioid crisis has specifically noted the absence of information on MMEs as an important limitation (see, e.g., Wen and Hockenberry 2018).¹¹ That limitation is not applicable here.

3.2 Provider Information

Though individual provider identifiers are encrypted, each observation includes the provider's primary taxonomy listed in the NPPES.¹² Throughout the analysis, I examine only physicians and NPs, as determined by their primary taxonomies. To present a complete picture of the effect of SOP laws, the primary analysis includes all physicians and NPs.

In supplementary analyses, I consider providers practicing in several different specialties to better understand the effect of SOP laws. Using the NPPES taxonomy information, I identify physicians practicing in four different specialties and NPs practicing in two different specialties. I

¹⁰ A patient obtaining opioids from multiple providers is counted separately as a unique patient for each provider. Thus, this variable should be interpreted as a provider-specific variable, not a measure of the number of patients taking opioids generally.

¹¹ A separate dataset includes all of the same prescribing information but includes the county in which a provider practices in addition to the state. To protect confidentiality, this separate dataset excludes specialty information, and the encrypted patient and provider identifiers are not linked over time. While this dataset cannot be combined with the primary dataset, it allows me to construct county-level versions of the prescription opioid variables described here. I use this county-level dataset in the robustness checks described below.

¹² Providers are obligated under federal law to maintain their information in the NPPES if they wish to maintain their National Provider Identifier (NPI) number. An NPI number is required for many transactions governed by the Health Insurance Portability and Accountability Act (HIPAA). I observe only their state of practice and primary taxonomy, i.e., specialty. Other identifying information is not included in the dataset I analyze.

focus on physicians practicing in emergency medicine,¹³ internal medicine,¹⁴ primary care,¹⁵ and surgery.¹⁶ Because NPs do not specialize in surgery and generally do not have separately listed specialties that correspond to all of the individual specialties of physicians (including the subspecialties of internal medicine) I limit my focus to NPs practicing in emergency/acute care¹⁷ and primary care.¹⁸

3.3 Summary Statistics

Table 1 provides an overview of all variables of interest across all years examined here. Panel A provides information across all years between 2011 and 2017. Over this time frame, the percentage of opioids prescribed by providers practicing in states allowing NPs to practice independently increased from 13.6 percent to 21 percent—a 54 percent increase. The mean MMEs prescribed by NPs and physicians and the mean number of unique patients receiving opioids from these providers increased slightly before decreasing overall by the end of the period. Mean total days supply similarly increases early in the period before decreasing, but mean total days supply is higher in 2017 than 2011.

¹³ Physicians listing “Emergency Medicine” as their primary taxonomy are included in this specialty.

¹⁴ Physicians listing “Internal Medicine” as their primary taxonomy are included in this specialty. I do not further disaggregate internists into the various subspecialties of internal medicine.

¹⁵ Physicians listing either “Family Medicine” or “General Practice” as their primary taxonomy are included in this specialty.

¹⁶ Physicians listing “Surgery,” “Colon & Rectal Surgery,” “Orthopaedic Surgery,” or “Thoracic Surgery” are included in this specialty. This is not an exhaustive list of all surgical specialties, but it does represent the largest groups of surgeons and the ones more likely to interact with NPs directly or indirectly.

¹⁷ NPs listing “Nurse Practitioner - Acute Care” or “Nurse Practitioner - Critical Care Medicine” are included in this specialty.

¹⁸ NPs listing any of the following are included in this specialty: “Nurse Practitioner,” “Nurse Practitioner - Community Health,” “Nurse Practitioner – Family,” “Nurse Practitioner - Primary Care,” “Nurse Practitioner - Women's Health.”

Panel B provides an overview of the variables of interest across different SOP regimes.¹⁹ Across almost all measures of prescription opioid use and SOP regimes, physicians prescribe more opioids than NPs. The lone exception to this pattern is mean total days supply in states that allow NPs to practice independently—in that case, NPs prescribe more opioids. Comparing prescription opioid use across states that restrict NP practices and states that allow NPs to practice independently, the mean of each opioid measure declines for physicians and increases for NPs, consistent with the expectations described above.

Figure 2 reports the mean of each outcome of interest across the four different categories of specialists considered here—emergency medicine/acute care, internal medicine, primary care, and surgery. Figure 2 separately reports each measure of opioid prescriptions for physicians and NPs. In general, primary care physicians prescribe the most MMEs each year, with primary care physicians prescribing more than twice the quantity of MMEs as primary care NPs. Emergency physicians prescribe the fewest MMEs each year, with emergency/acute NPs prescribing a somewhat lower amount. Measured in total days supply, the quantity of opioids prescribed by primary care providers dwarves that prescribed by emergency providers, but this pattern essentially reverses for the mean number of unique opioid patients. This reversal is consistent with emergency providers treating a large number of different patients with relatively small supplies of opioids per patient and primary care providers treating fewer patients with larger supplies of opioids over time—exactly the pattern one would expect given the different practice environments.²⁰

¹⁹ The summary statistics reported in Panel B include all providers who appear in the dataset. However, some of these providers are excluded from the regression analysis because of missing information on one or more of the outcome variables or because they appear in only one year of the dataset (meaning their fixed effect absorbs all of the variation).

²⁰ Emergency/acute NPs prescribe more opioids than emergency physicians as measured in total days supply. This is consistent with physicians practicing more in true emergency environments (where they see many unique patients)

4. Empirical Strategy

To examine the effect of SOP laws on the quantity of opioids prescribed by physicians and NPs in more detail, I estimate a series of difference-in-differences models. These models control for observed and unobserved characteristics of individual providers and states over time. They also control for observed and unobserved linear and nonlinear trends in the outcomes of interest over time. They can therefore provide estimates of the change in opioid prescriptions attributable to NP SOP laws. The difference-in-differences models rely on state variation in NP SOP laws over time for identification. During the time period analyzed, seven states changed their SOP laws; however, because these models are estimated at the individual provider level, the actual quantity of treated units, i.e., providers whose states changed their SOP laws, numbers in the thousands.

I estimate separate ordinary least squares (OLS) models for each of the three outcome variables with the following general specification:

$$Y_{ist} = \beta(NP\ Independence_{st}) + X_{st} + \delta_i + \varphi_s + \tau_t + \varepsilon_{ist}.$$

In this model, i indexes individual providers, s indexes states, and t indexes years. The dependent variable, Y_{ist} , is either the natural logarithm of MMEs prescribed by provider i , the natural logarithm of the total days supply of all opioids prescribed by provider i , or the natural logarithm of the number of unique patients receiving opioids from provider i . Because MMEs are generally considered the best measure of prescription opioids (Wen and Hockenberry 2018), the specifications focusing on this measure are the preferred specifications.

and NPs practicing in more urgent (as opposed to emergency) care environments where they may see repeat patients and prescribe more like primary care providers.

The independent variable of interest, *NP Independence*, is an indicator variable that equals one when a given state allows NPs to practice without physician oversight and prescribe a full range of medications. Based on the definition of this variable, the models compare situations in which NPs have the authority to prescribe opioids (which are included in the full range of medications) and can do so without physician involvement to situations in which NPs are either prohibited from prescribing opioids—opioids are generally the last class of medications which NPs gain the authority to prescribe—or are permitted to prescribe medications only under physician supervision. Either physician supervision or restrictions on the medications NPs can prescribe may serve as constraints that, consistent with the idea of SOP laws serving as safety provisions, prevent NPs from engaging in dangerous behavior. Thus, the most relevant SOP law regime is one in which NPs are under no restrictions that may ostensibly serve to protect patient safety. The *NP Independence* variable is calibrated to this regime.

The primary models include no other control variables, but models designed to test the sensitivity of the primary results include controls for whether a state had enacted a law mandating the establishment of a PDMP, whether a state had an operational PDMP in place, whether a state had enacted a law allowing access to medical cannabis, and whether a state had enacted a law allowing access to recreational cannabis. Prior work has shown that both PDMPs and laws allowing access to cannabis (for medical or recreational purposes) can affect opioid prescriptions (Bradford et al. 2018; Wen and Hockenberry 2018; Patrick et al. 2016; McMichael et al. 2018). These variables are included in the vector X .

Importantly, every model includes a full set of individual-provider fixed effects, δ_i , state fixed effects, φ_s , and year fixed effects, τ_t . Provider fixed effects control for observed and unobserved characteristics of providers and their patient mix. State fixed effects control for

observed and unobserved characteristics that are fixed over time, such as legal regimes that did not change between 2011 and 2017 and idiosyncratic aspects of the healthcare system in each state. Year fixed effects control for any linear or nonlinear trends in opioid prescriptions over time. The provider fixed effects absorb much of the heterogeneity present in opioid prescribing and allow the models to isolate the role of SOP laws from any idiosyncratic factors present at the provider level. The inclusion of these fixed effects obviates the need for many control variables since they better control for confounding factors than traditional state- or county-level variables. Throughout the analysis, I calculate two-way clustered standard errors at the state and provider level to correct for serial autocorrelation.

In the primary analysis, I include only providers that prescribed at least one opioid in a given year because, based on the definition of NP independence discussed above, it will be trivially true that a shift from restricted practice to independence will cause NPs who previously prescribed no opioids to prescribe some opioids. Indeed, in many states, granting NPs independence is designed specifically to increase the range of medications they can prescribe. Accordingly, I focus on the intensive margin—the quantity of opioids prescribed—instead of the extensive margin—whether a provider prescribes opioids. In supplementary analyses, I examine providers for whom I observe at least one prescription (not necessarily an opioid) in at least two years between 2011 and 2017. The results from this analysis are consistent with the results from the primary analysis.

5. Results

5.1 All Providers

Table 2 reports the results of the primary analysis. Because each specification is a log-linear model, the coefficients can be interpreted as the percent change in the dependent variable

that results from allowing NPs to practice independently.²¹ Panel A reports the results from the preferred specifications, which focus on the effect of NP SOP laws on MMEs. Across all providers, allowing NPs to practice independently results in a 1.2 percent decrease in the annual MMEs prescribed. NPs increase the quantity of MMEs they prescribe by 6.1 percent, and physicians decrease the MMEs they prescribe by 2.5 percent. Because physicians outnumber NPs and because physicians prescribe, on average, more MMEs, the relatively smaller decrease in physician prescriptions and relatively larger increase in NP prescriptions have a net negative effect on the quantity of MMEs prescribed across all providers.

Panel B reports results from specifications with the natural logarithm of total days supply as the dependent variable. The pattern of results is similar to those for MMEs. Overall, total days supply decreases by 1.1 percent, while the total days supply prescribed by NPs and physicians increase by 7.3 percent and decrease by 2.6 percent, respectively. Panel C, which focuses on the number of unique patients receiving opioids from a given provider, echoes the results for the other measures. Overall, the number of unique patients declines by 1.1 percent, and this measure increases by 4.4 percent for NPs and decreases by 2 percent for physicians.

Overall, I find consistent evidence across all three measures of prescription opioids. Allowing NPs to practice independently reduces the quantity of opioids prescribed by individual providers. NPs increase the quantity of opioids they prescribe in response to an independence grant, which is consistent with the purpose of these laws, i.e., to allow NPs to provide a wider range of care to more patients. However, physicians reduce their use of prescription opioids. The

²¹ Because the dependent variable is in logarithmic form, the marginal effect of an indicator variable with coefficient β is approximately $((\exp(\beta) - 1)(100))$ percent.

reduction in physician opioid prescriptions is overall larger than the increase in NP opioid prescriptions, which results in an overall negative effect of NP independence on prescription opioid use.

These effects are not consistent with the stated justification for maintaining restrictive SOP laws for NPs. While NPs increase their opioid prescriptions, physicians decrease their opioid prescriptions, consistent with a shift toward NP-delivered care and with NPs prescribing fewer opioids than physicians. The net effect of NP independence is a reduction in opioid prescriptions, consistent with an improvement in patient safety based on the demonstrated harms associated with recent levels of opioid prescriptions. While the analysis here does not consider an exhaustive list of patient safety measures, a reduction in opioid prescriptions suggests that, at least with respect to patient safety in the important context of the opioid crisis, restrictive NP SOP laws are not necessary to promote patient safety and may actually undermine patient safety.

5.2 Individual Specialties

To examine the effect of NP independence on specific sets of specialties, I estimate a series of models with the same general specification as outlined above but limited to providers within a given specialty. Table 3 reports results for physician specialties. Focusing on the preferred specifications reported in Panel A, allowing NPs to practice independently reduces the quantity of MMEs prescribed by emergency physicians and surgeons by about 3.8 percent and 5.1 percent, respectively. Independent practice has no statistically significant effect on the quantity of MMEs prescribed by internists or primary care physicians, though the point estimates are negative for both specialties. While the point estimates differ somewhat, allowing NPs to practice

independently has the same pattern of effects on total days supply in Panel B and number of opioid patients in Panel C across the four physician specialties considered here.

Table 4 reports results for NP specialties. Consistent with the primary results, primary care NPs increase the quantity of MMEs they prescribe by approximately 8.1 percent when allowed to practice independently, as reported in Panel A. They similarly increase the total days of opioids supplied and the number of patients to whom they prescribe opioids, as reported in Panels B and C, respectively. Interestingly, the point estimates for the effect of NP independence on NPs specializing in emergency and acute care are negative, although they are not statistically significant for any of the three outcomes considered here.

These specialty-specific results provide greater context for the effect of SOP laws on opioid prescriptions. The negative effect of NP independence on physician opioid prescriptions is concentrated in non-primary care specialties, and the positive effect of NP independence on NP opioid prescriptions is concentrated among primary care NPs. While these results may appear somewhat counterintuitive—as they suggest that patients may substitute the care provided by emergency physicians and surgeons for the care provided by primary care NPs—they are consistent with the existing literature on NPs within the healthcare system. Tracszynski and Udalova (2018) and Spetz et al. (2013) find strong evidence that allowing NPs to practice independently reduces patients' reliance on emergency departments and similarly intensive settings for the provision of primary care. Relatedly, McMichael (2018) finds that granting NPs independent practice increases the capacity of the primary care system, and Kuo et al. (2013) find that NPs care for more patients in states with relaxed SOP laws.

Collectively, the specialty results reported here are consistent with this evidence. Instead of presenting in an emergency department or other setting, individuals may seek care in primary

care settings because doing so is easier once NPs are allowed to practice independently and expand the capacity of the primary care system. Combined with the increase in opioid prescriptions among primary care NPs, the substantial decrease in opioid prescriptions among emergency care providers and surgeons suggests that primary care NPs are simply treating more patients who may need opioids and who may have, absent NP independence, sought care from physicians in higher intensity settings.²² Overall, the specialty-specific results provide greater context for the primary results reported above and are consistent with prior work demonstrating that NP independence allows patients to obtain care in primary care settings instead of other, more intensive, settings, like emergency departments.²³

6. Extensions and Robustness

6.1 Alternative Specifications

Because all of the models reported above include individual-provider fixed effects, they do not include other control variables. In general, individual fixed effects will absorb much of the heterogeneity in provider prescribing patterns and better control for unobserved patterns than state, county, or setting specific control variables could. However, prior work has demonstrated that other state laws may impact prescription opioid use—laws establishing PDMPs and allowing

²² The effect of NP independence on opioid prescribing by surgeons is somewhat different than its effect on prescribing by emergency physicians. Patients generally do not present to a surgeon initially and NPs cannot replace surgeons—they are not trained to perform surgery. However, surgeons may provide post-operative care which involves opioid prescriptions. And to the extent that NPs can better substitute for physicians in providing post-operative care following a grant of independence, the mechanism of effect is identical to that described above. Instead of having a surgeon treat a patient (and prescribe opioids), the patient is treated by an NP who is less likely to prescribe opioids.

²³ It is important to note that the data do not allow me to directly observe where care was provided—the data only include provider specialty, not where the provider cared for a given patient. While this prevents me from explicitly testing any hypotheses on patient migration from one setting to another, the specialty-specific results are consistent with such a migration and suggest that future work with more granular data should investigate the effects identified here in more depth.

access to cannabis, in particular. While there is no reason to believe that these laws are correlated with the passage of NP independence, I re-estimate the primary specifications to test whether these other laws may impact the NP independence results.

In the interest of succinctness, I report only the all-provider specifications here and for other specifications testing the sensitivity of the main results. Panel A of Table 5 reports results that include additional control variables for whether a state (1) mandated the establishment of a PDMP program, (2) established a functioning PDMP program, (3) allowed access to medical cannabis, and (4) allowed access to recreational cannabis. While the point estimates for NP independence change slightly, neither the statistical significance nor the qualitative nature of the results change when additional controls for PDMPs and cannabis access laws are added to the primary specifications.

Next, the entirety of the primary analysis focuses on provider-level data, and all of the estimated effects are at the provider level. If allowing NPs to practice independently results in substantial changes in the number of providers across jurisdictions, however, provider-level results may mask the effect of independent practice on opioid prescription rates. In general, prior work has found that allowing NPs to practice independently has no effect on the number of physicians practicing in a given area (McMichael 2018). Allowing independent practice affects the supply of NPs, but instead of affecting the overall number of NPs, independent practice decreases the number of NPs in areas with high physician supply and increases the number of NPs in areas with low physician supply (McMichael 2018).

To test whether the primary results hold net of any provider supply changes, I aggregate the provider-level data to the state and county levels and re-estimate the primary models.²⁴ In these models, state-years and county-years are the units of analysis. The state models include state fixed effects, and the county models include county fixed effects. All models are weighted by state or county population, as appropriate, with population data obtained from the Census Bureau. While this approach necessarily excludes a substantial amount of information, it can provide confirmation that the provider-level decreases translate into overall decreases, net of any changes in provider supply.²⁵ Panels B and C of Table 5 report results from state- and county-level models, respectively. In general, the magnitudes of the effects estimated in these models suggest that, if anything, NP independence has a stronger negative impact on opioid prescriptions than the provider-level models indicate—though, the effects in the state-level models are not statistically significant.²⁶ Overall, the state- and county-level results are consistent with the conclusion that allowing NPs to practice independently reduces opioid prescriptions.

²⁴ Specifically, I calculate the total amount of MMEs, total days supply, and number of unique opioid patients at the state level and the county level—I then apply a logarithmic transformation as above. Because the purpose of this analysis is to examine changes in overall opioid prescriptions at the state and county levels, I focus on overall totals of the three outcome variables at the state and county levels and estimate population-weighted regression models—using Census Bureau population data. However, replacing the totals with per capita measures of each outcome results in only small changes in the coefficient estimates. The qualitative nature of the per capita results is the same as the results from the analysis of state and county totals. In the interest of succinctness, the per capita results are not reported.

²⁵ These models cannot disentangle the direct effect of NP independence on individual providers' prescribing patterns from its indirect effect on opioid prescriptions via an effect on the aggregate supply of providers. However, the estimates derived from these models can elucidate the net effect of NP independence on opioid prescriptions overall.

²⁶ State- and county-level information on the number of unique patients receiving opioids across individual providers is included in the interest of completeness. However, because a patient may receive opioids from multiple providers (and be counted as a unique patient for each provider), these data do *not* represent the number of individuals receiving opioids across the state or county (they represent an overcount).

6.2 Pre-Treatment Trends

A potential concern in any difference-in-differences empirical approach is the violation of the parallel trends assumption, i.e., that the trends in the opioid prescription measures were the same in the states that adopted NP independence as those that did not prior to the adoption of the new laws. A related concern is the possibility that legislative endogeneity may bias the results. For example, if legislatures respond to changes in prescription opioid use by changing the SOP laws governing NPs, the legal indicator variables may not represent the true effect of legal changes. While prior work has demonstrated that NP SOP laws are driven primarily by politics and not by healthcare outcomes (McMichael 2017), such as prescription opioid use, I estimate a series of event study models based on the primary specifications reported above to address both of these potential concerns.

Because the data cover a seven-year period, long term event study models are not feasible, but I estimate event study models to the extent possible. Specifically, I replace the NP independence indicator in the general specification above with indicator variables for the following time periods: two or more years prior to enactment, one year prior to enactment, one year following enactment, two years following enactment, and three or more years following enactment. I estimate both individual-provider-level models, consistent with the primary results, and county-level models, consistent with the robustness checks described above. Figure 3 reports the results of these models—in the interest of succinctness, only the all-provider event study models are reported.

Both the individual-provider (Panel A) and county (Panel B) models demonstrate that all measures of opioid prescriptions decrease following a grant of NP independence. Opioid prescriptions decrease initially, and the point estimates decrease over time, suggesting that the

effect of NP independence phases in over several years and becomes stronger with time. Importantly, the results reported in Figure 3 also provide support for the parallel trends assumption and offer no indication of legislative endogeneity. There is little indication of pre-treatment trends in any of the outcome variables at either the individual-provider or county levels, which supports a causal interpretation of the difference-in-differences results.

6.3 Providers Who Prescribe No Opioids

As noted above, the primary analysis includes only providers who prescribed at least one opioid in a given year. To confirm that excluding providers who prescribe no opioids does not change the overall conclusions from the analysis, I re-estimate all of the primary models but include all providers who prescribed at least one medication of any type in at least two years of the dataset. While using this criterion results in the inclusion of many provider-years with zero opioid prescriptions in the analysis,²⁷ I estimate OLS models instead of more complex models. As Angrist and Pischke (2009) note, the marginal effects of variables from OLS models are accurate despite the inclusion of zeros, and more complex models involve imposing specific distributional assumptions on the data that may not be warranted. Additionally, these more complex models cannot accommodate individual-level fixed effects for both theoretical (e.g., the incidental parameters problem) and computational feasibility reasons.

Because of the subtle differences between the results of this analysis and those of the primary analysis, Table 6 reports all specifications, not just those that include all providers. In

²⁷ Because providers can have opioid prescription variables equal to zero, I add one to each observation before calculating the natural logarithm.

general, the direction and statistical significance of the *NP independence* coefficients do not change in the NP-only and physician-only models, though the magnitudes of the coefficients change somewhat. Similarly, the direction and statistical significance of *NP independence* in the all-provider model focusing on MMEs—the preferred specification—remain unchanged. The coefficients in the all-provider models focusing on the other opioid outcomes are not statistically significant.

Overall, the robustness analysis does not change the general conclusions from the primary analysis. No evidence suggests that allowing NPs to practice independently increases opioid prescriptions, and I find consistent evidence that opioid prescriptions decline following the passage of laws allowing NPs to practice independently.

7. Conclusion

The results of this study suggest that, contrary to the stated reason for maintaining restrictive NP SOP laws, allowing NPs to practice independently does not result in decreased patient safety. Evaluating the use of prescription opioids during the ongoing opioid crisis, I find no evidence suggesting that opioid prescriptions increase overall when NPs are allowed to practice independently. Instead, the clear majority of evidence demonstrates that granting NPs independence reduces the use of prescription opioids across three different measures of opioid prescribing. While NPs increase their opioid prescriptions, physicians decrease their use of these drugs, consistent with NPs both serving an increased share of patients and being less inclined than physicians to prescribe opioids.

The specialty-specific results suggest that the mechanism by which the changes in opioid prescriptions occur are consistent with the current understanding of how NP independence impacts

the healthcare system generally. Following a grant of independence, individual patients are better able to access primary care providers and rely less on more intensive settings, such as emergency departments (Traczynski and Udalova 2018). The results here suggest that primary care NPs increase their opioid prescriptions while emergency physicians and surgeons decrease their opioid prescriptions, consistent with the shifts in patient care induced in the healthcare system by NP independence.

These results have important implications for the ongoing debate over SOP laws and provide support for the National Academy of Medicine's (2011) conclusion that NPs should be allowed to practice to the full extent of their training. In particular, the evidence developed here undermines the primary justification for maintaining restrictive SOP laws—promoting patient safety. While patient safety may be endangered in different ways in different parts of the healthcare system, in the context of opioid prescriptions, allowing NPs to practice independently, if anything, reduces the use of opioids, consistent with an improvement in patient safety given the demonstrated harms associated with recent levels of opioid prescriptions. A potential alternative interpretation is that NP independence inappropriately reduces opioid prescriptions so that some patients who need opioids are unable to obtain them. However, the magnitudes of effect estimated here are consistently below a 10 percent decrease in opioid prescriptions. Given that Schnell (2017) finds that physicians overprescribe opioids by 20 percent, there is little reason to believe that NP independence results in an “over-correction” so that opioid prescriptions decline “too much.”

Finally, while SOP laws are not generally mentioned in the debate over the opioid crisis, the results here suggest that changing how the healthcare workforce is regulated via SOP laws could play a role in mitigating the effects of this crisis. This particular strategy has not been widely

discussed in the context of the opioid crisis, but the results here suggest that allowing NPs to practice with greater autonomy may ameliorate the ongoing crisis to some degree.

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Figures and Tables

Figure 1: Scope-of-Practice Laws Over Time

Figure 2: Opioid Prescriptions by Specialty

Panel A: Mean Annual MMEs

Panel B: Mean Annual Total Days Supply

Panel C: Mean Number of Unique Opioid Patients

Figure 3: Event Study Results

Panel A: Individual-Provider-Level Results

Panel B: County-Level Results

Notes: Each line reports the coefficients from a single regression. The regressions that form the basis of Panel A include individual-provider, state, and year fixed effects. The regressions that form the basis of Panel B include county and year fixed effects. Each point represents an individual coefficient estimate and the bars represent 90% confidence intervals based on standard errors clustered at the provider and state levels (Panel A) and state levels (Panel B). Each line is slightly offset to improve readability and not to indicate any differences in timing.

Table 1: Summary Statistics*Panel A: Summary Statistics by Year*

Year	% NP Independence	Mean MMEs	Mean Opioid Patients	Mean Total Days Supply
2011	13.6%	10,844.7	81.0	3,399.1
2012	15.7%	11,147.5	81.4	3,593.7
2013	16.3%	11,076.0	83.5	3,783.2
2014	18.1%	10,894.6	84.7	3,908.3
2015	20.2%	10,589.5	84.6	3,947.2
2016	21.1%	10,278.8	81.6	3,980.3
2017	21.0%	9,188.5	74.8	3,806.5

Panel B: Summary Statistics by SOP Regime and Provider Type

	N	Mean MMEs	Mean Opioid Patients	Mean Total Days Supply
<i>All Providers</i>				
All Observations	4,977,859	10,591.6	81.7	3,773.9
Physicians	4,320,528	11,137.4	85.4	3,936.9
NPs	657,331	7,004.5	57.5	2,702.7
<i>Restricted Practice</i>				
All Observations	4,083,900	10,668.2	84.0	3,905.8
Physicians	3,564,576	11,312.3	87.9	4,106.3
NPs	519,324	6,247.2	57.1	2,529.0
<i>NP Independence</i>				
All Observations	893,959	10,241.8	71.4	3,171.5
Physicians	755,952	10,312.4	73.7	3,137.8
NPs	138,007	9,854.5	58.8	3,356.3

Table 2: Effect of Scope-of-Practice Laws on Opioid Prescriptions*Panel A: Effect on Annual MMEs*

Variables	(1) All Providers	(2) NPs	(3) Physicians
NP Independence	-0.012** (0.005)	0.059*** (0.018)	-0.025*** (0.006)
Observations	4,888,416	635,641	4,252,775
R-squared	0.834	0.741	0.846

Panel B: Effect on Total Days Supply

Variables	(1) All Providers	(2) NPs	(3) Physicians
NP Independence	-0.011* (0.006)	0.070*** (0.019)	-0.026*** (0.006)
Observations	4,888,416	635,641	4,252,775
R-squared	0.845	0.758	0.857

Panel C: Effect on Number of Unique Opioid Patients

Variables	(1) All Providers	(2) NPs	(3) Physicians
NP Independence	-0.011*** (0.004)	0.043*** (0.012)	-0.020*** (0.004)
Observations	4,888,416	635,641	4,252,775
R-squared	0.851	0.755	0.863

Notes: The dependent variables in Panels A, B, and C are the natural logarithm of total annual MMEs, the natural logarithm of total days supply, and the natural logarithm of the number of unique patients receiving opioids, respectively. The providers included in each model are listed at the top of each column. All specifications include individual-provider fixed effects, state fixed effects, and year fixed effects. Standard errors clustered at the provider and state levels are reported in parentheses.

* significant at the $p < 0.1$ level; ** significant at the $p < 0.05$ level; *** significant at the $p < 0.01$ level

Table 3: Effect of Scope-of-Practice Laws on Opioids Prescribed by Different Physician Specialties

Panel A: Effect on Annual MMEs

Variables	(1) Emergency Medicine	(2) Internal Medicine	(3) Primary Care	(4) Surgery
NP Independence	-0.039** (0.019)	-0.011 (0.011)	-0.019 (0.015)	-0.053*** (0.017)
Observations	317,445	1,221,212	777,738	427,478
R-squared	0.744	0.829	0.786	0.804

Panel B: Effect on Total Days Supply

Variables	(1) Emergency Medicine	(2) Internal Medicine	(3) Primary Care	(4) Surgery
NP Independence	-0.058*** (0.018)	0.001 (0.011)	0.001 (0.016)	-0.094*** (0.017)
Observations	317,445	1,221,212	777,738	427,478
R-squared	0.740	0.845	0.790	0.812

Panel C: Effect on Number of Unique Opioid Patients

Variables	(1) Emergency Medicine	(2) Internal Medicine	(3) Primary Care	(4) Surgery
NP Independence	-0.044** (0.017)	-0.004 (0.007)	-0.011 (0.010)	-0.057*** (0.013)
Observations	317,445	1,221,212	777,738	427,478
R-squared	0.758	0.845	0.783	0.806

Notes: The dependent variables in Panels A, B, and C are the natural logarithm of total annual MMEs, the natural logarithm of total days supply, and the natural logarithm of the number of unique patients receiving opioids, respectively. The specialty of the physicians included in each model are listed at the top of each column. All specifications include individual-provider fixed effects, state fixed effects, and year fixed effects. Standard errors clustered at the provider and state levels are reported in parentheses.

* significant at the $p < 0.1$ level; ** significant at the $p < 0.05$ level; *** significant at the $p < 0.01$ level

Table 4: Effect of Scope-of-Practice Laws on Opioids Prescribed by Different Nurse Practitioner Specialties

Panel A: Effect on Annual MMEs

Variables	(1) Emergency/Acute	(2) Primary Care
NP Independence	-0.103 (0.080)	0.078*** (0.022)
Observations	31,577	476,123
R-squared	0.723	0.729

Panel B: Effect on Total Days Supply

Variables	(1) Emergency/Acute	(2) Primary Care
NP Independence	-0.105 (0.084)	0.097*** (0.023)
Observations	31,577	476,123
R-squared	0.718	0.746

Panel C: Effect on Number of Unique Opioid Patients

Variables	(1) Emergency/Acute	(2) Primary Care
NP Independence	-0.081 (0.062)	0.059*** (0.015)
Observations	31,577	476,123
R-squared	0.734	0.740

Notes: The dependent variables in Panels A, B, and C are the natural logarithm of total annual MMEs, the natural logarithm of total days supply, and the natural logarithm of the number of unique patients receiving opioids, respectively. The specialty of the NPs included in each model are listed at the top of each column. All specifications include individual-provider fixed effects, state fixed effects, and year fixed effects. Standard errors clustered at the provider and state levels are reported in parentheses.

* significant at the $p < 0.1$ level; ** significant at the $p < 0.05$ level; *** significant at the $p < 0.01$ level

Table 5: Robustness Checks*Panel A: Effect of Scope-of-Practice Laws on Opioid Prescriptions with Additional Controls*

Variables	(1) ln(MME total)	(2) ln(total days supply)	(3) ln(number of opioid patients)
NP Independence	-0.017*** (0.006)	-0.012** (0.006)	-0.010*** (0.004)
Observations	4,888,416	4,888,416	4,888,416
R-squared	0.835	0.845	0.852

Notes: The dependent variable is listed at the top of each column. All specifications include individual-provider fixed effects, state fixed effects, and year fixed effects. Standard errors clustered at the provider and state levels are reported in parentheses.

* significant at the $p < 0.1$ level; ** significant at the $p < 0.05$ level; *** significant at the $p < 0.01$ level

Panel B: Effect of Scope-of-Practice Laws on State-Level Opioid Prescriptions

Variables	(1) ln(MME total)	(2) ln(total days supply)	(3) ln(number of opioid patients)
NP Independence	-0.037 (0.032)	-0.025 (0.034)	-0.022 (0.030)
Observations	357	357	357
R-squared	0.993	0.995	0.997

Notes: The dependent variable is listed at the top of each column. All specifications include state fixed effects and year fixed effects. Standard errors clustered at the state level are reported in parentheses.

* significant at the $p < 0.1$ level; ** significant at the $p < 0.05$ level; *** significant at the $p < 0.01$ level

Panel C: Effect of Scope-of-Practice Laws on County-Level Opioid Prescriptions

Variables	(1) ln(MME total)	(2) ln(total days supply)	(3) ln(number of opioid patients)
NP Independence	-0.043** (0.022)	-0.024 (0.019)	-0.029** (0.015)
Observations	21,251	21,251	21,251
R-squared	0.992	0.993	0.996

Notes: The dependent variable is listed at the top of each column. All specifications include county fixed effects and year fixed effects. Standard errors clustered at the state level are reported in parentheses.

* significant at the $p < 0.1$ level; ** significant at the $p < 0.05$ level; *** significant at the $p < 0.01$ level

Table 6: Effect of Scope-of-Practice Laws on Opioid Prescriptions with Non-Opioid-Prescribing Providers Included

Panel A: Effect on Annual MMEs

Variables	(1) All Providers	(2) NPs	(3) Physicians
NP Independence	-0.015* (0.008)	0.145*** (0.023)	-0.042*** (0.008)
Observations	6,958,165	1,051,077	5,907,088
R-squared	0.819	0.749	0.828

Panel B: Effect on Total Days Supply

Variables	(1) All Providers	(2) NPs	(3) Physicians
NP Independence	0.004 (0.007)	0.157*** (0.020)	-0.022*** (0.007)
Observations	6,958,165	1,051,077	5,907,088
R-squared	0.837	0.761	0.848

Panel C: Effect on Number of Unique Opioid Patients

Variables	(1) All Providers	(2) NPs	(3) Physicians
NP Independence	-0.004 (0.004)	0.072*** (0.011)	-0.017*** (0.004)
Observations	6,958,165	1,051,077	5,907,088
R-squared	0.865	0.783	0.875

Notes: The dependent variables in Panels A, B, and C are the natural logarithm of total annual MMEs, the natural logarithm of total days supply, and the natural logarithm of the number of unique patients receiving opioids, respectively. The providers included in each model are listed at the top of each column. All specifications include individual-provider fixed effects, state fixed effects, and year fixed effects. Standard errors clustered at the provider and state levels are reported in parentheses.

* significant at the $p < 0.1$ level; ** significant at the $p < 0.05$ level; *** significant at the $p < 0.01$ level