Relaxing Occupational Licensing Requirements: Analyzing Wages and Prices for a Medical Service

Morris M. Kleiner *University of Minnesota*
Allison Marier *Abt Associates, Inc.*
Kyoung Won Park *Hanyang University*
Coady Wing *Indiana University, Bloomington*

Abstract

Occupational licensing laws have been relaxed in a large number of US states to give nurse practitioners the ability to perform more tasks without the supervision of medical doctors. We investigate how these regulations affect wages, hours worked, and the prevailing transaction prices and quality levels associated with certain types of medical services. We find that when nurse practitioners have more independence in their scope of practice, their wages are higher but physicians' wages are lower, which suggests some substitution between the occupations. Our analysis of insurance claims data shows that more rigid regulations increase the price of a well-child visit by 3–16 percent. However, we find no evidence that the changes in regulatory policy are reflected in outcomes that might be connected to the quality and safety of health services.

1. Introduction

In models of competitive labor markets, workers with overlapping skills are assumed to compete for work. The introduction of occupational licensing may function as a barrier to entry that drives up wages in the licensed occupation and

Research for this article uses health care charge data resources compiled and maintained by FAIR Health, Inc. The authors are solely responsible for the research and conclusions reflected in the article. FAIR Health, Inc., is not responsible for the research conducted or for the opinions expressed in this article. This article does not necessarily reflect the views or positions of Abt Associates, Inc. We especially thank Hwikwon Ham, David Harrington, and Kevin Stange for their comments and participants at seminars at the Allied Social Sciences annual meetings, American Society of Health Economists, London School of Economics, McMaster University, Minnesota Economics Association, University of Minnesota, University of Washington, and the W.E. Upjohn Institute for Employment Research for their comments and suggestions. All of the authors contributed equally to the study.

[*Journal of Law and Economics,* vol. 59 (May 2016)]

increases the prices of products and services that are produced by licensed workers (Friedman and Kuznets 1945; Friedman 1962; Kleiner and Krueger 2013). These regulations may benefit consumers by reducing allocative inefficiencies created by information asymmetries in some service and labor markets (Arrow 1963; Leland 1979; Shapiro 1986).

One kind of occupational regulation that is increasingly common in the health sector, the segment of the economy with the most occupational licensing, is scope-of-practice regulation (Kleiner and Park 2010). These laws specify the kinds of services and tasks that members of a particular occupation may perform, and they sometimes require supervisory or collaborative relationships between two occupations. In essence, scope-of-practice regulations affect the boundaries and shared work space between two occupations that might otherwise function as imperfect or even perfect substitutes in the production of goods and services. In models of competitive markets, these workers would compete with each other to perform the work. Under restricted-entry licensing regulations, the government determines which occupation will do the work. Scope-of-practice regulations create overlaps in the eligibility of different occupations to perform work tasks. Such rules are more complex than ordinary licensure regulations and are sometimes viewed as more important in creating an understanding of regulated markets. In this article, we analyze the consequences of scope-of-practice regulations that affect nurse practitioners (NPs). In particular, we examine how state regulatory frameworks affect wage and employment outcomes for physicians (MDs) and NPs, the prices of basic health services, and several measures of public health outcomes.

Understanding the consequences of outcomes in regulated markets is particularly important in the health sector because it is highly subject to occupational regulation and a large part of the US economy (Kleiner and Kudrle 2000). In 2009 the health sector accounted for about 18 percent of US gross domestic product, and expenditures on provider services represented about 21 percent of total expenditures on health services (Centers for Medicare and Medicaid Services 2010). The health sector is also central to employment: in 2012 it employed about 11.7 percent of all workers in the United States, and its share of workers is expected to grow over the next 10 years.[1] If regulations have even small effects on wages and prices, the aggregate cost of the regulations could be large in absolute dollars. This analysis examines the implications of proposed regulations that are currently on the agenda in many states. For example, the National Conference of State Legislatures reports that across 54 state or territorial governments that it monitors, 1,795 scope-of-practice bills were proposed during the 2-year period from January 2011 to December 2012, and about 20 percent of these bills were adopted (Issacs and Jellinek 2012).

We study the effects of regulations that affect the scope of practice afforded to NPs who are registered nurses (RNs) who have obtained additional training

[1] US Department of Labor, Bureau of Labor Statistics, Employment Projections (http://www.bls.gov/emp/ep_table_201.htm).

through a master's or Ph.D. degree program (Harper and Johnson 1998; Dueker et al. 2005). Nurse practitioners are trained to diagnose and treat common illnesses and injuries, manage chronic illnesses, prescribe medications, and provide counseling. They face a variety of state-specific occupational regulations that restrict their activities and their relationship with MDs.

We use a variety of data sources to evaluate the apparent effects of recent changes in NP scope-of-practice regulations on several different outcomes. There is clear evidence that NP regulations affect labor and product market outcomes. For example, granting NPs more independent scope of practice increases their wages by about 5 percent and decreases physicians' wages by about 3 percent. Using insurance claims data, we find that the price of well-child visits—a service that could easily be provided by either a physician or an NP—increased by 3–16 percent when states adopted regulations limiting the authority of NPs to prescribe medication (hereafter, prescription authority).

To assess the possibility that changes in physicians' oversight of NPs' scope of practice alters the risk of adverse health outcomes, we study the effects of regulatory changes on physicians' malpractice premiums. Granting more independence to NPs does not seem to affect malpractice premiums for physicians, which suggests that the laws do not prevent or induce large systematic changes in the risks of delivering health care services. We examine the effects of regulatory changes on infant mortality rates to look for a connection between more flexible NP practice standards and severe negative health outcomes. Here too the analysis provides little evidence that the regulatory environment had a meaningful influence on the relevant population's health.

2. Licensing and Regulation in the Health Sector

2.1. The Evolution in Licensing of Physicians, Nurses, and Nurse Practitioners

The first physician licensing laws were passed in the 1870s by the states to stem what was viewed by physicians as uncontrolled access to the market. By 1881, half of the states had physician licensure, although serious enforcement did not begin until the 1890s (Baker 1984). Under the new regulations, unlicensed medical practice was punishable by fine or imprisonment. The publication of the Flexner report (Flexner 1910), sponsored by the American Medical Association (AMA), eventually led to AMA control of medical education and regulation of physicians and auxiliary workers. A key issue is that licensure endows physicians with considerable control over what services and work tasks nonphysicians are allowed to perform under state law or administrative rules established by state administrative boards.

In contrast, nurse licensure started as certification or titling regulations imposed by state governments. By 1923, all 48 states had legislation that required nurses to hold certain qualifications in order to use the title of nurse (Comer 2007). New York enacted the first legislation requiring mandatory licensure for nurses in 1947. Currently, all states require that nurses be licensed. The terms

"registered nurse" and "licensed practical (vocational) nurse" are now legally protected titles, and one must pass a licensing examination and meet the requirements set by each state to practice as a nurse in that state (Eberly and Rooney 2012, p. 26).

Nurse practitioners receive additional graduate-level training to provide a range of health services, including diagnosing and treating common acute and chronic conditions, prescribing treatments including medication and medical devices, and counseling and educating patients.[2] The first NP graduate program opened at the University of Colorado in 1965. There are about 325 NP programs offered at universities across the United States, and there are about 220,000 practicing NPs in 2015 (Comer 2007).[3] Currently, there are no additional licensure requirements for NPs. National- and state-level certification regimes are in place, and the American Academy of Nurse Practitioners estimates that 97 percent of practicing NPs maintain a national certification (Comer 2007). Although licensure beyond the RN designation is not required, state governments regulate the activities of NPs using scope-of-practice laws that determine whether they can prescribe controlled medications, receive direct reimbursement for services by public and private health insurers, and require a formal supervisory relationship with an MD in certain types of practice environments.

2.2. Perspectives on Regulations

State NP regulations are sometimes considered arbitrary. For example, NPs who live on the border of Illinois and Missouri find that they are allowed to perform more tasks in Illinois than Missouri. Terry McQuaide, an advanced NP for Esse Health, comments, "As an advanced nurse practitioner with offices in Illinois and Missouri, I have a unique perspective. . . . [T]reatment for bronchitis can include cough syrup with codeine, and back pain may require a pain medication. In Illinois, after examination and diagnosis, I can write these prescriptions. In Missouri, I need to delay the patient and interrupt the physician to have him prescribe the medications. This creates unnecessary delays and may require extra trips for the patient" (McQuaide, Kelly, and Hawatmeh 2007, p. C3). Physicians' lobbying groups have generally opposed efforts to expand the authority of NPs. For example, the Missouri State Medical Association was largely opposed to providing NPs with the ability to prescribe controlled substances. It supported alternatives in which NPs had only partial or short-term prescription authority: "The medical association wants limits on how much nurse practitioners could prescribe capping the amount of medicine to enough for three to five days, for example, just to fill an immediate need before the patient could see a physician" (Lieb 2008). These cases seem to represent the kinds of arguments made by NP and MD organizations that lobby state governments.

[2] O*Net Resource Center, Summary Report for: 29-1171.00—Nurse Practitioners (http://www.onetonline.org/link/summary/29-1171.00).

[3] American Association of Nurse Practitioners, All about NPs, NP Fact Sheet (https://www.aanp.org/all-about-nps/np-fact-sheet).

In another example, a senior vice president for the Medical Society of the State of New York gave testimony to New York State lawmakers in which she argued that removing physicians' oversight of NPs "would seriously endanger the patients for whom they care" (Pettypiece 2013). One theme in popular coverage of debates about the regulation of health care workers is that those workers are the main actors in promoting policies for occupational regulations.

2.3. Prior Analysis of Occupational Regulation in the Health Sector

Earlier studies examine the implications of complementarity and substitutability of regulated occupations that provide similar services. In an early study of physicians' productivity, Reinhardt (1972, p. 55) finds that "the average American physician could profitably employ roughly twice the number of aides he currently employs and thus increase his hourly rate of output by about 25 per cent above its current level." We expect that this type of task shifting from physicians might encourage entry from the complementary occupation, NPs. If the two occupations are simple substitutes in the production of services without any task shifting, then physicians seem to have little incentive to support expanded authority for NPs. Scope-of-practice laws may impose a degree of production complementarity by tying NPs to MDs through supervision requirements, collaborative-practice requirements, limits on prescription authority, and restrictions on the ability of insurers to reimburse NPs directly.

Studies of other medical specialties show the importance of laws and administrative procedures for labor market outcomes. For example, Kleiner and Park (2010) show that occupational regulations on dentists and dental hygienists influence the earnings of both groups. Wing and Marier (2014) find that when states broadened dental hygienists' scope of practice, the prevailing price of basic dental services fell and utilization of basic dental services increased. In addition, Wing and McConeghy (2016) show that allowing pharmacists to provide influenza vaccinations in retail settings led to large increases in pharmacy-based vaccination rates but only small increases in overall vaccination rates, which suggests that the main effects of the regulations was to shift people to a more convenient delivery model.

Stange (2014) examines the link between the growing supply of NPs and levels of access, costs, and patterns of care and utilization for a broad population-based sample. Our study develops an analysis that is distinct from his: we study how the regulations affect the wages and employment of NPs and MDs and the prevailing prices for well-child visits, which is a more homogeneous health service than the overall utilization measures he considers. This narrower focus makes it easier for us to separate the regulatory price effects from general variations in prices of medical services.

In contrast to our results, Sass and Nichols (1996), using cross-sectional analysis of several private and public data sources, estimate that the wages of physical therapists are significantly lower in states that permit direct access relative to

states that require patients to obtain a physician's referral for physical therapy services. They also find that physical therapists who treat patients without a physician's referral gain at the expense of other therapists. Although cross-sectional estimates indicate that direct access may reduce wages for physical therapists, the use of a more robust difference-in-differences approach for NPs who work more closely with physicians may have different outcomes.

3. A Basic Model of Medical Services Production with Regulation

In an economic model of health care services, regulation's influence can be examined by extending a traditional production function. The model uses a framework in which the work of one occupation cannot legally be done without the inputs of the other occupation. The model serves as a basis to inform and develop hypotheses about the empirical work, rather than as a fully specified general equilibrium model of medical production under regulation, and uses a modified standard production function:

$$Q_{\mathrm{p}} = \mathrm{HH} = f(P[z],\ K) \tag{1}$$

and

$$Q_{\mathrm{n}} = \mathrm{HL} = f(P[z],\ \mathrm{NP}[z],\ K), \tag{2}$$

where Q_{p} is the output produced by the physician (MD), which we refer to as high-skilled patient services (HH). The term Q_{n} is the output produced by the NP, which we refer to as low-skilled patient services (HL). The term $P(z)$ represents the MDs' labor, where output relies on their decision of personal input, and $\mathrm{NP}(z)$ represents the NPs' labor, where output relies on their decision of personal input. The term K represents the quantities of capital inputs used in a medical practice (Reinhardt 1972).

By law, however, the technology needed for NPs to produce HL is tied to supervision by a physician. Nevertheless, in this profit function, the NP's wage is tied to the decisions of the physician to use the labor input and technology mix of the high-skilled provider, HH. Regulation acts as a shifter of both the supply and demand curves (Varian 1992). However, in the model, NPs can either raise their own earnings and those of physicians or raise their earnings at the expense of physicians. Physicians, who are generally in control of the production of these services, can allocate relatively low-skilled work such as well-child exams to NPs while taking on higher-skilled and higher-value-added services such as caring for sick or injured children and can thereby maximize rents from regulation for themselves as well as for the NPs. Our article examines these empirical questions in addition to the influence of regulation on prices and quality of care.

3.1. Measures of Licensing Requirements

We collected information on NP scope-of-practice regulations from *Nurse Practitioner*'s annual legislative updates for 1999–2010 (Pearson 1999, 2000,

2001, 2002, 2003, 2004; Phillips 2005, 2006, 2007, 2009, 2010; *Nurse Practitioner* 2008). We focus on two measures of NPs' scope of practice, independence in scope of practice and independent prescription authority, which represent a crucial inputs in the treatment of many health conditions. Limiting the ability of NPs to prescribe controlled medications could substantially alter the extent to which their services can serve as substitutes for MDs' services.

The appropriate treatment for a wide range of health conditions involves prescription medication. For many patients, the value of a visit to an NP may be sharply diminished if she is able to provide a diagnosis for the condition but only a referral for the prescription required for treatment. Since patients typically will not know if they need a prescription until after a visit, restricting NPs' authority may reduce patients' demand for their services. The measure of prescription authority distinguishes among three types of regulations. In states that allow independent prescription authority, NPs are allowed to prescribe controlled medications independent of any supervision by an MD. In states that allow supervised and/or delegated prescription authority, NPs are allowed to prescribe controlled medications under the supervision of an MD. Finally, in states that allow limited prescription authority, NPs are not allowed to prescribe controlled medications and may prescribe uncontrolled medications only under the supervision of a physician.

Figure 1 shows how prescription authority regulations have changed over time. The trend in the United States over the last 10 years has been toward greater autonomy for NPs. In 2000, nine states had limited prescription authority regulations that did not allow NPs to prescribe controlled medications. By 2011, only two states maintained that restrictive level of regulation. Similarly, in the early 2000s, many states transitioned from limited prescription authority to supervised or delegated prescription authority. This movement is an intermediate step or partial deregulation of the prescription authority environment. Toward the end of the decade, several states shifted from supervised or delegated prescription authority to independent prescription authority, which is the lightest form of regulation. Overall, Figure 1 shows that NPs have been gaining greater autonomy in providing services to patients.

Table 1 presents the licensing requirements of states during the period 2000–2011. Eleven states relaxed their licensing requirements to allow more prescription authority for NPs. There does not appear to be any significant regional bias to the changes that are shown in Table 1.

3.2. Labor Market Outcomes

The regulations described in Section 6.1 represent the policy treatments that motivate our analysis. We now examine regulations affecting the prevailing wage and employment levels of NPs and MDs. We use pooled data from the 2001–13 American Community Survey (ACS) to construct samples of NPs and MDs. The ACS offers a sample size large enough to allow the analysis of individual occu-

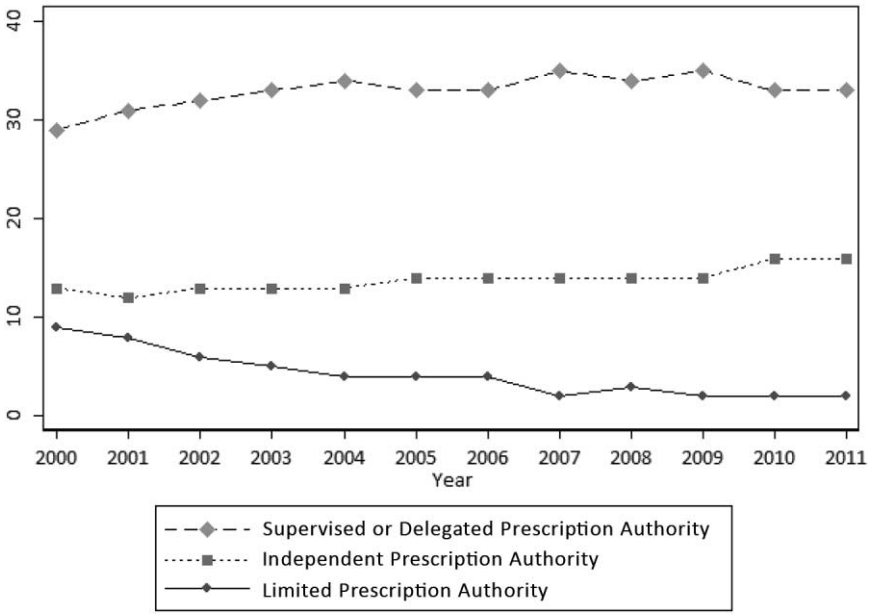

Figure 1. Changes in regulations governing prescription authority for nurse practitioners, 2000–2011.

pations and states. However, the ACS does not separately identify NPs. Consequently, we developed a sample selection method to create a sample that consists of practicing NPs rather than RNs.[4] The data in Table A1 illustrate the sample selection rule and its implications for NPs' earnings and hours worked. After imposing additional selection conditions based on the completeness of data on earnings, hours worked, and some key covariates, we are left with an NP sample of 23,820 observations. Our ACS data on physicians has a sample of 80,586 MDs with complete covariates.

Descriptive statistics for our ACS samples are presented in Table 2 for 2001–13. About 92 percent of the individuals in the NP sample are women and about 6 percent are black. The results also show that 29 percent of the NP observations are drawn from state-year cells with scope-of-practice independence, and 12 per-

[4] The American Community Survey (ACS) did not separately identify nurse practitioners (NPs) until 2010. In earlier years, NPs are pooled with registered nurses (RNs) in a single occupation code. To interpolate NPs, we use the sample of RNs and NPs who held a master's degree or Ph.D. in the post-2010 waves of the ACS to fit a simple predictive model of whether a person was an NP. The independent variables in the predictive logit model include measures of gender, race, immigration status, and marital status; a cubic function of age; a function of age; labor market sector (self-employed, for profit, or nonprofit); whether the person held a Ph.D.; and state fixed effects. We use the estimated coefficients from the model to compute predicted probabilities in the earlier waves of the ACS and limit our analysis to people who had predicted probabilities larger than the 10th percentile of predicted values in the 2011 ACS. Table 2 presents the statistics for NPs using this definition.

Table 1
Status of State Regulations for Nurse Practitioners' Prescription Authority, 2000–2011

	Regulation
No change:	
AL and FL	Limited prescription authority
AR, CA, CT, DE, GA, IL, IN, KS, MA, MI, MN, NC, NE, NJ, NY, OH, OK, PA, RI, SC, SD, TN, VA, VT, and WV	Supervised or delegated prescription authority
AK, AZ, DC, IA, ME, MT, NH, NM, OR, UT, WA, and WY	Independent prescription authority
Change:	
LA and NV	From no prescription authority to supervised or delegated prescription authority, 2000–2001
WI	From supervised or delegated prescription authority to independent prescription authority, 2000–2001
MS	From no prescription authority to supervised or delegated prescription authority, 2001–2
TX	From no prescription authority to supervised or delegated prescription authority, 2002–3
ID	From supervised or delegated prescription authority to independent prescription authority, 2003–4
KY	From no prescription authority to supervised or delegated prescription authority, 2005–6
MO	From no prescription authority to supervised or delegated prescription authority, 2006–7
CO and MD	From supervised or delegated prescription authority to independent prescription authority, 2009–10
HI	From supervised or delegated prescription authority to independent prescription authority, 2010–11

Note. With limited prescription authority, nurse practitioners are not allowed to prescribe controlled medications. With supervised or delegated prescription authority, nurse practitioners may prescribe controlled medications under a physician's supervision. With independent prescription authority, nurse practitioners may prescribe controlled medications without a physician's supervision.

cent of NPs are in state-year cells with unrestricted prescription authority. Our hourly earnings data are in real 2013 dollars and average about $40.25 per hour for our sample of NPs, about 60 percent of the hourly earnings for physicians. The substantial difference in wages between the two groups is one indication that scope-of-practice regulations that alter the mixture of NPs and MDs used to deliver health services could have effects on the costs of delivering those services and on the prevailing prices of certain health services.

3.3. Medical Service Prices

Scope-of-practice regulations could influence the prevailing prices of health services by altering the supply of health services and by changing the mix of providers available in the market. A key issue is the method of analyzing the price effects of the scope-of-practice regulations. Scope-of-practice regulation is only one of many factors that may determine the prevailing prices of health services. The influence of the regulations is likely to differ greatly across types of health

Table 2
Summary Statistics for Nurse Practitioners and Physicians: American Community Survey Data, 2001–13

	Nurse Practitioners (N = 23,820)		Physicians (N = 80,586)	
	Mean	SD	Mean	SD
Hourly earnings (2013 $)	40.25	21.76	75.66	48.64
Log earnings	3.59	.46	4.05	.82
Total hours worked	1,995	578	2,679	844
Age	46	10	44	10
Female	.92	.28	.33	.47
Married	.68	.47	.78	.42
White	.89	.32	.74	.44
Black	.06	.23	.05	.22
Immigrant	.08	.26	.26	.44
Citizen	.99	.08	.92	.27
Ph.D.	.02	.15	.15	.35
Sector:				
Self-employed	.01	.11	.19	.39
For-profit	.51	.50	.39	.49
Nonprofit	.30	.46	.21	.41
Scope of practice	.29	.45	.29	.45
Independent prescription authority	.12	.33	.12	.33

services depending on the relative importance of NPs and MDs with respect to the nature of the demand for a particular health service.

Consequently, we attempt to examine a health-service-related outcome that satisfies these conditions. First, we sought a service that is widely consumed and often provided by both MDs and NPs. Second, we wanted to examine a medical service that is relatively standardized in delivery so that our estimates do not detect price differences that arise mainly because of pooling complicated and uncomplicated cases and reflecting service heterogeneity rather than differences in prices for a homogeneous service. After consultations with colleagues in the School of Nursing at the University of Rochester, we chose insurance claims for well-child exams because they meet these criteria for a plausible test procedure that is homogeneous.[5] Well-child visits are widely consumed annually by large numbers of families in the United States, involve a standard set of tests and evaluations, and are routinely provided by both family practice physicians and NPs. Accordingly, well-child visits allow for a strong test for the role of scope-of-practice regulations on the prices of these exams.

Our analysis of prices is based on a large database of private insurance claims that is maintained by FAIR Health, Inc., a nonprofit organization that provides independent estimates of the distribution of charges for health services across the United States. The claims database is widely used by insurance companies and

[5] We thank Irena Pesis-Katz at the University of Rochester School of Nursing for helpful discussions about the appropriate choice of a health service for analysis.

Table 3
Basic Price Data from FAIR Health, Inc., for Well-Child Visits

CPT Code	Description	Age (Years)	Claims (*N*)	Allowed Amount		
				Mean ($)	Median ($)	SD ($)
99381	Preventive visit, new patient	0–1	551,972	108.91	106.00	30.06
99382	Preventive visit, new patient	1–4	353,231	119.57	117.44	32.22
99383	Preventive visit, new patient	5–11	425,911	117.64	114.97	31.91
99384	Preventive visit, new patient	12–17	508,421	124.58	122.40	36.24
99391	Preventive visit, established patient	0–1	8,040,000	86.72	84.90	23.99
99392	Preventive visit, established patient	1–4	8,390,000	96.86	94.70	26.20
99393	Preventive visit, established patient	5–11	6,238,129	96.10	93.53	26.20
99394	Preventive visit, established patient	12–17	5,074,770	104.85	102.47	29.59

Note. CPT = current procedural terminology.

health care providers to better understand geographical variation in the prices of health services. The insurance companies that participate have access to data on the price and quantity of health procedures as a basis for negotiating prices with hospitals and medical clinics. We extracted insurance claims with current procedural terminology (CPT) codes that correspond to well-child visits: CPT codes 99381–99384 and 99391–99394. Each insurance claim contains information about the type of claim, the geographical location of the office where the service was provided, the billed charge that was submitted by the provider, and the allowed amount that the insurance company ultimately paid the provider after taking into account negotiated discounts, copayments, and the details of insurance plans. The allowed amount can be seen as the total amount that the provider receives for the service (Nicholson 2012). We analyze the allowed amount because it comes closest to the theoretical concept of the transaction price of health services that is relevant to economic theory and analysis.

Table 3 reports statistics for each type of insurance claim in our analysis. There are almost 30 million claims for these eight health service categories over the period 2005–10. The price of a well-child visit increases somewhat with the age of the child, and prices are higher for new-patient visits than for established-patient visits. In general, well-child visits cost about $80–$100, with a standard deviation across all claims of around $30.

The FAIR Health database consists of individual insurance claims provided by a large set of contributing insurance companies that operate in markets across the United States. Each contributing company agrees to submit a complete and unadulterated data set of the insurance claims it processed over a calendar year. Because of the structure of the insurance industry in the United States, these companies may be affiliated with a larger parent company, and so it may not be reasonable to think of each contributor as an independent company. Despite the large number of claims in the database, it is important to note that the claims are not the result of a formal random-sampling process. They are, instead, the prod-

uct of the decisions of individual health insurance firms to join the network of firms that contribute to the database, so contributing firms may be different from noncontributing firms in unknown ways.

We think that it is unlikely that firms select into the network of FAIR Health contributors on the basis of the distribution of prices they pay for well-child visits or that these participation choices are correlated with responses to occupational regulations for NPs. Nevertheless, to examine and evaluate the representativeness of the database, we compared the data from the FAIR Health database with claims data from the Truven (formerly Thomson Reuters) MarketScan Research database. The MarketScan Research database is similar in construction to the FAIR Health database, but it consists of claims from self-insured employers rather than from independent health insurance companies. MarketScan is widely used in the academic literature.[6] We have FAIR Health data for 2005–10, but for MarketScan we have information only for 2007, so we limit our comparisons to claims for 2007.[7]

Our analysis of the price data was conducted at a level of aggregation other than the individual claim level. We conducted a state-level analysis by computing mean and median prices in state-year product code cells. We also conducted some analyses of prices within selected metropolitan statistical areas (MSAs) by classifying claims using the zip code of the provider's location. Throughout, we reduced the influence of outliers (which are likely data entry errors) by top coding the price data at $1,000 and removing prices that are missing or negative. We kept 99.8 percent of the price data observations.

3.4. *Empirical Framework*

We pursue a quasi-experimental approach to analyzing how NP scope-of-practice regulations affect the wages, employment levels, service prices, and quality levels that prevail in the health services market. The analysis uses a generalized difference-in-differences design that exploits within-state changes in regulations. We use a two-way fixed-effects model to estimate the effects of the regulations. The basic model takes the following form:

$$Y_{ist} = \boldsymbol{X}_{ist}\alpha + \beta \boldsymbol{R}_{st} + \boldsymbol{\theta}_s + \boldsymbol{\theta}_t + \varepsilon_{st}. \quad (3)$$

[6] Truven maintains a bibliography of the scientific publications that make use of the MarketScan Research database. The bibliography contains entries for publications in a variety of fields including economics, health services research, medicine, nursing, statistics, and physiology (see Truven Health Analytics, MarketScan Studies: Abbreviated Bibliography [http://truvenhealth.com/Portals/0/Assets/Life-Sciences/Bibliographies/2016-Truven-Health-MarketScan-Bibliography.pdf]).

[7] Figure A1 shows kernel density estimates of the distribution of prices for established-patient well-child visits for children ages 0–1 (99391), 1–4 (99392), 5–11 (99393), and 12–17 (99394). The distributions of the prices across the two sources of data are remarkably similar. Prices are slightly higher in the FAIR Health data; on average the price of a well-child visit is about $10 more than in the MarketScan data. These differences are statistically significant using simple *t*-tests and on Kolmogorov-Smirnov tests for the equality of the two distributions. Overall, we think that both data sets would lead to similar inferences about the influence of changes in regulations on the prices of these services.

The specifications of the models differ slightly across labor and service markets of the analysis. For the labor market analysis of regulation, Y_{ist} represents measures of the wages and annual hours worked for NPs and physicians and R_{st} is a binary variable for whether the board of nursing sets NPs' scope of practice independently and a measure of whether NPs can prescribe controlled medications independently. These regulatory variables influence the derived demand for labor market services that NPs can offer patients without the supervision of a physician. The labor market outcomes also adjust for $\boldsymbol{X}_{ist}$, which is a vector of demographic and human capital control variables that are measured at the individual level. The variables $\boldsymbol{\theta}_s$ and $\boldsymbol{\theta}_t$ represent a full set of state and year fixed-effects controls, so estimates of the regulatory effect, β, are identified using within-state changes in regulations.

In the analysis of service market and population health outcomes, the analysis is conducted at the state level. We remove the subscript for individuals and drop the person-specific control variables to obtain the following model:

$$Y_s = \beta \boldsymbol{R}_{st} + \boldsymbol{\theta}_s + \boldsymbol{\theta}_t + \varepsilon_{st}.$$

In these models, Y_{st} is the average price paid by insurance companies for well-child visits, the average malpractice premium for various types of physicians, and the infant mortality rate in the state-by-year cell. The term $\boldsymbol{R}_{st}$ consists of two binary measures of NPs' prescription authority: limited prescription authority (heavy regulation) and supervised or delegated prescription authority (moderate regulation). The reference group in these estimates refers to state-year cells where NPs can prescribe controlled substances under relatively broad conditions.

In the identification strategy used, suppose that $\boldsymbol{\theta}_s$ is a vector of time-invariant state-level variables that include supply and demand factors that could influence state regulatory decisions and health service wages, employment patterns, prices, and quality levels. Similarly, suppose that $\boldsymbol{\theta}_t$ is a vector of time-varying factors that might also affect regulatory decisions and health service outcomes over time. The research design begins with the assumption that state-by-year-level NP regulations are statistically independent of other factors that systematically affect health service outcomes, conditional on the information from the vectors $\boldsymbol{\theta}_s$ and $\boldsymbol{\theta}_t$. In essence, this is the conditional independence assumption, $\varepsilon_{ist} \perp \boldsymbol{R}_{st} \mid \boldsymbol{\theta}_s, \boldsymbol{\theta}_t$. The independence assumption implies that if all of the confounding variables in $\boldsymbol{\theta}_s$ and $\boldsymbol{\theta}_t$ were observed, we could estimate regulatory treatment effects by simply matching states with the same characteristics but different regulations and then comparing their mean outcomes. In practice, we do not observe all of the variables in the vectors, but we can use standard panel data methods to account for these unobserved variables as long as there is sufficient within-state variation in the regulatory variables to estimate the regulation coefficients. In the two-way fixed-effects models just described, $\boldsymbol{\theta}_s$ and $\boldsymbol{\theta}_t$ are differenced out of the equation using a set of state and time-period fixed effects. The core assumption is that there are no state-specific time-varying factors that affect both regulations and market outcomes.

4. Empirical Results

4.1. Regulation and Wage Determination

The model we implement is applied to occupation-specific log wages and is a two-way fixed-effects version of the standard cross-sectional human capital wage equation. We estimate the earnings equations using two different approaches. In the first approach, we use the full microlevel data set and estimate standard errors that are robust to heteroskedasticity and clustering at the state level. In the second approach, we aggregate the data to the level of state × year cells using the two-stage procedure described in Hanushek (1974), Amemiya (1978), and Conley and Taber (2011). In the first stage, we regress individual-level outcomes on individual covariates and a full set of state-by-time fixed effects. The coefficients on the state-by-time fixed effects represent state-by-time cell means that have been purged of the variation associated with the within-cell variation in the covariates. In the second stage, the covariate-adjusted cell means are regressed on the policy variables, state fixed effects, and year fixed effects. Standard errors are again constructed to allow for heteroskedasticity and clustering at the state level.

In this model, the covariates help balance the means within cells over time and reduce unexplained variation in the outcomes. The key analysis occurs at an aggregate level, which mitigates the clustering problem. And because the estimation relies on within-cell variation in the covariate vector—$\boldsymbol{X}_i$—there is no need to assume that the covariates are independent of shocks at the state-by-time-period level. The policy variable still has to satisfy this exogeneity assumption. Conley and Taber (2011) suggest that these are small but conceptually appealing advantages that work in favor of the two-stage approach. But the key point is still how to best account for dependencies in the error structure. Aggregation seems to help a lot, especially when combined with other methods. And this two-step approach is a way of performing aggregation while allowing for adjustment of individual-level covariates, which is a limitation of pure aggregation.

The estimated models of NPs' and MDs' hourly earnings are presented in Table 4 for 2001–13 using data from the ACS.[8] There is little change in the estimates or significance based on the sample selection rule used for the estimates for wage determination or hours worked. Table 4 shows that both modeling approaches granting NPs more control over scope of practice raise wages by approximately 5 percent relative to states that have more restrictive policies. The estimates for independent prescription authority are not statistically significant and have small point estimate magnitudes. The results suggest that when states adopt laws that expand the scope of practice of NPs, MDs' earnings decline by about 3 percent relative to a counterfactual case in which NPs have much more limited scope of practice. Interestingly, MDs' wages do not appear to change when NPs have independent prescription authority, which is consistent with the earnings estimates for NPs.

[8] We also included time-varying state-level controls such as state median household income but found that they have no explanatory power. The results are available from the authors on request.

Table 4
Effects of Regulations Governing Nurse Practitioners on the Log Hourly Earnings of Nurse Practitioners and Medical Doctors, 2001–13

	Nurse Practitioners		Physicians	
	(1)	(2)	(3)	(4)
Independence in scope of practice	.052***	.045**	−.026+	−.028*
	(.013)	(.015)	(.015)	(.014)
Independent prescription authority	−.005	−.016	.005	−.005
	(.032)	(.033)	(.025)	(.026)
R^2	.098	.630	.368	.471
First-stage *N*	23,820	23,820	80,586	80,586
Second-stage *N*		663		663

Note. All models use American Community Survey data and include individual covariates, state and year fixed effects, and indicators for quadratic and cubic functions in age, gender, marital status, race (white or black versus others), education (Ph.D. or professional degree), immigration status, and industrial sector (for profit or self-employed versus nonprofit). The one-stage models (columns 1 and 3) are estimated using ordinary least squares regression. The two-stage models (columns 2 and 4) adjust for covariates in a first-stage regression of individual log wages on covariates and a full set of state × year fixed effects; in the second stage, the state × year fixed effects (covariate-adjusted mean wages) are regressed on state and year fixed effects and the regulation variables. The second-stage regressions are weighted by the inverse of the state × year cell sample sizes. Standard errors, in parentheses, are constructed using the heteroskedasticity-robust covariance matrix that allows for clustering at the state level.

+ Significant at the 10% level.
* Significant at the 5% level.
** Significant at the 1% level.
*** Significant at the .1% level.

These findings are consistent with the theoretical model presented earlier and suggest that when a patient visits an NP, those visits come at the expense of a visit to an MD. Moreover, NPs and MDs may be substitutes in the production of services so NPs gain relative to MDs when they can perform more tasks for patients.

4.2. Regulation and Employment Patterns

Consistent with the potential influence of scope-of-practice regulations on wages, a relaxation of licensing requirements might increase the employment of NPs by allowing them to do more medical tasks and signaling to the market that their skills are of high quality. These issues are tested in Table 5 using the ACS data and a modeling approach that parallels the approach we use in the analysis of wages. The dependent variable is the annual number of hours worked by NPs and MDs.

The estimated employment effects in Table 5 are small and show that scope-of-practice regulations have little influence on the hours worked per year for NPs or MDs. However, prescription authority is weakly positive in its association with hours worked for NPs, increasing them by about 65–75 hours per year, or about 3–4 percent. There is no association with hours worked, scope of practice, or pre-

Table 5
Effects of Regulations Governing Nurse Practitioners on Annual Hours of Labor for Nurse Practitioners and Medical Doctors, 2002–13

	Nurse Practitioners		Physicians	
	(1)	(2)	(3)	(4)
Independence in scope of practice	−5.785	14.805	4.913	10.893
	(21.230)	(17.823)	(17.312)	(16.453)
Independent prescription authority	65.523+	79.478*	10.539	13.962
	(36.478)	(31.988)	(18.902)	(20.599)
R^2	.045	.257	.067	.322
First-stage *N*	23,820	23,820	80,586	80,586
Second-stage *N*		663		663

Note. All models use American Community Survey data and include individual covariates, state and year fixed effects, and indicators for quadratic and cubic functions in age, gender, marital status, race (white or black versus others), education (Ph.D. or professional degree), immigration status, and industrial sector (for profit or self-employed versus nonprofit). The one-stage models (columns 1 and 3) are estimated using ordinary least squares regression The two-stage models (columns 2 and 4) adjust for covariates in a first-stage regression of individual annual hours of labor on covariates and a full set of state × year fixed effects; in the second stage, the state × year fixed effects (covariate-adjusted mean wages) are regressed on state and year fixed effects and the regulation variables. The second-stage regressions are weighted by the inverse of the state × year cell sample sizes. Standard errors, in parentheses, are constructed using the heteroskedasticity-robust covariance matrix that allows for clustering at the state level.

+ Significant at the 10% level.

* Significant at the 5% level.

scription authority for physicians. For both occupations, hours worked per year are, at best, modestly influenced by the provisions in state laws that govern them.

4.3. Regulation and the Prices of Well-Child Visits

Consistent with theory and previous analysis, NP scope-of-practice regulations may drive up the prevailing prices of some health services in a variety of ways. Prices could increase if the regulations restrict the supply of health services. A subtler point is that the regulations could force the health care system to adopt a more physician-intensive production process than it would under a more flexible regulatory environment. It is also possible that NPs might offer services that are distinct from those offered by MDs. Nurse practitioners might provide health services at more convenient times and locations than MDs or might have more appealing interpersonal relationships with patients. These service attributes could be reflected in market prices and could lead to changes in the way that MDs offer services as well. Regulations that reduce the ability of NPs to compete on these margins are likely to make these service attributes less available to consumers and will minimize the role of NPs in the market.

To study the effects of NP prescription authority regulations on the prices of well-child visits, we estimate the same generalized difference-in-differences model described earlier using only the data in state-year cells. The dependent variable is the median allowed price observed in state *s* at time *t*. We include a

Table 6
Estimates of the State Price Effects for Well-Child Visits

	(1)	(2)	(3)	(4)
Supervised or delegated prescription authority	3.85	6.63*	6.65*	6.50
	(10.57)	(3.66)	(3.69)	(4.41)
Limited prescription authority	17.92	16.41	16.43***	16.16**
	(11.21)	(6.01)	(6.06)	(7.14)
State covariates	No	Yes	Yes	Yes
Year × product	No	No	Yes	Yes
State × product	No	No	No	Yes
R^2	.64	.65	.65	.79
N	2,110	1,054	1,054	1,054

Note. All models include year, state, and product fixed effects. Standard errors, clustered by state, are in parentheses.

* Significant at the 5% level.

** Significant at the 1% level.

*** Significant at the .1% level.

vector of time-varying state characteristics and a full set of state and year fixed effects. Since we pool well-child visits for children of different ages and for initial and repeat visits, in some specifications we also include service category fixed effects and allow them to vary across states and over time.

The results are presented in Table 6. The estimates of the price effects show that more restrictive requirements for NPs increase prices for well-child examinations. The moderate level of regulation, under which NPs can prescribe only with MDs' supervision, increases the price of well-child visits by about $6. The more stringent level of regulation, under which NPs are not allowed to prescribe controlled medications, increases the price of well-child visits by about $16. Since the typical price of a well-child visit is around $100, these price effects are relatively large.

5. Tests for Robustness

5.1. Sensitivity Analysis: Accounting for Potential Bias

A concern with the generalized difference-in-differences strategy used throughout the analysis of wages, employment patterns, and service prices is that unobserved factors that determine the demand for health services in a state might vary over time within states and might be correlated with changes in scope-of-practice laws. This type of unobserved confounding factor could introduce bias into all three parts of our analysis. We developed two strategies to examine this issue. The first method focuses on a dependent variable (prices for dental services) that should be affected by state-by-time-specific unobserved shocks to the demand for basic health services but should not be affected by NP scope-of-practice regulations (Imbens and Rubin 2015). The second method attempts to avoid omitted-variable problems by altering the level of geography: we limit the analysis to

Table 7
State Price Effects Using Dental Regulations as a Falsification Test for Well-Child Visits

	(1)	(2)
Supervised or delegated prescription authority	11.60***	5.52**
	(3.13)	(2.87)
Limited prescription authority	8.73***	4.05**
	(1.88)	(1.61)
State covariates	No	Yes
R^2	.98	.99
N	612	306

Note. Results are triple-differenced. The dependent variable is the median allowed price in a state × year × product cell. All regressions include year, state, product, year × product, and state × product fixed effects. Standard errors, clustered by state, are in parentheses.
** Significant at the 1% level.
*** Significant at the .1% level.

MSAs that straddle the borders of states that have different NP occupational regulation but should share the same local demand and supply conditions. We apply both stratgies because the data are amenable to this type of analysis. However, the absence of apparent confounding bias in the price analysis also lends support to the identifying assumptions used in the wage and employment analysis.

5.2. Outcome Variables

To study the possibility of unobserved time-varying state-level confounders using an alternative dependent variable, we use insurance claims data for a set of seven basic dental procedures: teeth cleaning, fluoride treatment, local anesthesia, nitrous oxide, sealant application, amalgam restoration, and X-rays. These dental services are widely used by children and adults and have prices that are comparable to those for well-child exams. The services are provided by dentists and dental hygienists, two occupational groups that share a skill and wage relationship that is qualitatively similar to that of MDs and NPs in the production of basic medical services. The fundamental assumption is that the market for basic dental services is likely to be affected by many of the same demand factors that affect the general demand for health services in a given state and year. However, the markets for these dental services should not be affected by NP scope-of-practice regulations because NPs are not involved in the production of dental services. We aggregated the dental claims data into state-year-procedure code cells and combined them with the data on well-child visits. We then estimated triple-differenced regressions in which the dental data serve as a control group for the well-child-visit data. The results are presented in Table 7 as a placebo or falsification test.

In these models, we present the results including a full set of state, year, and state-by-year fixed effects. The estimated regulatory effects are given by the difference in the estimated effect of the regulations on well-child visits—which should

Table 8
Trends in the Prices of Well-Child Visits before Passage of the Regulation, by Prescription Authority Level

	Supervised or Delegated	Limited
State effect in year of regulation	–.003*	.001
	(.002)	(.0009)
State effect$_{t-1}$	–.002*	.0004
	(.0007)	(.0005)
State effect$_{t-2}$	–.003*	.0007
	(.001)	(.001)
R^2	.35	.18

Note. All models include state covariates. Standard errors, clustered by state, are in parentheses. $N = 129$.
* Significant at the 5% level.

be affected by the regulations—and the effect on dental visits—which should not be affected by the regulations. In the most complete model, which includes a vector of time-varying state covariates, we find that the intermediate level of regulation increases the price of well-child visits by about $5.52 and the more stringent regulation increases prices by about $4.05. The results are statistically significantly different from 0 and are broadly consistent with the main results presented in Table 6, although the magnitude of the stronger regulation is substantially reduced when the dental data and regulations are used as a control group. The number of observations is halved in the estimates that include all of the covariates because the regulation and price data are for 2005–10, but the covariates span the period 2008–10.

We also estimate models that assess the effects of lagged and leading values of the regulations on contemporaneous prices as way of ruling out particular forms of reverse causality. The results in Table 8 show no significant changes in the trend lines prior to the passage of the changes in the regulations for NPs. We also examine if the laws were passed in states with specific underlying economic characteristics. Table 9 presents the results from a hazard model of time to the passage of a more relaxed law based on the characteristics of the state. The estimates show that none of the standard economic characteristics in the state are associated with the passage of the law, which suggests that economic conditions are not a source of bias. These results suggest there is little to no evidence of the endogeneity of our estimates with either the trends in prices or the likelihood of the passage of the laws.

5.3. Metropolitan-Statistical-Area-Level Analysis

To further estimate and test the robustness of our price effects of regulation, we specify a model in which the data are limited to zip codes that belong to MSAs that fall on both sides of a border between states that have different regulations for NPs. Here the quasi experiment is constructed to account for local demand

Table 9
State Characteristics Determining the Timing of Passage of Regulations Granting Nurse Practitioners Greater Autonomy

	Coefficient	SE
log(Population)	1.034	.211
% Black (1×10^{12})	8.760	7.120
Households per zip code	1.000	.000
Income per household	1.000	.000
log(Average house value)	1.196	.933

Note. Results are from a proportional hazard model. Standard errors are clustered by state. $\chi^2(5) = .30$; $N = 65$.

and supply conditions that are common across the MSA (Card and Krueger 1997; Holmes 2006). To implement the research design, we identified which zip codes are located in an MSA that straddles states with different regulations. Thirty-five MSAs meet the criteria. We aggregated these data to state-year-product cells and use them to estimate the following model:

$$Y_{mstp} = \beta_M M_{st} + \beta_H H_{st} + \theta_p + \theta_m + \theta_t + \varepsilon_{mstp}, \quad (4)$$

where the dependent variable is the median allowed charge for product p at time t in state s in MSA m. The variables θ_p, θ_m, and θ_t are product category, MSA, and year fixed effects, and ε_{mstp} is the error term. Table 10 shows the MSAs in our sample. The MSAs represent a wide range of areas and do not appear to be systematically different across areas of the country or size of the MSA. Figure 2 shows the numbers of MSAs that have concordant and discordant regulations for NP prescription authority. The results show that there is a clear movement toward states having similar statutes across MSAs.

Table 11 shows the influence of the regulations on prices using our MSA analysis of different regulations in adjoining states. The results are similar to those from the analysis that uses dental services as an untreated comparison group. We find that the intermediate level of regulation increases the price of well-child visits by about $3.67 and that the more stringent regulation increases prices by about $5.31.

5.4. Sensitivity Analysis: Statistical Inference Based on Placebo Laws

Another potential issue for the validity of our analysis arises because recent studies show that nominal standard error estimates are often too small in the type of generalized difference-in-differences models that we employ. Several studies have shown that statistical tests based on permutation or randomization distributions seem to perform well even with clustered data and a relatively small number of groups (Moulton 1990; Bertrand, Duflo, and Mullainathan 2004; Donald and Lang 2007; Rosenbaum 2002, 2009; Conley and Taber 2011).

Table 10
Metropolitan Statistical Areas in the State Border Sample

	State 1	State 2	State 3	State 4
Augusta, Aiken	GA	SC		
Boston, Worcester, Lawrence	MA	NH	ME	CT
Chattanooga	TN	GA		
Chicago, Gary, Kenosha	IL	IN	WI	
Cincinnati, Hamilton	OH	KY	IN	
Clarksville, Hopkinsville	TN	KY		
Columbus	GA	AL		
Cumberland	MD	WV		
Davenport, Moline, Rock Island	IA	IL		
Evansville, Henderson	IN	KY		
Fargo, Moorhead	ND	MN		
Flagstaff	AZ	UT		
Fort Smith	AR	OK		
Huntington, Ashland	WV	KY	OH	
Johnson City, Kingsport, Bristol	TN	VA		
Kansas City	MO	KS		
La Crosse	WI	MN		
Las Vegas	NV	AZ		
Memphis	TN	AR	MS	
Minneapolis, St. Paul	MN	WI		
New York, northern New Jersey, Long Island	NY	NJ		
Norfolk, Virginia Beach, Newport News	VA	NC		
Omaha	NE	IA		
Parkersburg, Marietta	WV	OH		
Portland, Salem	OR	WA		
Providence, Fall River, Warwick	RI	MA		
Sioux City	IA	NE		
St. Louis	MO	IL		
Steubenville, Weirton	OH	WV		
Washington, DC, Baltimore	DC	MD	VA	WV
Wheeling	WV	OH		

To assess the robustness of our results, we conducted a series of permutation tests based on the state-level models. In the most basic implementation of the approach, we randomly selected a set of state-year cells and defined them as pseudo-regulated markets. We then estimated the regression model using placebo regulations instead of the real regulations and stored the coefficients on the pseudo regulations. We repeated this process 500 times to construct a distribution of placebo effects. On average, the placebo laws should have no effect on prices because they are simply randomly chosen cells. But some placebo laws will lead to a large effect simply by chance. Comparing the regulatory effect produced by the actual regulations to the empirical distribution produced by the placebo laws helps us understand the likelihood that our effect is observed by chance without appealing to the asymptotic distribution of a given estimator. In practice, we do not know the true law-generating process, and so we experiment by

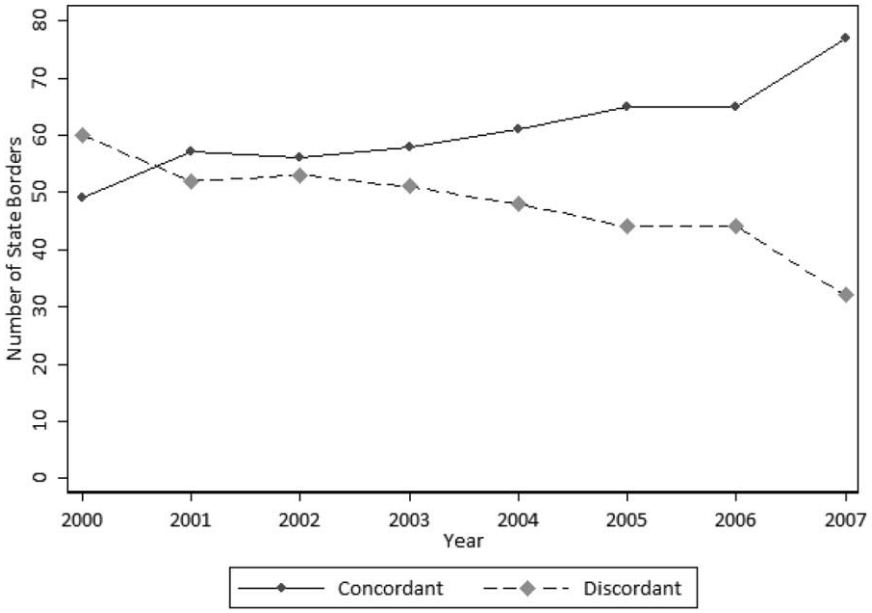

Figure 2. Metropolitan statistical areas that straddle the borders of states with concordant and discordant regulations for nurse practitioners' prescription authority.

constructing placebo law distributions by randomly selecting cells in three ways: across all state-year-product cells, within years, and within states. Figure 3*A* and 3*B* present kernel density plots of the distribution of estimated coefficients on the two regulation variables included in the model. The key point in the graphs is that the placebo distributions represent the sampling distribution of the estimated coefficients under the null hypothesis that the regulations have no effect on prices. The vertical lines in the graphs indicate the effect in our actual sample, and it lies in the extreme tail of the placebo distribution. This is evidence that the results are not likely produced by statistical chance.

5.5. Safety and Quality Concerns for Expanding Scope of Practice

The analysis thus far suggests that expanding NP scope-of-practice regulations to allow greater prescription authority for NPs leads the health care system to rely more heavily on NPs' labor inputs, reduces the price of a basic health service, increases the wages of NPs, and reduces the wages of MDs. An important additional issue is how such a shift may affect the quality of health services that are available and consumed in the marketplace. Quality effects are conceptually difficult to measure. Moreover, the welfare implications of changes in quality are not obvious because a given health service may represent a bundle of convenience and quality attributes. Several major studies in medical journals examine

Table 11
Metropolitan Statistical Area (MSA) Analysis of Prices for Well-Child Visits

	(1)	(2)	(3)	(4)
Supervised or delegated prescription authority	–1.40	3.67**	3.87***	3.04*
	(3.79)	(1.36)	(1.41)	(1.57)
Limited prescription authority	–3.53	5.13**	5.31**	4.47*
	(5.26)	(2.01)	(2.03)	(2.32)
State covariates	No	Yes	Yes	Yes
Year × product	No	No	Yes	Yes
MSA × product	No	No	No	Yes
R^2	.73	.77	.78	.82
N	3,581	1,756	1,756	1,756

Note. The dependent variable is the median allowed price in a MSA × state × year × product cell. All models include year, state, MSA, and product fixed effects. Standard errors, in parentheses, are clustered by MSA.

* Significant at the 5% level.

** Significant at the 1% level.

*** Significant at the .1% level.

whether patients either perceive or receive better care if they are examined by an NP rather than an MD (for example, Kinnersley et al. 2000; Carter and Chochinov 2007). These studies find that patients visiting MDs and NPs experience very similar outcomes in a variety of health care settings. Even if this pattern does not hold for some types of health services or for some patients, it is important to note that if scope-of-practice deregulation leads to an increase in services of lower quality but with greater convenience, consumers who value convenience will be better off as a result of deregulation. Still, concerns about health service quality and population health appear to be the main arguments against expanded scope of practice for NPs. To further assess the quality-related consequences of allowing NPs to provide more services, we examine evidence of an increase in major medical errors that could lead to serious injuries or death.

We implemented two approaches for evaluating changes in quality. First, we estimated the effects of the regulatory environment on infant mortality rates using state policy variations over time. Since mortality is an extreme outcome that may not capture smaller nonlethal changes in quality, we also examined the effects of relaxing licensing requirements on the malpractice insurance rates of physicians in the states that changed their statutes. Table 12 displays results using a lagged model to estimate the influence of changing the statutes for NPs on mortality rates for children under the age of 1. We use this approach to capture the changes in mortality that occur over time following the change in the statute. The estimates in Table 12 use the 5-year mortality rate for the year after the regulation was changed and then subtract the 5-year mortality rate for the current year. The procedure differences out 5 years of infant mortality data, and the estimates then reflect whether the difference in mortality rates is affected by the changes in regulation. The results for both supervised or delegated prescription authority and limited prescription authority show no influence of changes in the regulatory

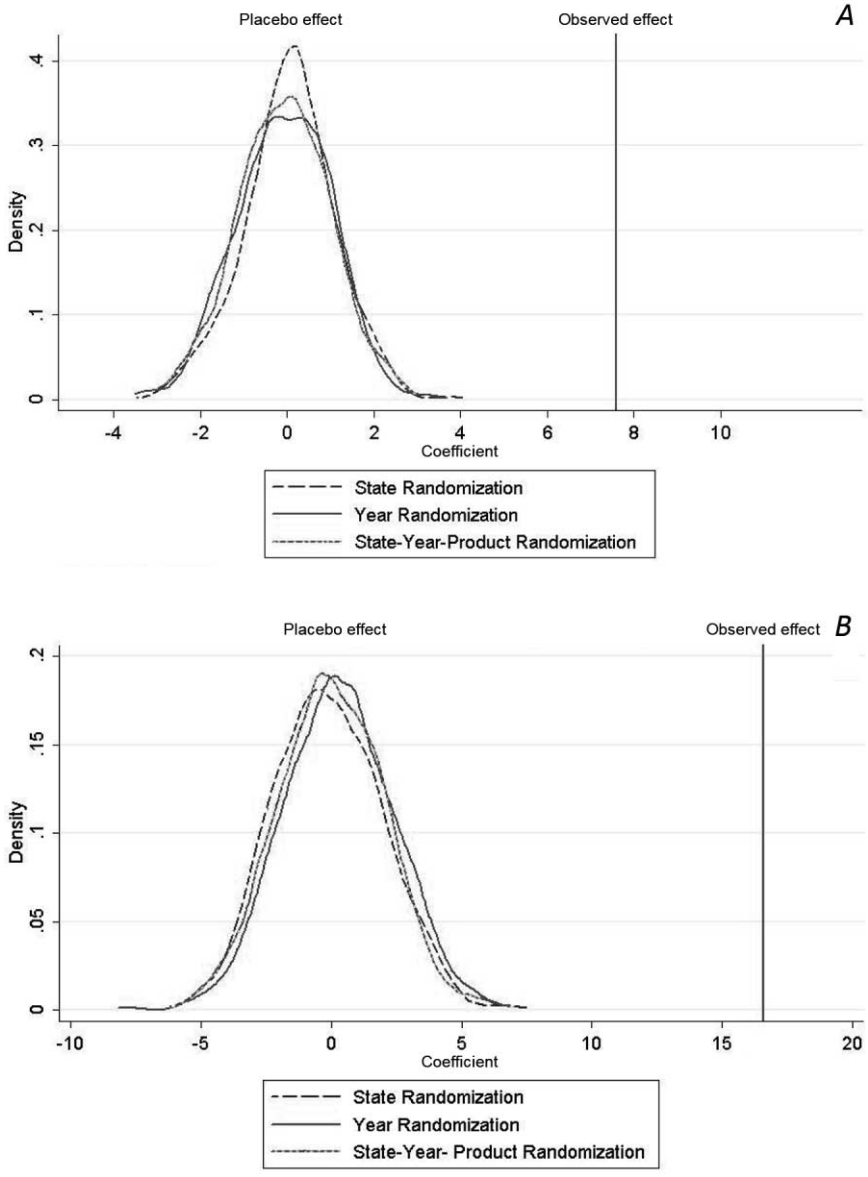

Figure 3. Falsification tests of regulation effect: *A*, supervised or delegated prescription authority; *B*, limited prescription authority.

Table 12
Effects on Infant Mortality Rates of Granting Nurse Practitioners Greater Autonomy, 1999–2004

	(1)	(2)	(3)
Supervised or delegated prescription authority	–.130	–.007	.017
	(.101)	(.011)	(.018)
Limited prescription authority	–.160***	–.029	–.003
	(.057)	(.043)	(.042)
State fixed effects	No	Yes	Yes
Year fixed effects	No	No	Yes
R^2	.066	.938	.945

Note. Standard errors, clustered by state, are in parentheses. Five-year county-level child mortality rates are from US Department of Health and Human Services (2015–16). $N = 306$.

*** Significant at the .1% level.

Table 13
Effects on Physicians' Malpractice Insurance of Allowing Nurse Practitioners to Have Greater Autonomy, 1999–2004

	ln(Internal Medicine)	ln(Obstetrics/ Gynecology)	ln(General Surgery)
Supervised or delegated prescription authority	.098	.126	.096
	(.126)	(.127)	(.139)
Limited prescription authority	.039	–.010	.044
	(.098)	(.080)	(.123)
State fixed effects	No	Yes	Yes
Year fixed effects	No	No	Yes
R^2	.938	.918	.920

Note. Standard errors, clustered by state, are in parentheses. Historical annual medical malpractice rates for 1999–2004 are available for purchase from *Medical Liability Monitor,* Rate Survey (http://www.medicalliabilitymonitor.com/rate-survey.php). $N = 299$.

law on the mortality rates of infants, who would likely be the most vulnerable to poor-quality pediatric medical services.

As an additional robustness check on the influence of the regulatory changes on quality, we examine the effects on the malpractice insurance rates paid by physicians in states where the changes in regulation occurred. We expect that if NPs are lower-quality providers of services and generate an increase in severe injuries to children, then malpractice insurance rates will rise. Table 13 shows the impact of changes in the law on malpractice premiums for 1999–2004 for internal medicine, obstetrics and gynecology, and surgery. In none of the estimates does the change in regulations allowing NPs more flexibility in tasks statistically influence these malpractice premiums. All of the results for the influence of regulation on quality yield imprecise estimates. We are not able to find any influence of the relaxation of licensing statutes on blunt, overarching, but important measures of health outcomes.

6. Conclusions

In this study we investigate how easing regulations that affect NPs may affect wages, employment, prices, and quality in health service markets. Initially, we examined an approach in which scope-of-practice regulations might affect the production of health services. Next, using data from the ACS for the period 2001–13, we studied how changes in state licensing regulations have affected the wages and hours worked of NPs and MDs. Subsequently, we analyzed a large database of private health insurance claims for well-child exams to estimate the effect of the changes in regulation on the supply prices of standard medical services. The estimates show that giving NPs greater independence tends to increase their wages and decrease the wages of physicians. We also found that restricting the prescription authority of NPs tends to increase the prevailing prices of a basic health care service. One interpretation of this finding is that NPs and MDs are substitutes in the production of some health services and that occupational regulation reduces the amount of substitution that is allowed to occur in this segment of the economy.

To test the sensitivity of our results, we use the prices of other routine health services (dental procedures) that should not be influenced by NP regulations. In addition, we analyzed these policies at the level of MSAs to account for local supply and demand conditions using MSA fixed effects. In addition, we conducted placebo law tests that are robust to nonstandard error structures and examined the link between the timing of the introduction of state regulations and state-level characteristics to assess whether regulatory changes occur because of changes in states' characteristics. Overall, these sensitivity analyses generally support our basic results.

Our analysis shows how regulating and relaxing provisions for the occupational groups involved in the delivery of health services can affect both wages and prices. We found that providing more independence for NPs increased their wages by about 5 percent and decreased MDs' wages by about 3 percent. These changes in relative wages imply that NPs and MDs are substitutes in the production of a nontrivial set of health services. Our study of the transaction prices of well-child visits shows that expanding NPs' scope of practice also reduces the price of those visits by 3–16 percent. We did not find any influence of these changes in the regulatory climate on infant mortality rates or malpractice insurance rates, which suggests that relaxing these regulations does not appear to affect the rates of the most serious adverse medical outcomes.

Our results suggest that the use of NPs may be an important way to enhance access to medical care for patients. The estimates from our models suggest that regulations that restrict the independence of NPs may generate substantial economic costs, even when viewed in a very narrow way that is limited to the services we examined.[9] The regulations likely affect the prices of other health ser-

[9] A simple back-of-the-envelope estimate suggests that relaxing these regulations nationally could save about $600 million for this one medical procedure per year as an upper bound, if the savings

vices as well; therefore, occupational regulations may be an important factor to consider in federal or state health care policies that are intended to reduce the costs of medical care under the Affordable Care Act. However, there is a need for additional analysis on more medical procedures and further work on the implications for patients' quality of care before these results can become the focus of new public policies.

Appendix

Validity of Sample Data Construction

We use data from the 2001–13 ACS to construct samples of NPs and MDs. The ACS offers a sample size large enough to allow the analysis of individual occupations and states. However, the ACS does not separately identify NPs until 2010. In earlier years, NPs were pooled with RNs in a single occupation code. To construct an analytic sample of NPs, we use the sample of RNs and NPs who held a master's degree or PhD in the post-2010 waves of the ACS to fit a simple predictive model of whether a person was an NP. The independent variables in the predictive logit model include measures of gender, race, immigration status, marital status, a cubic function of age, labor market sector, whether the person held a PhD, and state fixed effects. We use the estimated coefficients from the model to compute predicted probabilities of whether a person was an NP in the earlier waves of the ACS. In our main analysis, we limit our sample to people who had predicted probabilities larger than the 10th percentile of the predicted values in the 2011 sample. Appendix Table A1 shows how the results of our main regressions change under alternative sample construction criteria. The results for education are based on a sample that classifies all nurses (NPs and RNs) who hold a graduate degree as NPs. The other rows show the results when the sample is defined using each corresponding percentile of the predicted NP status distribution. The main results are not very sensitive to the alternative sample definitions. However, as expected, the sample size shrinks as more restrictive sample inclusion criteria are applied.

---

are about $10 per visit and there are about 60 million procedures— the approximate number of exams per year in the United States, according to our data from Fair Health and MarketScan.

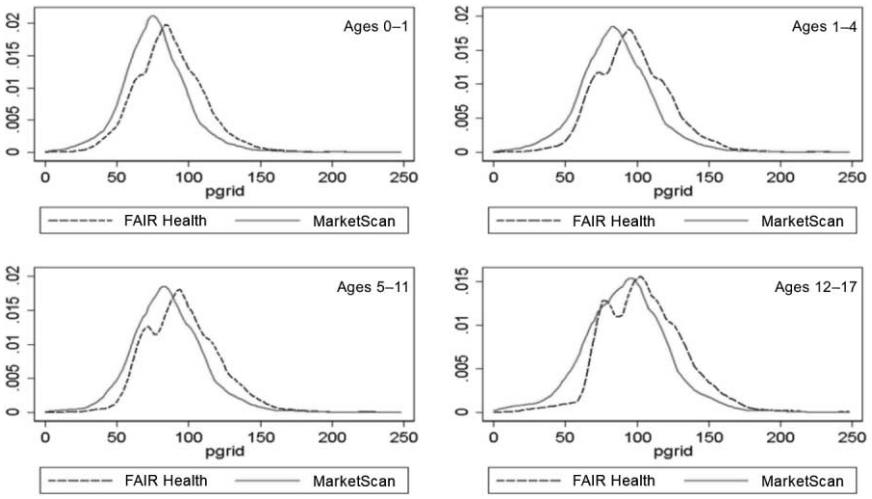

Figure A1. Well-child exam prices: FAIR Health versus MarketScan data

Table A1
Sensitivity of Earnings and Hours Worked by Nurse Practitioners: Sample Selection Rule

	One-Stage Model			Two-Stage Model	
	N	Independence in Scope of Practice	Independent Prescription Authority	*N*	Independence in Scope of Practice	Independent Prescription Authority
ln(Hourly earnings):						
Education	36,084	.023+	–.007	663	.026*	–.003
10%	23,820	.052***	–.005	663	.045**	–.016
25%	20,859	.050**	–.003	663	.034*	–.018
50%	15,521	.068**	.014	663	.044+	–.007
75%	9,656	.080**	–.021	663	.056*	–.037
Annual hours of work:						
Education	36,084	4.399	-14.602	663	-1.629	1.815
10%	23,820	–5.785	65.523+	663	14.805	79.478*
25%	20,859	8.811	80.887+	663	24.842	100.092**
50%	15,521	44.045+	77.459+	663	55.934**	96.792*
75%	9,656	35.156	132.384***	663	85.745	133.953

Note. All models include indicators for quadratic and cubic functions in age, gender, marital status, race (white or black versus others), education (Ph.D. or professional degree), immigration status, and industrial sector (for profit or self-employed versus nonprofit).The one-stage models are estimated using ordinary least squares regression. The two-stage models adjust for covariates in a first-stage regression of individual log wages or annual hours of labor on covariates and a full set of state × year fixed effects; in the second stage, the state × year fixed effects (covariate-adjusted mean wages) are regressed on state and year fixed effects and the regulation variables. The second-stage regressions are weighted by the inverse of the state × year cell sample sizes. Standard errors are constructed using the heteroskedasticity-robust covariance matrix that allows for clustering at the state level.

+Significant at the 10% level.
*Significant at the 5% level.
**Significant at the 1% level.
***Significant at the .1% level.

References

Amemiya, Takeshi. 1978. A Note on a Random Coefficients Model. *International Economic Review* 19:793–96.

Arrow, Kenneth J. 1963. Uncertainty and the Welfare Economics of Medical Care. *American Economic Review* 53:941–73.

Baker, Samuel. 1984. Physician Licensure Laws in the United States, 1865–1915. *Journal of the History of Medicine and Allied Sciences* 10:173–97.

Bertrand, Marianne, Esther Duflo, and Sendhil Mullainathan. 2004. How Much Should We Trust Differences-in-Differences Estimates? *Quarterly Journal of Economics* 19:249–75.

Card, David, and Alan Krueger. 1997. *Myth and Measurement: The New Economics of the Minimum Wage*. Princeton, NJ: Princeton University Press.

Carter, Alex, and Alecs Chochinov. 2007. A Systematic Review of the Impact of Practitioners on Cost, Quality of Care, Satisfaction and Wait Times in the Emergency Department. *Canadian Journal of Emergency Medicine* 9:286–95.

Centers for Medicare and Medicaid Services. 2010. National Health Expenditures Accounts. https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NationalHealthAccountsHistorical.html.

Comer, Shirley K. 2007. Nursing Licensure. Adventure of the American Mind–Governors State University. http://aam.govst.edu/projects/scomer/student_page1.html.

Conley, Timothy G., and Christopher R. Taber. 2011. Inference with "Difference in Differences" with a Small Number of Policy Changes. *Review of Economics and Statistics* 93:113–25.

Donald, Stephen G., and Kevin Lang. 2007. Inference with Difference-in-Differences and Other Panel Data. *Review of Economics and Statistics* 89:221–33.

Dueker, Michael J., Ada K. Jacox, David E. Kalist, and Stephen J. Spurr. 2005. The Practice Boundaries of Advanced Practice Nurses: An Economic and Legal Analysis. *Journal of Regulatory Economics* 27:309–30.

Eberly, Janice, and Jo Ann Rooney. 2012. Supporting Our Military Families: Best Practices for Streamlining Occupational Licensing across State Lines. US Department of the Treasury and US Department of Defense, Washington, DC. http://archive.defense.gov/home/pdf/Occupational_Licensing_and_Military_Spouses_Report_vFINAL.PDF.

Flexner, Abraham. 1910. *Medical Education in the United States and Canada: A Report to the Carnegie Foundation for the Advancement of Teaching.* Bulletin No. 4. Boston: Merrymount Press.

Friedman, Milton. 1962. *Capitalism and Freedom*. Chicago: University of Chicago Press.

Friedman, Milton, and Simon Kuznets. 1945. *Income from Independent Professional Practice*. New York: National Bureau of Economic Research.

Hanushek, Eric A. 1974. Efficient Estimators for Regressing Regression Coefficients. *American Statistician* 28:66–67.

Harper, Doreen C., and Jean Johnson. 1998. The New Generation of Nurse Practitioners: Is More Enough? *Health Affairs* 17:158–64.

Holmes, Thomas J. 2006. Geographic Spillover of Unionism. Working Paper No. 12025. National Bureau of Economic Research, Cambridge, MA.

Imbens, Guido, and Donald Rubin. 2015. *Causal Inference for Statistics, Social, and Biomedical Sciences*. New York: Cambridge University Press.

Isaacs, Stephen, and Paul Jellinek. 2012. *Accept No Substitute: A Report on Scope of Prac-*

tice. Physicians Foundation. http://www.physiciansfoundation.org/uploads/default/A_Report_on_Scope_of_Practice.pdf.

Kinnersley, Paul, Elizabeth Anderson, Kate Parry, John Clement, Luke Archard, Pat Turton, et al. 2000. Randomised Controlled Trial of Nurse Practitioner versus General Practitioner Care for Patients Requesting "Same Day" Consultations in Primary Care. *British Medical Journal,* April 15, pp. 1043–48.

Kleiner, Morris M., and Alan Krueger. 2013. Analyzing the Extent and Influence of Occupational Licensing on the Labor Market. *Journal of Labor Economics* 31:S173–S202.

Kleiner, Morris M., and Robert T. Kudrle. 2000. Does Regulation Affect Economic Outcomes? The Case of Dentistry. *Journal of Law and Economics* 43:547–82.

Kleiner, Morris M., and Kyoung Won Park. 2010. Battles among Licensed Occupations: Analyzing Government Regulations on Labor Market Outcomes for Dentists and Hygienists. Working Paper No. 16560. National Bureau of Economic Research, Cambridge, MA.

Leland, Hayne. 1979. Quacks, Lemons, and Licensing: A Theory of Minimum Quality Standards. *Journal of Political Economy* 87:1328–46.

Lieb, David A. 2008. Missouri Senate Endorses Bill to Expand Nurse Prescription Powers. *Associated Press*, February 12.

McQuaide, Terry, Karen Kelly, and Sam Hawatmeh. 2007. Expert Diagnosis: Should Nurses Be Able to Prescribe Controlled Drugs in Missouri? *St. Louis (MO) Post-Dispatch,* October 31.

Moulton, Brent R. 1990. An Illustration of a Pitfall in Estimating the Effects of Aggregate Variables on Micro Units. *Review of Economics and Statistics* 72:334–38.

Nicholson, Sean. 2012. Research Opportunities of a New Private Health Insurance Claims Data Set. *Health Management, Policy and Innovation* 1:37–41.

Nurse Practitioner. 2008. Twentieth Annual Legislative Update. *Nurse Practitioner* 33(1):14–34.

Pearson, Linda J. 1999. Annual Update of How Each State Stands on Legislative Issues Affecting Advanced Nursing Practice. *Nurse Practitioner* 24(1):16–83.

———. 2000. How Each State Stands on Legislative Issues Affecting Advanced Nursing Practice. *Nurse Practitioner* 25(1):16–68.

———. 2001. Annual Legislative Update: How Each State Stands on Legislative Issues Affecting Advanced Nursing Practice. *Nurse Practitioner* 26(1):7–57.

———. 2002. Fourteenth Annual Legislative Update: How Each State Stands on Legislative Issues Affecting Advanced Nursing Practice. *Nurse Practitioner* 27(1):10–52.

———. 2003. Fifteenth Annual Legislative Update: How Each State Stands on Legislative Issues Affecting Advanced Nursing Practice. *Nurse Practitioner* 28(1):26–58.

———. 2004. Sixteenth Annual Legislative Update: How Each State Stands on Legislative Issues Affecting Advanced Nursing Practice. *Nurse Practitioner* 29(1):26–51.

Pettypiece, Shannon. 2013. Nurses Spar with Doctors as 30 Million Insured Seek Care. *Bloomberg,* March 3. http://www.bloomberg.com/news/articles/2013-03-04/nurses-spar-with-doctors-as-30-million-insured-seek-care.

Phillips, Susanne J. 2005. A Comprehensive Look at the Legislative Issues Affecting Advanced Nursing Practice. *Nurse Practitioner* 30(1):14–47.

———. 2006. Eighteenth Annual Legislative Update: A Comprehensive Look at the Legislative Issues Affecting Advanced Nursing Practice. *Nurse Practitioner* 31(1):6–38.

———. 2007. Nineteenth Annual Legislative Update: A Comprehensive Look at the Legislative Issues Affecting Advanced Nursing Practice. *Nurse Practitioner* 32(1):14–42.

———. 2009. Legislative Update 2009: Despite Legal Issues, APNs Are Still Standing Strong. *Nurse Practitioner* 34(1):19–41.
———. 2010. 22nd Annual Legislative Update: Regulatory and Legislative Successes for APNs. *Nurse Practitioner* 35(1):24–47.
Reinhardt, Uwe. 1972. A Production Function for Physician Services. *Review of Economics and Statistics* 54:55–66.
Rosenbaum, Paul R. 2002. *Observational Studies*. New York: Springer Verlag.
———. 2009. *Design of Observational Studies*. New York: Springer Verlag.
Sass, Tim R., and Mark Nichols. 1996. Scope-of-Practice Regulation: Physician Control and the Wages of Non-physician Health-Care Professionals. *Journal of Regulatory Economics* 9:61–81.
Shapiro, Carl. 1986. Investment, Moral Hazard, and Occupational Licensing. *Review of Economic Studies* 53:843–62.
Stange, Kevin. 2014. How Does Provider Supply and Regulation Influence Health Care Markets? Evidence from Nurse Practitioners and Physician Assistants. *Journal of Health Economics* 33:1–27.
US Department of Health and Human Services. 2015–16. Area Health Resources Files: County-Level Data. US Department of Health and Human Services, Health Resources and Services Administration, Bureau of Health Workforce, Rockville, MD.
Varian, Hal R. 1992. *Microeconomic Analysis*. 3d ed. New York: W.W. Norton.
Wing, Coady, and Allison Marier. 2014. Effects of Occupational Regulations on the Cost of Dental Services: Evidence from Dental Insurance Claims. *Journal of Health Economics* 34:131–43.
Wing, Coady, and Kevin McConeghy. 2016. A National Examination of Pharmacy-Based Immunization Statutes and Their Association with Influenza Vaccinations and Preventive Health. *Vaccine* 34:3463–68.