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Healthcare Workforce Shortages and Job Autonomy: Nurse Practitioners and Entrepreneurship in the United States

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Abstract

The laws governing nurse practitioners' scope of practice significantly impact the degree of autonomy and independence they have in their professional roles. Low-autonomy environments resulting from restrictions on nurse practitioners' scope of practice can have long-term adverse effects on their recruitment, training, and retention. These laws directly affect the range of services they can offer, their decision-making authority, and their ability to establish and manage their practices. By lowering both monetary and non-monetary benefits of practice ownership, restrictions on independent practice make it more difficult for nurse practitioners to start a practice. Thus, these regulations potentially exacerbate the shortage crisis in primary care, especially within communities already struggling with access to healthcare. We track sole proprietor nurse practitioners in each US state from 2016-2023 to analyze how the scope of practice laws influence sole proprietorship among nurse practitioners. Our results help lay the groundwork for future evidence-based policy surrounding nurse practitioner scope of practice.

Keywords: Scope of Practice, Entrepreneurship, Nurse Practitioner, Primary Care, Healthcare Workforce
JEL Classifications: D73, K42, O17, P16, J44

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1 Introduction

With increasing physician shortages (Mann, 2020) and the associated reductions in health outcomes (Macinko et al., 2007), policymakers and healthcare professionals have been searching for ways to increase the supply of preventative and primary care in areas that require more providers. As physician-focused solutions, like increasing the supply of physicians or primary care reimbursements, are either prohibitively expensive or require decades for effects to come to fruition (Bodenheimer and Smith, 2013), the scope of practice laws for nurse practitioners and other types of advanced practice registered nurses have been targeted as low-cost and high-return policy levers (Shakya and Plemmons, 2020).

In this study, we trace the cohort of actively practicing nurse practitioners in the United States from 2016 to 2023, utilizing data from the National Plan and Provider Enumeration System (NPPES) based on consistently archived data every year in March since 2016 for the past eight years. Our investigation seeks to analyze the impact of expanded scope of practice laws for nurse practitioners on their capacity to establish themselves as sole proprietors.

Nurse practitioners differ from registered nurses because they hold a graduate degree in advanced nursing practices (most commonly a Ph.D., but sometimes a master's degree) and undergo extensive supervised clinical experience. Due to these two to four years of additional training in primary care and pharmacology, twenty-seven states and the District of Columbia have moved to allow nurse practitioners to own their businesses and perform all necessary job tasks related to providing primary care independent of physician oversight, empowering nurse practitioners by allowing them to practice to the full extent of their training and enabling physicians to focus on more complicated patient cases and specialties.

Granting nurse practitioners the autonomy to practice without supervision or expensive collaboration contracts has resulted in a great deal of success and is associated with improved health outcomes (Gaglioti et al., 2016; Grumbach et al., 2003; Lenz et al., 2004;

Martin, 2000; Perry, 2009; Stange, 2014). In terms of quality and safety for the patient, the majority of studies observe negligible differences in primary care provided by a physician or nurse practitioner (Laurant et al., 2005; Lenz et al., 2004; Mundinger et al., 2000; Swan et al., 2015; Shakya and Plemmons, 2022; Bae et al., 2023). Areas that expand the scope of practice regulations to allow nurse practitioners to provide this care without unnecessary and expensive oversight have fewer shortages of primary care providers, particularly in rural areas and low-socioeconomic communities where healthcare shortages are more common (DePriest et al., 2020; Yang et al., 2021).

Expansions in nurse practitioners' scope of practice can also empower these providers to open their practices, removing hurdles in obtaining business licenses and legal requirements to either have a physician on-site or contract with and make monthly payments to an off-site physician. While growing, entrepreneurship among nurse practitioners is rare, and explanations for this dearth often rely on cultural attitudes that are antithetical to entrepreneurship in the nursing profession (Jakobsen et al., 2021).

Another potential explanation for low rates of nurse-based entrepreneurship is that scope of practice laws act as barriers to entry into self-employment for nurse practitioners. The impact of nurses' scope of practice, though well understood in its relationship to patient outcomes, is critically understudied in terms of how it affects self-employment and entrepreneurship. This gap in the literature is important, as nurses overwhelmingly make up the majority of healthcare providers, comprising 80 percent of all healthcare workers (Hughes, 2006). While nurse practitioners are only a small portion of this larger body of nurses, autonomy for those with advanced graduate education may incentivize more healthcare workers to continue their education to provide independent and collaborative care.

Further, nurses have initiated healthcare innovations in the US as early as 1850 (Hiestand, 2000). For example, Florence Nightingale was a leading figure in the introduction of bedpans across the United States (Gupta, 2020); Anita Dorr created a prototype of the first crash cart with her husband after noticing how long it took nurses to retrieve

vital supplies during emergencies (Nelson, 2020); and Letitia Geer patented the first one-handed syringe, giving nurses the ability to more effectively and safely administer medicine (Myers, 2019). However, the autonomy of nurses, and in our case, nurse practitioners with extensive graduate training, is severely limited by the restrictive scope of practice laws, and restrictions on nurse practitioner scope of practice can influence the supply and quality of healthcare by increasing costs of doing business. Besides lowering the pecuniary benefits of entrepreneurship, restrictions to the scope of practice also reduce the non-pecuniary attractiveness of entrepreneurship by eliminating autonomy. Thus, empowering nurse practitioners by removing practice restrictions can drastically increase entrepreneurship. This mechanism can increase innovation, supply, and quality in the healthcare industry.

We attempt to fill this critical gap in the literature by investigating whether granting full practice authority, defined as the ability to work to the full extent of one's education and training independently and without collaboration contracts (Kandrack et al., 2021), leads to an increased prevalence of entrepreneurship among nurse practitioners. In doing so, we contribute to foundations for future evidence-based policies related to nurse practitioner scope of practice. A few other studies have investigated how the scope of practice laws impact self-employment among nurse practitioners using survey data (Markowitz and Adams, 2022; DePriest et al., 2020). However, because of data issues, these studies are unable to differentiate between nurse practitioners and certified nurse midwives[1]; further, these studies do not differentiate self-employment from business ownership. We build on this ongoing research using unique data from the National Plan and Provider Enumeration System (NPPES), which allows us to define nurse practitioners precisely. We also focus on business ownership in the form of sole proprietorships rather than simply defining entrepreneurship as self-employment. This is a critical distinction as many self-employed nurse practitioners may be contracted through an office or hospital. Sole-

[1]While nurse practitioners and certified nurse midwives are both forms of advanced practice registered nurses, the legislation for practice and prescriptive authority expansions for advanced practice registered nurses in some states specifically do not apply to the sub-designations of certified nurse midwives or certified nurse anesthetist.

proprietor nurse practitioners own their practice as a business and may employ others, have a physical location, and maintain their own billing systems and tax responsibilities.

Section 2 delves into the institutional background of nurse practitioners and full practice authority. Section 3 presents our central hypothesis in the context of a literature review on entrepreneurship, emphasizing entrepreneurship in the nursing profession. The data and methodology used to investigate our hypothesis regarding the impact of full practice authority on entrepreneurial endeavors among nurse practitioners are outlined in Sections 4 and 5. Section 6 encompasses descriptive analysis, summary statistics, primary results, robustness checks, and falsification tests. Lastly, Section 7 discusses and concludes our study.

2 Institutional Details

Two broad explanations exist for the prevalence of regulation. While regulation is conceptualized in neoclassical economics to be a treatment for market failures (Pigou, 2017), theories in public choice recognize that government agents are self-interested. This self-interest often manifests itself in industry incumbents who lobby for regulations to reduce market competition (Stigler, 2021). Of course, these explanations need not be mutually exclusive - regulations are potent fuel when public welfare interests align with private self-interests (Smith and Yandle, 2014).

In the case of nurse practitioner scope of practice laws, the stated purpose for limiting nurse practitioner behavior in the absence of physician supervision concerns patient welfare. Indeed, the first physician licensing laws were introduced in the late 19th century to combat what was perceived to be a proliferation of quack, or illegitimate, doctors (Janik and Jensen, 2011). By 1910, the American Medical Association controlled the education and regulation of physicians and other healthcare workers; it also began to dictate the services non-physicians, including nurses broadly defined, could legitimately provide (Kleiner et al., 2016). By 1923, healthcare workers across the United States had

to hold specific certifications to legally call themselves nurses (Comer, 2007). While the educational programs for nurse practitioners are the same throughout the US, regulatory frameworks determine what they can do with their license, which significantly differs based on the state where they reside and work. These regulations include limitations on legally prescribing medicine, receiving insurance reimbursement, and practicing independently without physician supervision (Kleiner et al., 2016). The American Medical Association continues to campaign against expanding the nurse practitioner's scope of practice, often arguing that non-physician care is inferior to physician care (Iglehart, 2013).

However, there is little evidence concern for patient safety is warranted - nurse practitioners provide care similar to physicians in the vast majority of cases (Hughes et al., 2015). Primary health services managed by nurse practitioners are also often met with high patient satisfaction rates (Wilson et al., 2012). Other research suggests removing restrictions to nurse practitioner independent practice decreases reported rates of poor health, including poor mental health (Bae et al., 2023). Allowing nurse practitioners to practice independently is associated with fewer hospitalizations and emergency department visits (Spetz et al., 2013; Yang et al., 2021). Other benefits of removing restrictions to nurse practitioners' scope of practice include healthcare cost savings (Kleiner et al., 2016) and greater access to healthcare in rural and under-served areas with high rates of poverty (DePriest et al., 2020; Yang et al., 2021). Overall, only some patient benefits are associated with restricting nurse practitioners' abilities to practice to the full extent of their training.

Further, there is a documented association between physician interest group political spending and restrictive scope of practice regulations (McMichael, 2017). These restrictions to nurse practitioners' scope of practice then raise physician wages at the expense of nurse practitioner wages (Kleiner et al., 2016), implying support for restrictive nurse practitioner scope of practice laws comes from those who are most likely to compete to provide the same services as nurse practitioners. Physician associations also openly lobby

to restrict legal definitions of primary care providers, advocating for these definitions to include only physicians (Kleiner et al., 2016).

The above evidence suggests that public choice theories of regulation and rent-seeking better explain the restrictions on nurse practitioners' scope of practice than neoclassical theories revolving around market failures. While physician interest groups argue that restrictions to nurse practitioner job duties are needed to ensure patient safety (Iglehart, 2013), there is scant evidence that nurse practitioner-provided care is inferior to physician-provided care (Hughes et al., 2015; Wilson et al., 2012). At the same time, physicians profit from restrictions on nurse practitioners' abilities to practice independently (Kleiner et al., 2016). To the extent that nurse practitioners provide care similar to physicians, the restrictive scope of practice laws unnecessarily limits health care supply by restricting the services that nurse practitioners can provide without supervision. While decreases in nurse practitioner-provided healthcare often come in the form of reduced hours worked (Markowitz and Adams, 2022), decreases in nurse practitioner-owned businesses represent another mechanism.

3 Theory and Literature

In general, entrepreneurship among nurses (broadly defined) is rare, and this is true across the globe. Indeed, only 0.5-1 percent of all nurses worldwide engage in entrepreneurship (Jakobsen et al., 2021). Some have ascribed this dearth in entrepreneurship among nurses to cultural attitudes in the nursing profession - generating profit from their services is seen by many nurses as unethical and produces a sense of internal conflict (Arnaert et al., 2018; Jakobsen et al., 2021). Nurse entrepreneurs also face skepticism from colleagues who question the decision to merge a duty to care for patients with profit considerations (Neergård, 2021; Wall, 2015). Further, nurses, even those with extensive graduate education, such as nurse practitioners, often need more knowledge of the technical aspects of business and entrepreneurship, making the entrepreneurial process more

difficult (Arnaert et al., 2018; Sharp and Monsivais, 2014).

At the same time, because nurse practitioners spend more time with patients than other health care professionals, they are uniquely positioned to recognize patient care problems and identify entrepreneurial opportunities (Ayvaz et al., 2019). Therefore, the restrictive scope of practice laws offers another intuitive explanation for low entrepreneurship rates among nurse practitioners (Wilson et al., 2012; Sharp and Monsivais, 2014). The scope of practice restrictions can stifle entrepreneurship by making the exploitation of identified opportunities more complex.

While nurse practitioners universally require a license to practice, state-level restrictions on the scope of practice represent additional occupational constraints that differ depending on geographic location, even after holding education constant (Kleiner et al., 2016). Likewise, the adverse impacts of occupational licensing and other regulations on entrepreneurship are well documented in the literature (Plemmons, 2021; van Stel et al., 2007; Slivinski, 2017). There are two broad mechanisms whereby occupational and business regulations adversely impact the exploitation of identified entrepreneurial opportunities: an increase in startup costs and an increase in operating expenses. Startup costs mainly impact nascent entrepreneurs contemplating starting a business or entrepreneurs in the early stages of business creation; operating costs primarily impact those already in business but can deter nascent entrepreneurs (van Stel et al., 2007).

Startup costs are a commonly cited reason for low business formation rates - by increasing the time and money it takes to start a business, regulations that increase startup costs act as barriers to entry (Branstetter et al., 2014). In the context of nurse practitioner-owned practices in states with reduced or restricted scope of practice, the first, and perhaps most significant, of these costs involves finding collaborating physicians. These costs, which include investments in both time and money, represent a one-time fixed cost of doing business and monthly fees paid to the physician, making the startup and subsequent phases of entrepreneurship more difficult (Djankov et al., 2002).

Even after business formation, regulations can increase the burdens of operating a

business. Complying with the scope of practice restrictions entails several costs for nurse practitioners without full practice authority. These include requiring nurse practitioners to pay fees to maintain collaborative relationships with physicians or physically located in specific buildings or practices for direct supervision. Time burdens arise from the need to consult physicians to secure approval for procedures and prescriptions (Markowitz and Adams, 2022). Scope of practice restrictions can also make hiring more expensive. For example, costs related to collaboration agreements often vary based on employers - nurse practitioners who work for large physician-owned practices are significantly less likely to have to pay collaboration-related fees compared to nurse practitioners who work in nurse-owned practices, who may have to pay fees north of $3000 a month. Thus, the restrictive scope of practice laws increases hiring costs and other business costs for nurse practitioner-owned practices relative to physician-owned practices (Markowitz and Adams, 2022).

More importantly, the aforementioned business regulations impose costs that inhibit nurse practitioners while leaving physicians free to practice without the burden of oversight requirements or expensive collaboration contracts. In doing so, these costs are a competitive disadvantage for nurse practitioner-owned practices, making it more difficult for them to compete with practices run by physicians (Stigler, 2021).

We also expect restrictive nurse practitioner scope of practice regulations to disincentivize entrepreneurship among nurse practitioners by reducing their autonomy and independence. Nurse practitioners who start their practices often do so because of non-monetary benefits, like a desire for job autonomy and control of which job duties they perform or services they offer (Waite, 2019). In places without full practice authority, nurse practitioners cannot enjoy complete job independence even if they own their practice because they must be supervised by or part of a collaborative agreement with a physician before performing some job functions such as ordering tests or prescribing medications. Such constraints limit the non-pecuniary benefits of entrepreneurship. These non-pecuniary benefits weigh heavily in the calculus of potential entrepreneurs, who of-

ten start businesses out of a desire for independence and freedom from a boss (Burke et al., 2002). Thus, we expect practice ownership among nurse practitioners to be more prevalent where the scope of practice regulations does not limit them, and they have more control over their job tasks.

Because full practice authority increases both monetary and non-monetary benefits associated with practice ownership for nurse practitioners, we expect it to increase nurse entrepreneurs' prevalence by attracting nurse practitioners to the area and improving their labor supply. Nurse practitioners value autonomy and independence, so there is reason to expect them to be attracted to locations that allow them to practice to the full extent of their training. Indeed, researchers have found that nurse practitioners who move are much more likely to move to states with full practice authority (Shakya and Plemmons, 2020). Other work shows that scope of practice regulations impact healthcare availability by increasing the number of hours worked by nurse practitioners (Markowitz and Adams, 2022).

4 Data

We use data from the National Plan and Provider Enumeration System (NPPES) public use file from 2016 to 2023, provided by the Centers for Medicare & Medicaid Services (CMS).[2] Since May 23, 2007, CMS has assigned a unique identifier to each health care provider, known as a National Provider Identifier (NPI). These identifiers are the standard identifier for all healthcare providers in HIPAA-covered entities. Centers for Disease Control and Prevention (CDC) defines the Health Insurance Portability and Accountability Act of 1996 (HIPAA) as a federal law requiring national standards to protect sensitive patient health information from being disclosed without the patient's consent or knowledge. The NPPES data files contain all data for active and deactivated providers in NPPES that must be disclosed according to the Freedom of Information Act.

[2] https://download.cms.gov/nppes/NPI_Files.html

We define nurse practitioners based on taxonomy codes provided by through a database.

The NPPES database undergoes bi-weekly updates to incorporate new entries of healthcare professionals activating or deactivating their NPI. While historical database versions are not readily available through CMS, over the past eight years, we have consistently gathered this data every March from 2016 to 2023, allowing us to create a unique annual snapshot of the healthcare workforce in the United States. This data includes taxonomy codes and information regarding practice location.

We isolate all the relevant taxonomy codes of nurse practitioners. Joint Commission on Accreditation of Healthcare Organizations (1998) define nurse practitioners as "(1) A registered nurse provider with a graduate degree in nursing prepared for advanced practice involving independent and interdependent decision making and direct accountability for clinical judgment across the health care continuum or in a certified specialty. (2) A registered nurse who has completed additional training beyond basic nursing education and provides primary health care services by state nurse practice laws or statutes. Tasks performed by nurse practitioners vary with practice requirements mandated by geographic, political, economic, and social factors. Nurse practitioner specialists include, but are not limited to, family nurse practitioners, gerontological nurse practitioners, pediatric nurse practitioners, obstetric-gynecologic nurse practitioners, and school nurse practitioners." The nurse practitioner level-II classification taxonomy code we use to define nurse practitioners is 363L00000X.

However, there can be several specialty or level-III classifications where the nurse practitioner may also be categorized. Therefore, we also gathered the taxonomy codes associated with the level III classification of nurse practitioner specialties. These taxonomy codes include Acute Care (363LA2100X), Adult Health (363LA2200X), Community Health (363LC1500X), Critical Care Medicine (363LC0200X), Gerontology (363LG0600X), Neonatal (363LN0000X), Neonatal Critical Care (363LN0005X), Obstetrics & Gynecology (363LX0001X), Occupational Health (363LX0106X) Pediatrics (363LP0200X), Pediatrics Critical Care (363LP0222X), Perinatal (363LP1700X), Primary Care (363LP2300X),

Psychiatric/Mental Health (363LP0808X), School (363LS0200X), and Women's Health (363LW0102X).

Based on these taxonomies, we track individual NPIs and all data for nurse practitioners that CMS must disclose according to the Freedom of Information Act. From this data, we identify nurse practitioners' information, including their name and gender, along with their practicing location for each year from 2016 to 2023. We also track whether they are a sole proprietor or not.

Furthermore, we gathered county-level population data from the American Community Survey (ACS). We use definitions provided by McMichael and Markowitz (2023) to uniformly classify nurse practitioner scope of practice laws. Note, these definitions do differ slightly from the ones regularly offered through the American Association of Nurse Practitioners because they differentiate practice and prescriptive authority, include policy changes made through articles or department decisions rather than direct legislation, and account for non-binding collaborative agreements where the state does not actively enforce or check for the collaboration beyond an initial signature. We present states' historical staggered adoption of full practice authority in Figure 1.

5 Methods

5.1 Generalized Difference-in-Differences

To estimate the effect of full scope of practice authority (FPA) on sole proprietorship among nurse practitioners, we use a generalized difference-in-differences framework with the following equation:

$$y_{ct} = \delta D_{ct} + \nu_s + \mu_t + \epsilon_{ct} \tag{1}$$

Where c and t are county and time indexes. y_{ct} is the dependent variable with an inverse hyperbolic sine (asinh) transformation. This dependent variable takes two forms in our analysis: we study the number of nurse practitioners sole proprietors and the count

of sole proprietorships among nurse practitioners per 100,000 residents. These dependent variables, at level, are non-negative and positively skewed.

The treatment indicator, represented by $D_{ct} = treat \times post$, assumes a value of 1 when a state where county c is located experiences the treatment (a policy switch to the full scope of practice authority, or FPA) and 0 otherwise. In Figure 1, a visual depiction of staggered treatments at the state level is provided, specifically tailored to our sample period (2016-2023). FPA is defined by a uniform classification of nurse practitioner scope of practice laws, outlined in McMichael and Markowitz (2023). States and the timing of FPA for nurse practitioners are highlighted with a dark shade of gray, while a lighter shade of gray indicates states and years where FPA was not implemented.

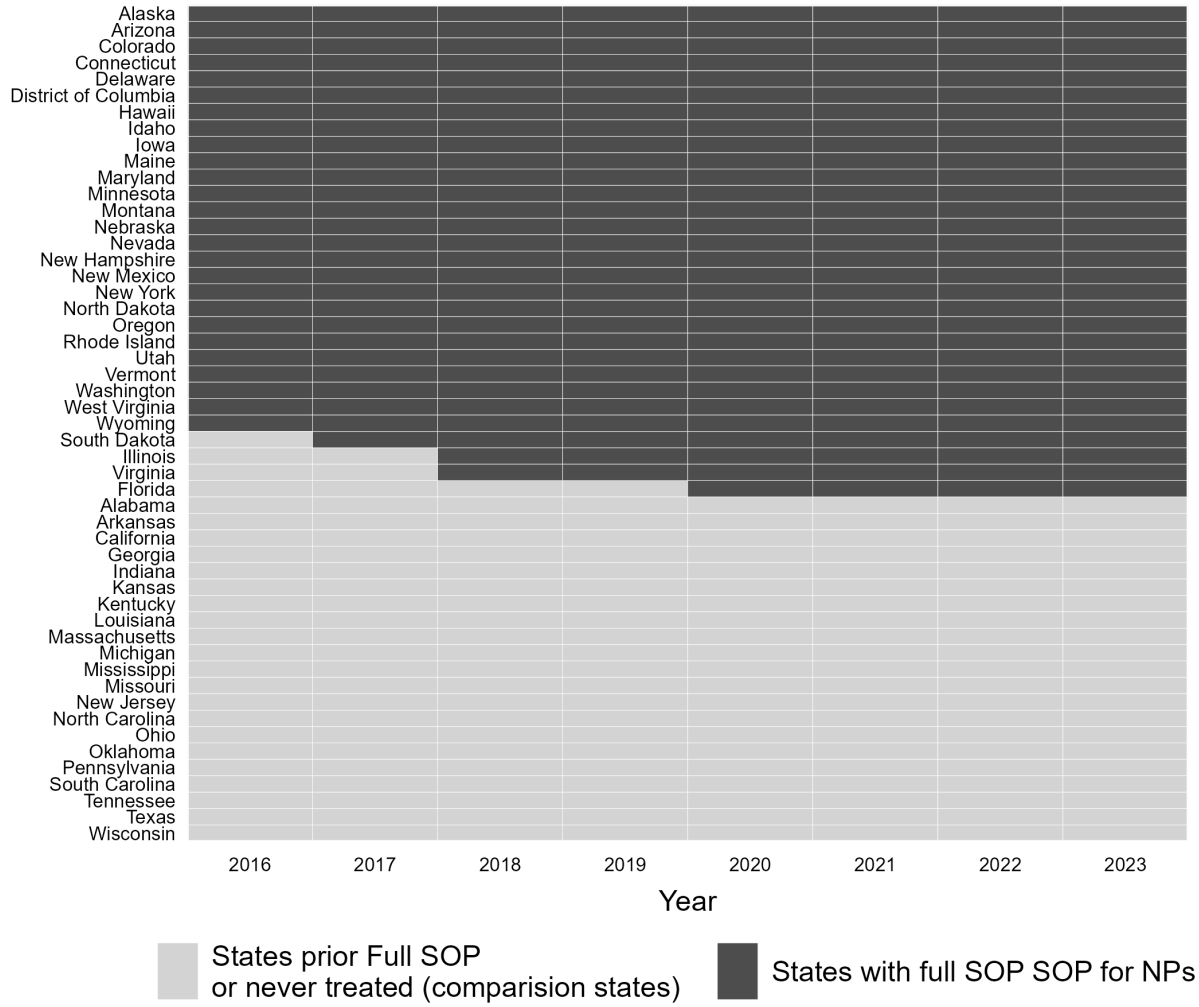
Equation 1 provides estimates of δ or the average treatment effect. ν_c and μ_t are additive individual county and year fixed effects respectively. A significant negative value of δ would suggest that the FPA reduces the entrepreneurial activities among nurse practitioners. A positive and significant δ implies that states with FPA have higher entrepreneurial activities among nurse practitioners than states that do not have FPA.

5.2 Goodman-Bacon Decomposition

Goodman-Bacon decomposition is a method used to better understand the differences-in-differences estimator in a two-way fixed effects model where treatment timing varies, or there is a staggered adoption of the treatment.

Goodman-Bacon decomposition (Goodman-Bacon, 2021) decomposes the differences-in-differences estimator into a weighted average of all possible two-by-two difference-in-differences comparisons: comparisons between relatively early adopters and later adopters over the periods when the later adopters are not yet treated; comparisons between early adopters and later adopters over the periods when the early adopters are treated – so that they can be used as a comparison group for the later adopters; and finally, comparisons between different groups of adopters (e.g., early adopters or later adopters) and the never-treated group if there is one. Thus, this decomposition type can help identify potential

Figure 1: Staggered adoption of expansion of scope of practice laws for nurse practitioners, 2016-2023



Source: McMichael and Markowitz (2023)

changes in treatment effects over time. The differences-in-differences estimator is biased when treatment effects change over time within units or groups.

5.3 Event Study

We implement an event study framework as follows:

$$y_{gt} = \sum_{l=-K}^{-2} \lambda_l D_{gt}^l + \sum_{l=0}^{L} \tau_l D_{gt}^l + \mu_s + \nu_t + \varepsilon_{gt} \tag{2}$$

The variable D_{gt}^l is a binary indicator set to 1 when the observation period relative

to group g's initial treated period is the same as the value l; otherwise, it is set to 0 (and 0 for all never-treated groups). The parameters of interest are denoted as λ_l and τ_l.

It is important to note that the values of l associated with λ_l are negative, representing "lags" and indicating periods before implementation of FPA. Consequently, the estimates of λ_l capture the effects of FPA implementation before implementation. According to the parallel trends assumption necessary for causal inference, the estimates of λ should be statistically zero, meaning the average outcomes of treated and control units follow parallel paths in pre-treatment periods.

On the other hand, the values of l linked to τ_l are zero or positive, signifying "leads" and indicating periods following the implementation of FPA. Consequently, the estimates of τ_l capture the assessed impact of FPA implementation at l periods post-implementation. The variable $-K$ represents the lowest number of lags, concluding at period $l = -2$, which aligns with pre-treatment periods in the observed sample. Variable L signifies the highest number of lags, commencing from $l = 0$, corresponding to post-treatment periods in the observed sample. One of the periods must be dropped to avoid perfect multicollinearity (as in most fixed effects setups), and $l = -1$ is used as the dropped reference.

6 Results

6.1 Descriptive Analysis

We present several descriptive statistics to describe the environment of sole proprietorships among nurse practitioners. Table 1 provides the annual totals of nurse practitioners under different definitions. Column (1) includes all providers within the nurse practitioner taxonomy. This definition leads to the double-counting of nurse practitioners, counting skills or roles rather than individuals. It is worth noting that the standard practice, as observed in agencies like NPI Dashboard (Shakya et al., 2022), is to count skills or roles rather than individuals. Columns (2) and (3) disaggregate these total providers and provide individual- and organization-level provider counts. Bae et al. (2023) and Plem-

mons et al. (2023) consider individual nurse practitioners in their analyses. In Column (4), we introduce a refined definition that considers the unique combinations of nurse practitioners and their respective taxonomy codes. This approach excludes redundantly counted nurse practitioners who may operate in multiple locations or roles. Subsequently, Columns (5) and (6) break down these total providers into individuals and organizations. Moving on to Column (7), we propose an additional definition wherein we exclusively count those who designate nurse practitioners as their primary taxonomy. We also disaggregate totals under this definition and provide counts of individuals and organizations in columns (8) and (9), respectively.

Table 1: Annual total numbers of nurse practitioners

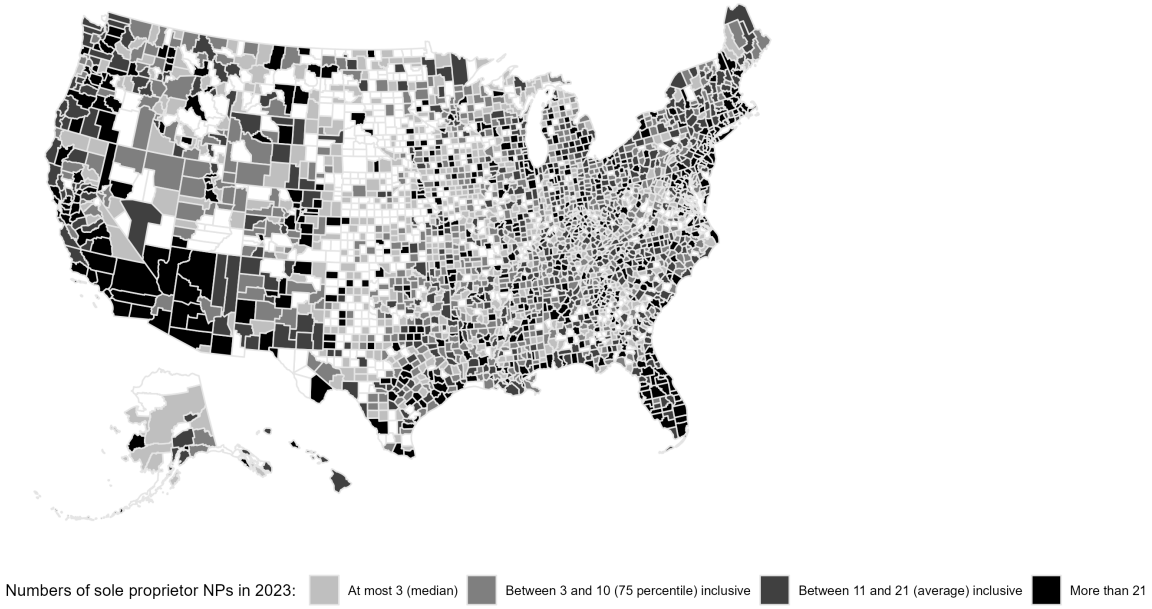
	Taxonomy as NP			Based on unique NPI			Primary taxonomy as NP		
Year	Total	Individual providers	Organizational providers	Unique total	Individual providers	Organizational providers	Total	Individual providers	organizational providers
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
2016	250,521	232,807	17,714	219,803	204,477	15,326	197,398	189,006	8,392
2017	283,157	263,431	19,726	246,444	229,349	17,095	217,984	211,092	6,892
2018	315,747	294,172	21,575	273,121	254,472	18,649	243,801	236,288	7,513
2019	353,519	330,048	23,471	303,404	283,164	20,240	269,395	258,206	11,189
2020	394,861	368,993	25,868	336,050	313,847	22,203	298,018	288,632	9,386
2021	435,869	406,718	29,151	367,651	342,736	24,915	327,454	313,437	14,017
2022	485,616	452,511	33,105	405,352	377,077	28,275	358,178	342,151	16,027
2023	536,736	499,344	37,392	442,316	410,447	31,869	386,751	368,555	18,196

Subsequently, our analysis focuses solely on individual nurse practitioners, excluding those working for organizations. Within this subgroup, we identify nurse practitioners who designate themselves as 'sole proprietors' in the NPPES database. For additional granularity, Appendix A Tables A1 and A2 offer detailed tabulations of nurse practitioners and sole proprietor nurse practitioners across US states and territories from 2016 to 2023. Note that territories are not included in our analysis as these areas have substantially different policies and norms than within US states, but the counts are provided in the event they are of interest to the reader.

Figure 2 illustrates the geographical distribution of sole nurse practitioners as of March 2023. Counties without sole proprietor nurse practitioners are depicted in white. Notably, half of the counties in the United States have three or fewer sole proprietor nurse practitioners, while three-quarters of counties have ten or fewer. On average, there are 21 sole

proprietor nurse practitioners per county.

Figure 2: County level distribution of sole proprietor NPs in 2023



Notes: Counties without sole proprietor nurse practitioners are depicted in white.

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6.2 Summary Statistics

Table 2 presents the summary statistics for our variables of interest: total sole proprietor nurse practitioners, total sole proprietor nurse practitioners per 100,000 residents, and respective inverse hyperbolic sine transformations (designated asinh). Notably, these variables exhibit positive skewness at the level, as evidenced by a higher mean relative to the median and a maximum value exceeding three times the standard deviation. However, applying the inverse hyperbolic sine transformation re-scales the variables, aligning the mean and median more closely and constraining the maximum and minimum values within three standard deviations of the means.

6.3 Generalized Difference-in-Differences

Our objective is to assess the extent to which the implementation of FPA at the state level influences entrepreneurial activities among nurse practitioners, as proxied by rates

Table 2: Summary statistics, 2016–2023

Variable	Min	Median	Mean	Max	SD
Nurse practitioners					
Total sole proprietor	1.00	5.00	28.05	3440.00	104.59
Total sole proprietor, asinh	0.88	2.31	2.58	8.84	1.46
Total sole proprietor, per 100,000 population	0.88	13.67	17.94	543.48	18.40
Total sole proprietor, per 100,000 population, asinh	0.79	3.31	3.29	6.99	0.76

Notes: We exclude counties without sole proprietary nurse practitioners.

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of sole proprietorships rather than merely self-employment. Table 3 presents estimates of Equation 1 under various specifications with heteroskedasticity robust standard errors clustered at the state level.

In Table 3 Column (1), a straightforward regression of the number of sole proprietor nurse practitioners on the binary indicator D is conducted. This indicator assumes the value of 1 when state, s, undergoes the treatment (FPA) and 0 otherwise. Initially, counties within states without FPA exhibit 2.57 sole proprietor nurse practitioners, as measured by an inverse hyperbolic sine transformation.

In Table 3 Column (2), adjustments are made for county and year-fixed effects, revealing a treatment effect of 0.123. This result suggests that counties in states with FPA experience a 13% increase, or $exp(0.123) - 1 = 0.13$, in the number of sole proprietor nurse practitioners.

In Table 3, Column (3) presents estimates for border contiguity generalized difference-in-difference specification, specifically comparing counties in states implementing full practice authority (FPA) with border counties in non-FPA states. This comparison is made while accounting for county and year-fixed effects. Under the assumption that border counties are more likely to be similar in both observable and unobservable characteristics, this approach allows for the potential control of unobserved confounding heterogeneities between counties in states implementing FPA and those without FPA (Deyo and Plemmons, 2022; Shakya and Ruseski, 2023; Shakya and Fries, 2023; Bae et al., 2023).

Column (3) indicates an estimate of approximately 11%, or $exp(0.102) - 1 = 0.11$, more sole proprietor nurse practitioners in counties of states with FPA compared to

border counties in non-FPA states.

Table 3: Impact of D on sole proprietor NPs (asinh transformation), 2016–2023

Dependent Variable:	Sole proprietor NPs (asinh transformation)			Sole proprietor NPs per 100,000 (asinh transformation)		
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
Constant	2.57***			3.25***		
	(0.092)			(0.058)		
D	0.026	0.123***	0.102***	0.116	0.114***	0.099***
	(0.176)	(0.025)	(0.036)	(0.082)	(0.025)	(0.029)
Fixed-effects						
county		Yes	Yes		Yes	Yes
year		Yes	Yes		Yes	Yes
S.E. Clustered	state	state	state	state	state	state
Fit statistics						
Observations	18,510	18,510	7,019	18,510	18,509	7,019
R^2	0.000	0.969	0.969	0.005	0.872	0.870
Within R^2		0.004	0.002		0.003	0.002

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

In Table 3, Columns (4), (5), and (6) maintain the exact specifications as Columns (1), (2), and (3), respectively, with a notable modification of the dependent variable. Here, we shift from analyzing counts of sole proprietor nurse practitioners to analyzing sole proprietor nurse practitioners per 100,000 residents. The results reveal an estimate of approximately 10%, or $exp(0.099) - 1$, indicating a 10% increase in sole proprietor nurse practitioners per 100,000 residents for counties in states with FPA.

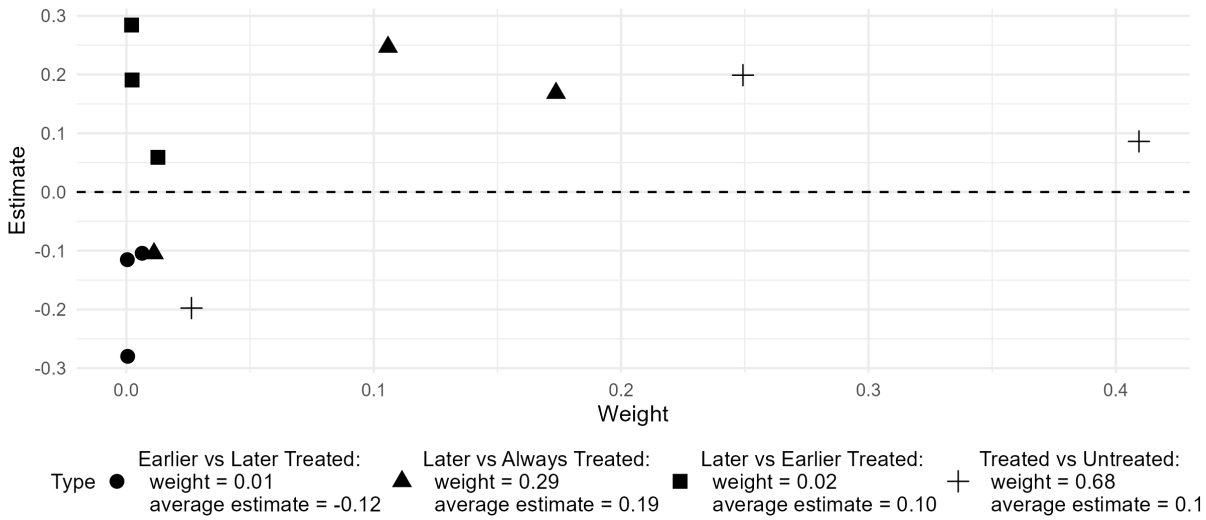
6.4 Test for Treatment Heterogeneity

Estimations of the impact of FPA on the entrepreneurial pursuits of nurse practitioners, as outlined in Table 3, are derived from a generalized difference-in-differences framework. This framework leverages the temporal variability in adopting state-level FPA laws for identification purposes. As depicted in Figure 1, the implementation of FPA is staggered across the sample period, 2016 to 2023. The estimates presented in Table 3 represent weighted averages of all conceivable two-group/two-period difference-

in-differences comparisons within the dataset. It is crucial to note that this estimation might be biased in the presence of heterogeneous treatment effects that fluctuate over time within units or groups (Goodman-Bacon, 2021).

To enhance identification in the case of staggered treatment timing, Goodman-Bacon (2021) recommends decomposing treatment effects. This decomposition allows us to discern the individual contributions of each two-group/two-period comparison to the total weighted average treatment effect. Following Goodman-Bacon (2021), we employ this decomposition to assess heterogeneity in treatment effects across three specific comparison groups: 1) treated and untreated (in our context, FPA states versus non-FPA states); 2) early adopters of FPA compared to late adopters; and 3) late adopters of FPA compared to early adopters. It's essential to compare treated and untreated counties to understand potential systematic differences between states implementing FPA and those not. The outcomes of the Goodman-Bacon decomposition are illustrated in Figure 3.

Figure 3: Goodman-bacon decomposition



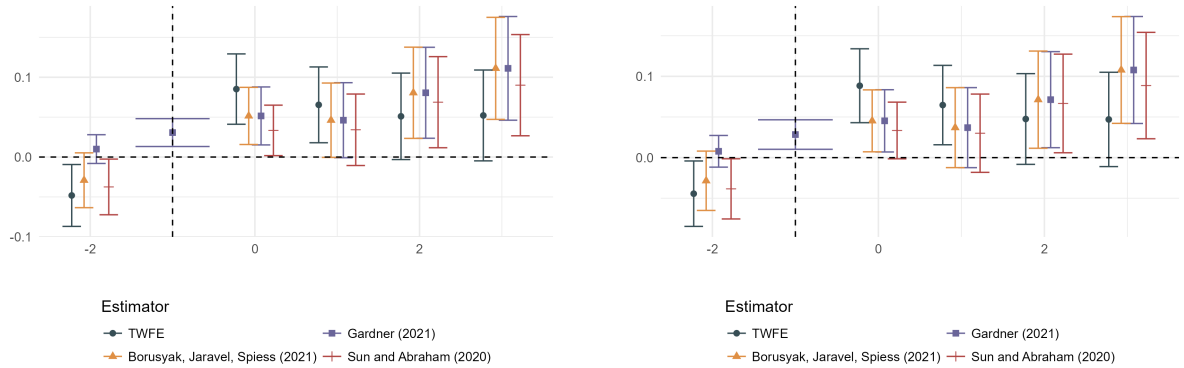
Counties within early adopters of full practice authority (FPA) exhibit an 11.3% decrease, $exp(0.12) - 1$, in the number of sole proprietor nurse practitioners compared to counties within later FPA adopters. This negative treatment effect suggests treatment heterogeneity; however, the weight assigned to this estimate is negligible, 1%, denoted by •. In contrast, counties of early FPA adopters demonstrate a 21% increase,

$exp(0.19) - 1$, in the number of sole proprietor nurse practitioners compared to FPA adopters before the sample period of our analysis, denoted by ▲. This estimate carries a weight of approximately 29%. Counties of early FPA adopters also exhibit a 10.5% increase, $exp(0.10) - 1$, in the number of sole proprietor nurse practitioners compared to adopters of FPA before our analysis's sample period, denoted by ■, with a weight of 2%. When comparing only counties within states with FPA with counties within non-FPA states, the former has a 1% higher count of sole proprietor nurse practitioners, with a weight of 68%, denoted by +. The weighted sum of these estimates amounts to $-0.12 \times 0.01 = 0.19 \times 0.29 + 0.10 \times 0.02 + 0.1 \times 0.68 \approx 0.1375$, surpassing the estimate reported in Table 3 Column (2). Goodman-Bacon decomposition applies only to balanced panel data; therefore, we exclude counties lacking consistent data across the sample period when performing this decomposition (Goodman-Bacon, 2021).

6.5 Event Studies

We employ an event study, utilizing Equation 2, to delve into dynamic treatment effects. The Goodman-Bacon decomposition in Figure 3 uncovers weakly heterogeneous treatment effects from our sample's staggered treatment timing.

Figure 4: Event study



(a) Dynamic treatment effect on sole proprietor NPs, asinh

(b) Dynamic treatment effect on sole proprietor NPs per 100,000, asinh

While implementing two-way fixed effects, we integrate event study frameworks de-

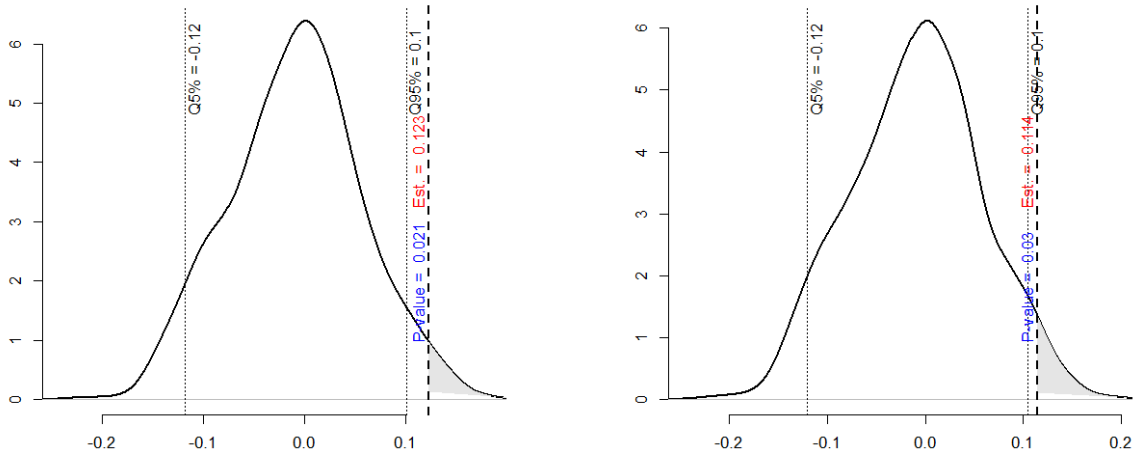
veloped by Gardner (2022), Borusyak et al. (2021), and Sun and Abraham (2021) in Figure 4. These frameworks adjust treatment heterogeneity under different assumptions, including parallel trends for all units, limited anticipation, and the correct specification of $Y(0)$, as outlined by Butts (2021). Cohort weights used by Sun and Abraham (2021), known for robustness to treatment effect heterogeneity compared to conventional two-way fixed effects estimators, are considered when estimating Equation 2. Figure 4 shows the plausibility of growth in sole proprietor nurse practitioners and sole proprietor nurse practitioners per 100,000 residents due to FPA implementation.

6.6 Randomized Inference Test

We simulate randomized treatment effects by iteratively assigning states as treated, defined as implementing FPA in our context, over 1000 iterations. The objective is to estimate the impact of randomly assigning FPA on our outcome variable of interest, nurse practitioners' entrepreneurial activities, to discern whether the treatment effects reported in columns (2) and (5) of Table 3 are attributable to chance or represent genuine effects. The results from these 1000 iterations illustrate the distribution of treatment effects due to random chance, visualized in Figure 5. Panel (a) represents the randomized treatment effect on counts of sole proprietor nurse practitioners, while Panel (b) illustrates the effect on sole proprietor nurse practitioners per 100,000 residents.

Randomized treatment effects include 95% confidence intervals in both panels, illustrated with a loosely dotted line. The reported treatment effect in columns (2) and (5) of Table 3 is represented by a solid line, and it falls outside or borders the 95% confidence interval of reported randomized treatment effects. This graphical representation suggests that reported treatment effects are genuine rather than mere chance, supporting that FPA leads to increased entrepreneurial activities among nurse practitioners.

Figure 5: Randomized inference test



(a) Randomized treatment effect on sole proprietor NPs, asinh

(b) Randomized treatment effect on sole proprietor NPs per 100,000, asinh

Notes: Randomized treatment effects were obtained by randomly assigning of state implementing FPA over 1000 iterations. The 95% confidence interval in both panels is depicted with a loosely dotted line. A dotted line represents the reported effect in Table 3 Column (2) and (5), respectively.

7 Discussion and Conclusion

We study restrictions on nurse practitioners' scope of practice and entrepreneurship among nurse practitioners. While others have demonstrated that scope of practice restrictions decrease aggregate self-employment among different types of advanced practice registered nurses, we add to the conversation by more precisely concentrating on nurse practitioners and business formation in the form of sole proprietorships. Our results reinforce the findings of those before us and indicate that nurse practitioners' scope of practice restrictions inhibit entrepreneurship among nurse practitioners. More specifically, our estimates suggest that granting full practice authority to nurses increases nurse entrepreneurship by about 10%. This is a crucial result for public policy, as the stated importance of the scope of practice expansions is to address healthcare workforce shortages, especially in areas where no physicians are providing primary care. The ability to start and maintain their own business without expensive collaboration contracts al-

lows nurse practitioners to fully enjoy entrepreneurship's monetary and non-monetary benefits, empowering them to move into communities with unmet needs.

Our findings come with a few vital implications. Most importantly, we provide evidence that can help guide future healthcare policy. Allowing nurse practitioners full practice authority is becoming more and more common; as such, researchers can assess how healthcare outcomes are impacted when nurse practitioners are allowed to practice independently. We add to a growing body of literature that finds a variety of benefits associated with the implementation of full practice authority (Gaglioti et al., 2016; Grumbach et al., 2003; Lenz et al., 2004; Martin, 2000; Perry, 2009; Stange, 2014; DePriest et al., 2020; Yang et al., 2021). Our results, and those of others before us, indicate that removing nurse practitioner occupational restrictions is a cheap and effective way to improve healthcare outcomes when healthcare shortages are becoming salient (Mann, 2020).

We also explain low entrepreneurship rates among nurse practitioners that rely on something other than assumptions about attitudes among or about nurses and their profession. While nurse practitioners, and nurses more broadly, may shy away from entrepreneurship because of cultural attitudes in the healthcare profession (Jakobsen et al., 2021), our empirical evidence shows restrictions on the ability to practice independently do not help. In places where nurse practitioners are legally empowered to practice independently, they are more likely to open their practice. Scope of practice laws is a much easier policy level to pull than trying to change cultural attitudes within and about the healthcare profession.

Our results further suggest that restrictive scope of practice regulations decrease healthcare availability by discouraging nurse practitioners from forming their practices and moving into communities needing primary care providers. Other work suggests limitations on nurse practitioners' scope of practice reduce healthcare availability, especially in areas with healthcare shortages (Xue et al., 2018). Our work reinforces the notion that restrictive scope of practice laws lower healthcare availability by disincentivizing business

formation among nurse practitioners.

Finally, our research opens the door for interesting future work. While we study how the scope of practice of nurse practitioners influences the prevalence of practices owned by nurse practitioners, we do not observe the performance of those practices. Our front-end theory suggests nurse practitioner occupational restrictions should negatively impact the performance of businesses owned by nurse practitioners. We also do not observe the performance or prevalence of physician-owned practices. Future work can uncover how physician-owned practices are impacted when it is easier for nurse practitioners to start their ventures.

Given a lack of evidence that nurse practitioners provide sub-optimal care compared to physicians (Laurant et al., 2005; Lenz et al., 2004; Mundinger et al., 2000; Swan et al., 2015; Bae et al., 2023), our research opens up the possibility that occupational licensing restrictions in the form of restrictions to nurse practitioners' scope of practice are unnecessarily contributing to healthcare supply shortages by decreasing practice ownership. By empowering nurse practitioners and releasing them from burdensome occupational constraints, government officials can address healthcare shortages safely, cheaply, and effectively.

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A Appendix A

Table A1: Numbers of nurse practitioners by US states and territories

State	2016	2017	2018	2019	2020	2021	2022	2023
AK	825	886	950	1,039	1,111	1,197	1,287	1,393
AL	3,880	4,563	5,193	5,884	6,575	7,177	7,969	8,644
AR	2,287	2,640	3,036	3,445	3,884	4,316	4,854	5,265
AS	2	3	3	2	2	2	2	2
AZ	5,628	6,408	7,094	8,014	8,914	10,017	11,279	12,508
CA	17,357	19,433	21,532	23,902	26,367	28,817	31,833	35,105
CO	4,137	4,790	5,419	6,176	7,005	8,003	8,986	10,044
CT	4,284	4,671	5,080	5,553	5,978	6,439	7,027	7,527
DC	1,154	1,245	1,334	1,486	1,602	1,745	1,918	2,058
DE	1,189	1,318	1,445	1,556	1,716	1,803	1,983	2,207
FL	16,588	19,390	22,252	26,025	29,825	34,141	39,471	44,909
GA	7,396	8,550	9,800	11,286	12,662	13,904	15,415	16,954
GU	29	33	46	58	61	71	81	79
HI	814	913	995	1,099	1,150	1,284	1,450	1,613
IA	2,582	2,826	3,136	3,468	3,940	4,336	4,845	5,295
ID	1,228	1,350	1,487	1,687	1,874	2,138	2,426	2,710
IL	7,517	8,856	10,041	11,371	12,816	14,157	15,619	17,219
IN	6,091	6,921	7,849	8,815	9,892	10,947	12,192	13,492
KS	2,850	3,144	3,466	3,727	4,054	4,436	4,885	5,458
KY	6,625	7,516	8,354	9,264	10,275	11,364	12,630	13,739
LA	3,907	4,362	4,851	5,367	5,954	6,514	7,211	7,964
MA	8,406	9,200	9,992	10,769	11,685	12,663	13,786	15,104
MD	4,961	5,574	6,112	6,969	8,007	8,992	10,245	11,616
ME	1,639	1,768	1,893	2,085	2,282	2,477	2,711	2,952
MI	6,572	7,393	8,327	9,361	10,364	11,375	12,553	13,725
MN	5,066	5,507	6,033	6,720	7,768	8,931	9,626	10,426
MO	6,089	6,908	7,636	8,471	9,375	10,123	11,177	12,106
MP	8	8	8	8	13	12	13	13
MS	3,548	3,979	4,392	4,926	5,430	5,909	6,383	6,891
MT	839	950	1,086	1,203	1,321	1,475	1,710	1,876
NC	8,276	9,489	10,426	11,289	12,663	13,867	15,607	17,813
ND	728	797	865	986	1,134	1,262	1,408	1,594
NE	1,668	1,843	2,041	2,266	2,567	2,831	3,170	3,416
NH	1,631	1,821	1,972	2,188	2,413	2,665	2,965	3,284
NJ	5,334	6,055	6,703	7,424	8,296	9,146	10,256	11,379
NM	1,745	1,924	2,159	2,429	2,719	2,968	3,306	3,675
NV	1,522	1,833	2,134	2,526	3,000	3,453	4,101	4,749
NY	16,701	18,257	19,925	21,923	24,150	26,379	28,919	31,495
OH	10,250	11,907	13,618	15,529	17,408	19,340	21,620	23,636
OK	2,081	2,389	2,718	3,123	3,558	3,944	4,429	4,867
OR	3,488	3,827	4,191	4,593	5,008	5,452	5,906	6,370
PA	10,014	11,131	12,280	13,448	14,700	15,956	17,537	19,053
PR	36	41	43	45	54	64	85	100
RI	1,056	1,158	1,289	1,458	1,641	1,862	2,031	2,259
SC	3,461	4,018	4,555	5,200	5,982	6,630	7,547	8,380
SD	788	890	985	1,130	1,251	1,361	1,527	1,714
TN	9,841	10,947	12,041	13,206	14,336	15,304	16,704	18,072
TX	16,903	19,652	22,368	25,603	29,334	32,688	37,093	41,883
UT	1,867	2,101	2,343	2,616	2,970	3,301	3,825	4,320
VA	5,907	6,688	7,455	8,275	9,276	10,314	11,491	12,849
VI	28	33	30	30	32	30	36	38
VT	614	672	723	787	856	932	1,013	1,087
WA	6,097	6,734	7,369	8,094	8,979	9,772	10,813	11,920
WI	4,911	5,503	6,062	6,699	7,352	7,975	8,746	9,624
WV	1,624	1,829	2,066	2,305	2,574	2,837	3,075	3,344
WY	452	513	544	611	706	771	839	921
Total	250,521	283,157	315,747	353,519	394,861	435,869	485,616	536,736

Table A2: Numbers of sole proprietor nurse practitioners by US states and territories

State	2016	2017	2018	2019	2020	2021	2022	2023
AK	153	163	167	176	188	218	237	266
AL	491	578	636	726	831	972	1,199	1,430
AR	343	411	469	554	658	777	889	963
AZ	1,053	1,215	1,393	1,601	1,817	2,102	2,446	2,784
CA	4,029	4,587	5,081	5,694	6,410	7,130	8,029	9,041
CO	492	587	660	747	901	1,098	1,318	1,540
CT	568	622	680	747	849	947	1,102	1,213
DC	234	242	257	291	326	364	396	416
DE	131	150	155	173	181	200	260	302
FL	3,349	4,141	4,919	6,075	7,223	8,713	10,426	12,175
GA	1,177	1,440	1,674	1,975	2,297	2,681	3,104	3,522
GU	5	5	8	13	14	18	24	21
HI	188	207	218	248	259	307	360	406
IA	212	246	263	309	357	382	463	522
ID	168	191	222	245	286	356	430	504
IL	1,128	1,392	1,575	1,792	2,077	2,401	2,711	3,055
IN	477	547	597	663	760	911	1,081	1,271
KS	316	354	372	398	445	500	614	711
KY	616	739	836	964	1,138	1,336	1,601	1,807
LA	715	796	917	995	1,094	1,228	1,356	1,507
MA	1,124	1,259	1,373	1,483	1,645	1,873	2,129	2,406
MD	775	934	1,039	1,244	1,524	1,773	2,007	2,355
ME	125	140	144	163	176	204	253	283
MI	877	986	1,133	1,299	1,491	1,705	2,002	2,239
MN	372	432	473	550	630	815	926	1,023
MO	678	777	852	937	1,051	1,129	1,282	1,390
MP	1	1	1					
MS	574	658	750	874	970	1,075	1,193	1,331
MT	128	146	167	189	203	233	300	337
NC	937	1,042	1,139	1,184	1,380	1,563	1,850	2,176
ND	57	68	68	75	91	103	132	154
NE	198	214	225	242	273	319	385	430
NH	131	140	146	167	201	245	296	361
NJ	1,368	1,595	1,756	1,944	2,155	2,432	2,761	3,105
NM	297	324	379	422	473	530	593	708
NV	245	280	333	451	547	679	877	1,075
NY	4,222	4,665	5,083	5,565	6,079	6,766	7,519	8,281
OH	1,615	1,950	2,299	2,740	3,127	3,567	4,102	4,597
OK	283	340	393	459	548	642	763	877
OR	615	666	704	753	808	866	965	1,081
PA	1,236	1,377	1,479	1,590	1,750	1,921	2,238	2,478
PR	24	27	29	28	32	38	48	54
RI	140	170	191	223	245	293	327	364
SC	380	468	524	592	697	799	954	1,110
SD	44	52	59	72	81	96	116	137
TN	1,161	1,282	1,431	1,540	1,691	1,856	2,146	2,414
TX	2,791	3,441	4,007	4,703	5,621	6,523	7,640	8,864
UT	371	428	485	531	600	695	842	951
VA	646	742	847	927	1,065	1,264	1,563	1,888
VI	7	8	7	7	8	8	9	9
VT	62	72	72	80	90	107	125	138
WA	849	932	1,042	1,181	1,324	1,464	1,644	1,880
WI	336	408	434	496	565	644	759	856
WV	194	209	236	256	313	357	413	454
WY	84	93	90	109	131	154	172	187
AS				1	1	1	1	1
Total	38,792	44,939	50,489	57,463	65,697	75,380	87,378	99,450