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How does provider supply and regulation influence health care markets? Evidence from nurse practitioners and physician assistants☆

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ABSTRACT

Nurse practitioners (NPs) and physician assistants (PAs) now outnumber family practice doctors in the United States and are the principal providers of primary care to many communities. Recent growth of these professions has occurred amidst considerable cross-state variation in their regulation, with some states permitting autonomous practice and others mandating extensive physician oversight. I find that expanded NP and PA supply has had minimal impact on the office-based healthcare market overall, but utilization has been modestly more responsive to supply increases in states permitting greater autonomy. Results suggest the importance of laws impacting the division of labor, not just its quantity.

1. Introduction

The Patient Protection and Affordable Care Act (ACA) of 2010 contains a number of provisions predicated on the belief that adequate availability of primary care providers is crucial if expanded insurance coverage is to translate into greater healthcare access. The ACA calls for a significant expansion of the National Health Service Corps (NHSC), more primary care residency positions, and increases in Medicare and Medicaid reimbursement for primary care services, among others.[1] These provisions of the ACA represent just the latest manifestation of public concern for the number, quality, and geographic distribution of healthcare providers in the United States. This concern stretches back more than a century, when Flexner's (1910) conclusion that the United States had an oversupply of poorly trained physicians resulted in a substantial contraction in the number of medical schools and new physicians at the start of the 20th century (Blumenthal, 2004). Subsequent policy attempts to influence the healthcare workforce has taken many forms, from funding for graduate medical education via Medicare to the establishment in 1972 of the NHSC and its recent expansions through the ACA and the American Recovery and Reinvestment Act of 2009.

A recent development in this old policy issue is the emergence of nurse practitioners (NPs) and physician assistants (PAs) as part of the solution.[2] Though around since the 1960s, only after experiencing rapid growth in the 1990s have these professions become sizable enough to provide a large scale complement or alternative to physician care (Fig. 1). With more than 85,000 PAs and 150,000 NPs eligible to practice, their ranks now exceed the number of general and family practice MDs and are approaching the

☆ The dataset used in this paper was constructed in collaboration with Dr. Deborah Sampson of the Boston College School of Nursing. Helpful feedback was also provided by seminar participants at the RWJ Health Policy Scholars 2009 and 2010 Annual Meetings, the University of Michigan (Ford School of Public Policy, School of Public Health, Economics Department), the Upjohn Institute, the 2011 Association for Public Policy Analysis and Management Annual Meeting, the University of Chicago, and the 2012 American Society of Health Economists meeting. I am grateful for the excellent research assistance provided by Morgen Miller in particular, and also by Phil Kurdunowicz, Jennifer Hefner, Sheng-Hsiu Huang, and Irine Sorser. Funding from the University of Michigan RWJ HSSP small Grant Program and the Rackham Spring/Summer Research Grant Program is gratefully acknowledged. Lastly, I thank Christal Ramos and David Ashner of the AAPA and numerous state Boards of Nursing, Medicine, Licensing, and Health for providing data and responding to many inquiries and questions.

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[1] American Association of Medical Colleges (2010) summarizes the workforce provisions of the ACA.

[2] A recent report by the Kaiser Commission on Medicaid and the Uninsured (2011), for instance, highlights the potential of NPs and PAs to address the primary care physician shortage.

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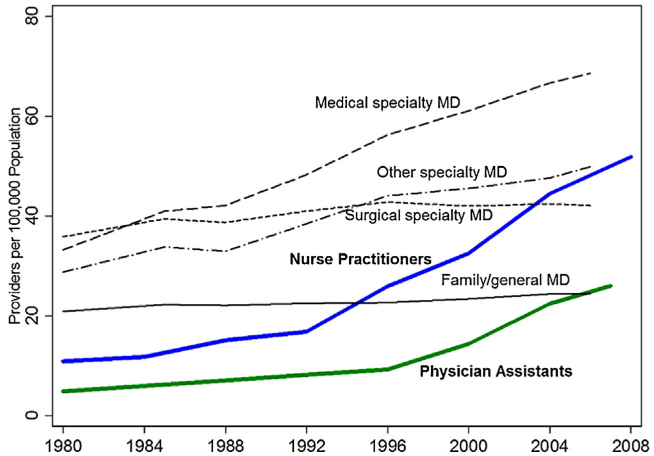

Fig. 1. Aggregate trends in health care providers, 1980–2008.
Source: Health Resources and Service Administration Area Resource File, National Survey Sample of Registered Nurses, American Academy of Physician Assistants.

number of primary care physicians, estimated to be about 260,000.[3] In many communities, physician assistants and nurse practitioners are already the principal providers of primary care and their ranks are projected to grow even further (Auerbach, 2012).

Supply growth has occurred against the backdrop of considerable cross-state variation in what NPs and PAs are permitted to do, with some states permitting autonomous practice while others mandating extensive physician oversight and collaboration. In fact, one of the four key messages in a recent Institute of Medicine study was that "nurses should practice to the full extent of their education and training," noting that a "variety of historical, regulatory, and policy barriers have limited nurses' ability to generate widespread transformation" to the healthcare system (Institute of Medicine, 2011). Significant occupational restrictions thus may limit the extent to which expansions in the number of providers has translated into meaningful changes in healthcare outcomes. Though several states have broadened scope-of-practice laws and expanded prescriptive authority – innovations that should enable NPs and PAs to operate more independently from physicians – substantial restrictions on the substitutability of NP and PA for physician care still remains in many states.

These workforce and regulatory changes have significantly altered how primary care is delivered in this country, but the consequences for health care markets have not yet been studied. Previous research on the effects of physician supply is mostly cross-sectional (limiting causal inference), has found mixed results, and may not inform the likely effects of NPs and PAs. To fill this gap, I exploit variation in NP and PA concentration and regulatory environment across areas and over time, made possible by a newly constructed panel dataset on the number of licensed NPs and PAs at the county level. I employ two complementary identification strategies to address the possible endogeneity of NP and PA supply. A county fixed effects approach exploits within-county variation in provider supply over time while an instrumental variables approach exploits cross-sectional geographic variation in provider supply that is due to the historical location of educational infrastructure for training registered nurses and PAs.

My findings suggest that, on average, greater supply of NPs and PAs has had minimal impact on utilization, access, use of preventative health care services, or prices. However, primary care utilization is modestly more responsive to provider supply in states that grant NPs the greatest autonomy. I find no evidence that increases in provider supply decreases prices, even for visits most likely to be affected by NPs and PAs: primary care visits in states with a favorable regulatory environment for NP and PAs. My estimates are sufficiently precise to rule out fairly small changes in price and utilization. I can rule out increases in the likelihood of having at least one visit of 0.75 (1.12) percentage points associated with a large 50% increase in NP (PA) supply and an elasticity of 0.03 (0.08) on the intensive utilization margin. Results using the county fixed effects and 2SLS approaches are very similar. I also examine the direct effect of occupational regulation by exploiting changes in state-level prescribing laws over time. I find that expansions in prescriptive authority for NPs are associated with modest increases in utilization and expenditure, though no consistent pattern emerges for expansions to PA prescriptive authority. Neither change appears to consistently reduce visit prices.

This study is the first to quantify the effects of increased supply of non-physician clinicians on access, costs, and patterns of utilization for a broad population-based sample. Previous research has focused on very specific settings or populations or has not accounted for fixed differences between areas that may be correlated with regulations, provider supply and outcomes. Understanding the effects of one of the largest changes in the delivery of healthcare in the past few decades is a first-order question for health policy. This paper also represents one of the first analyses of the consequences of occupational regulation on output markets. How changes in occupational boundaries affect demand for and supply of services as well as prices and quality is not well understood. Findings about the impact of scope-of-practice regulations have implications for many other sectors, both within and outside of health care, that have seen a blurring of occupational boundaries and an increase in licensing. Dental hygienists, paralegals, and tax professionals now perform many duties historically performed by dentists, lawyers, and accountants. The occupational regulatory environment moderates these shifts in the division of labor, but has not been studied extensively.

The remainder of this paper proceeds as follows. The next section provides a brief background on NPs and PAs, summarizes related literature, and describes anticipated effects. Section 3 introduces the data, including the new dataset on county-level NP and PA supply and state-level regulations that was assembled for this project. Section 4 describes my empirical strategy. Results are presented in Sections 5 and 6 and Section 7 concludes.

2. Background

2.1. *Nurse practitioners and physician assistants: background and recent changes*

Nurse practitioners (NPs) and physician assistants (PAs) are health care professionals that perform tasks similar to many physicians. Both professions emerged in the 1960s as a way for individuals with existing healthcare expertise to provide higher-level care more autonomously to underserved areas. NPs are registered nurses (RNs) that have received advanced training which permits them to diagnose patients, order and interpret tests, write prescriptions, and provide treatment for both acute and chronic illnesses. NPs have typically completed a two-year nurse practitioner masters program, passed a national exam, and are licensed by state boards of nursing. NPs practice in settings similar to physicians: doctors' offices, hospitals, outpatient clinics, community clinics, or their own practice (in some states). Physician assistants can

[3] These figures come from the American Academy of Physician Assistants, American Academy of Nurse Practitioners, and the author's analysis of the Area Resource File.

perform any duties delegated to them by physicians, though in practice the range of activities performed by PAs is very similar to NPs. PAs have typically graduated from a two-year PA program (usually housed in a medical school), passed a national exam, and are licensed by state boards of medicine.

The level of physician supervision or collaboration required of NPs and PAs and their permitted tasks (referred to as "scope-of-practice" laws) is determined by state law and thus varies tremendously by state. The West and New England regions are thought to be the most favorable to non-physician clinicians, but there is variation within regions and across the two professions (US Health Resources and Service Administration, 2004). Individual state licensing laws regulating health professions have also been changing in many states to permit NPs and PAs to practice more independent (Fairman, 2008). The ability to write prescriptions is one important feature that has changed dramatically over the past two decades, as depicted in Fig. 2. Currently NPs and PAs can prescribe at least some controlled drugs in almost all states, up from 5 and 11, respectively, as recently as 1989.

Care provided by nurse practitioners and physician assistants is reimbursed by insurers in two ways (US Department of Health and Human Services, 2011). Reimbursement can be made directly through these providers' own National Provider Identifier (NPI), often at a fraction of the physician reimbursement rate. For instance, Medicare reimburses direct-billed services provided by NPs and PAs at 85% of the physician rate, as do many private insurers and many state Medicaid programs (Chapman et al., 2010). Alternatively, if NP or PA care is provided as part of an episode of care provided by a physician, the services can be reimbursed at 100% through the physician's NPI, which is referred to as reimbursement for NP or PA care provided "incident-to" physician care. In this case, the physician must both be on-site when the service is performed and must treat the patient on the patient's first visit, though different payers and states interpret these requirements quite differently. Thus organizations where the higher rate is sufficient to offset the cost of additional physician oversight time may find it desirable to bill most NP and PA-provided care through the physician's NPI number.[4]

Historically NPs and PAs are more likely to provide care for the underserved and locate in rural areas than physicians (Larson et al., 2003; Grumbach et al., 2003; Everett et al., 2009). For states with provider supply data available (described in a later section), I estimate that the number of NPs per primary care physician increased from 0.25 in 1996 to 0.49 in 2008 and the number of PAs per primary care MD increased from 0.13 to 0.29, though there is considerable cross- and within-state variability these trends.

2.2. *Expected effects of non-physician supply and regulation*

An expansion of non-physician clinicians could impact the health care market both through prices and utilization. On the price side, more NPs and PAs may lower prices indirectly by injecting more competition into the market for primary care services (regardless of provider type). Economic theory predicts that an increase in the supply of a key input to production (labor) should lower output prices if markets are competitive. As imperfect substitutes for physicians, more NPs and PAs could also lower output prices directly by enhancing labor productivity through a more extensive division of labor.[5] The efficient division of labor is determined, in part, by coordination costs between workers (Becker and Murphy, 1992), which may be low if NPs and PAs work collaboratively with physicians. However, the primary care market is unlikely to be competitive, so increased provider supply could be associated with no changes or even increases in price if greater NP and PA supply makes consumers' provider search more difficult (Pauly and Satterthwaite, 1981) or if it shifts bargaining power from insurance companies to health care providers.

Utilization may also respond to greater provider presence through several channels, though the combined effect is theoretically ambiguous. Greater supply may increase utilization for people who previously went without care because they were not able to find a primary care provider. However, additional non-physician providers may partially "crowd-out" physicians if physician supply responds to the increased competition. The net effect on provider availability is likely to be positive, though the magnitude will depend on the extent to which the NPs and PAs increase the number of primary care providers rather than merely substitute for physicians. NPs or PAs may also make more referrals to specialists and physicians may substitute to performing more specialized procedures, both of which would increase the utilization of (more costly) specialist care. However, greater use of primary care and NPs' greater focus on prevention may also reduce the need for some health services, thus reducing utilization.

Since these providers have different training than the physicians they substitute for, the growth of NPs and PAs may also impact quality of care (either real or perceived). Evidence suggests that patients treated by NPs have similar outcomes as those treated by physicians, but some critics still voice concern about non-physicians' ability to detect rare or severe illnesses.[6] Even if physicians and non-physicians provide care of equal clinical quality, *perceived* quality differences between provider types could also lead to changes in utilization as the mix of providers is altered. Furthermore, expanded NP supply may also increase rates of immunization, screening, and routine checkups, as the nursing model stresses prevention and health behaviors.

Theoretical work on occupational regulation generally concludes that stricter regulation increases prices, but has ambiguous effects on utilization due to offsetting effects via supply (regulation restricts supply, reducing quantity) and demand (regulation assures quality and motivates human capital investment, increasing quantity) (Leland, 1979; Shaked and Sutton, 1981; Shapiro, 1986). While this theoretical work focused on the strictness of occupational entry requirements, it is reasonable to apply the result to task regulation as well. States that permit NPs and PAs to perform more tasks independent from physicians should experience lower prices, but ambiguous effects on utilization.

Thus a loosening of scope-of-practice laws for NPs and PAs is expected to reinforce expansions in provider supply. I expect larger effects of non-physician supply on utilization and prices in states that permit NPs and PAs to practice more autonomously, as this allows production to be closer to the possibilities frontier. A similar logic implies that the effect of supply will be largest for the tasks (or types of visits) for which NPs, PAs, and physicians are most substitutable.

[4] There is no dataset that is able to document what fraction of NP- and PA-provided care is billed under the NPI of an NP/PA, but Skillman et al. (2012) estimate that only 76% of NPs in 2010 had an NPI. This would be an upper bound of the fraction of visits that are billed through the NP's NPI (similar estimates for PAs are not available).

[5] Scheffler et al. (1996) estimate that 70–80% of the work done by primary care physicians could be done by nurse practitioners.

[6] See Mundinger et al. (2000) and Lenz et al. (2004) for the results from one randomized trial and Horrocks et al. (2002) and Laurant et al. (2004) for broader reviews.

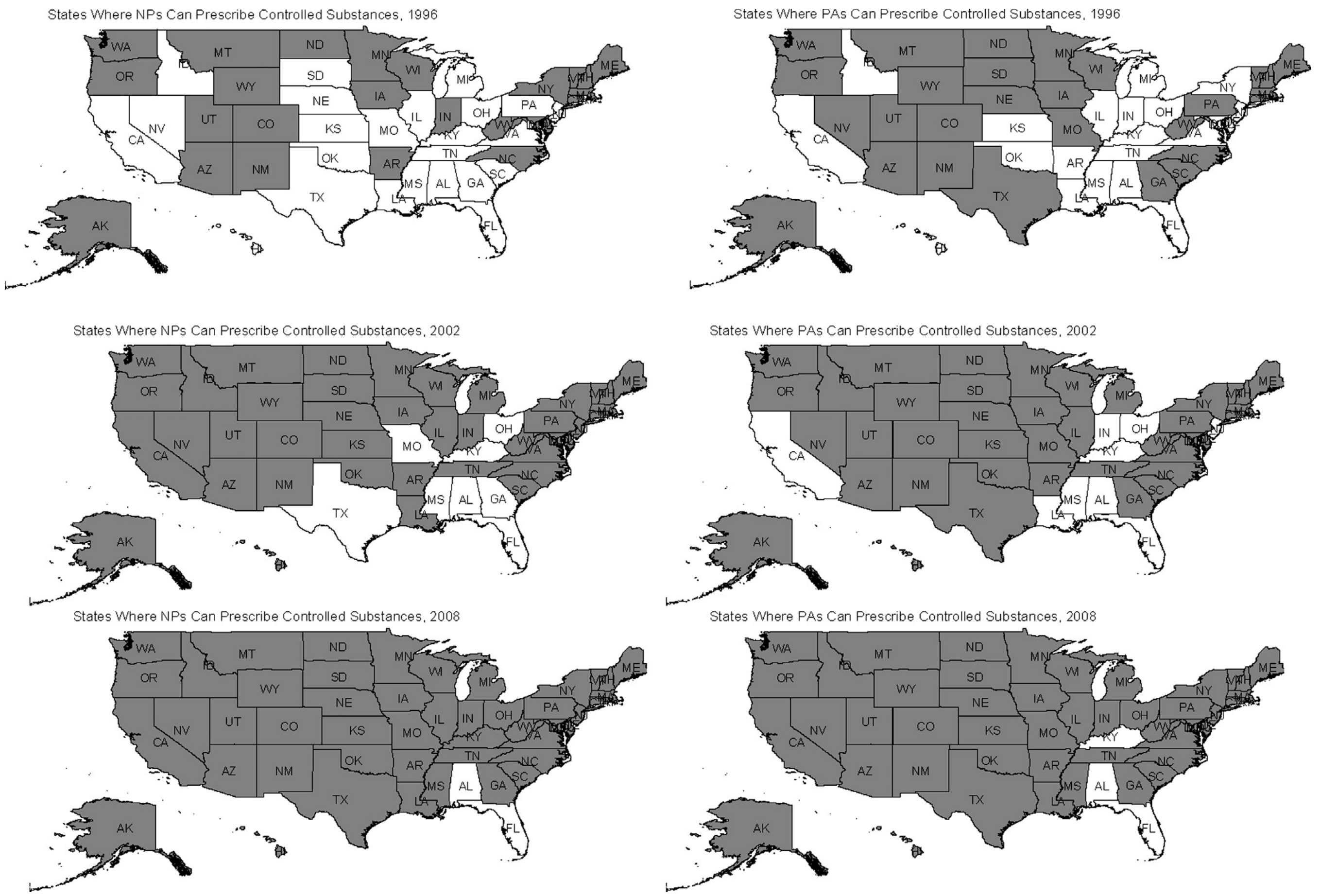

Fig. 2. States where NPs and PAs can prescribe controlled substances, 1996–2008.
Source: Author's tabulations from *The Nurse Practitioner*, Annual Legislative Update (various years) and *Abridge State Regulation of Physician Assistant Practice*, distributed by the American Academy of Physician Assistants.

2.3. Previous research on the effects of provider supply

Previous research has documented the aggregate growth of nurse practitioners and physician assistants and discussed the importance for primary care delivery, but has not quantified the consequences.[7] Previous analysis on provider supply has been cross-sectional and focused on physicians, finding fairly mixed evidence of effects on utilization, prices, and expenditure. Some have found that more primary care physicians is associated with more primary care visits, less emergency department use, greater use of preventive health measures, fewer hospitalizations for ambulatory-sensitive conditions (suggesting better primary care access) and lower mortality (Chang et al., 2011; Laditka et al., 2005; Guttman et al., 2010; Continelli et al., 2010). Other studies find no such relationship between provider concentration and self-reported measures of access (Grumbach et al., 1997). These cross-sectional studies might be subject to omitted variable bias (of unknown direction) if provider supply is correlated with unobserved demand factors.

On the expenditure side, Chang et al. (2011) finds no consistent association between provider supply and Medicare spending, though Baicker and Chandra (2004a,b) do find that areas with more specialist rather than generalist MDs have higher health care expenditures. Chernew et al. (2009) find that a greater concentration of primary care physicians is not associated with lower spending growth, despite being correlated with lower spending levels at a point in time. An earlier line of research found a positive association between physician supply and prices, interpreting it either as evidence of physician-induced demand or diminished consumer information when physician supply increases (Pauly and Satterthwaite, 1981). No prior work provides direct estimates of the market-wide effects of NPs or PAs on healthcare markets.

2.4. Previous research on occupational regulation

There is also relatively little research on the labor and output market effects of occupational restrictions.[8] Extant research has focused on the consequence of stricter entry regulations for a single licensed profession, rarely looking at the effects of regulations delineating the division of labor between various licensed professions. I am not aware of any previous work that examines how occupational regulation moderates the growth of input supply to influence output markets.

Higher entry barriers have typically been associated with higher prices and lower quantity, though quality effects are mixed. For

[7] See Cooper et al. (1998a,b), Hooker and McCaig (2001), Hooker and Berlin (2002), Druss et al. (2003), US GAO (2008), and Scheffler (2008) for descriptive work on the trends in NPs and PAs.

[8] For an overview of the theoretical and empirical literature, see Kleiner (2000, 2006).

instance, Kleiner and Kudrle (2000) find that stricter licensing raises the price of dental services and earnings of dentists, but is not associated with better oral health. Schaumans and Verboven (2008) find that entry restrictions and regulated mark-ups for pharmacies result in a welfare loss for consumers by inflating prices and significantly reducing the number of pharmacies and physicians. Hotz and Xiao (2011) find that stricter child care regulations reduce supply of child care (particularly in low-income markets), but also increase the quality of services provided (particularly in higher income markets). Thus child care regulation creates a tradeoff between higher quality care for high income families but restricted supply in low income markets.

Research on laws regulating which functions a licensed profession can do is sparse and only a handful of studies exploit variation in laws over time to address the potential omitted variable bias in cross-sectional approaches.[9] Dueker et al. (2005) find that greater prescriptive authority for advance practice nurses (APNs) is associated with lower earnings for APNs and physicians, but higher wages of physician assistants. The present study is most closely related to Kleiner and Won Park (2010) and Kleiner et al. (2011), which examine the labor market impact of scope-of-practice regulations for dental hygienists and NPs, respectively. In the former, the authors find that laws that permit hygienists to operate independent from dentists increase hygienists' wages and result in lower wages and employment growth for dentists. The latter study finds that wages of NPs increase and the price of well-child visits decreases when NPs were permitted to do more tasks in the mid-2000s.

These studies suggest that the growth of NP and PA independence should have both labor and output market consequences, but no previous study has explored the output market side extensively. Nor has the role of occupational regulations in moderating the effects of input supply been examined.[10] Relative to Kleiner et al. (2011), the present study examines utilization and access, focuses on the interactive effects of provider supply and regulation, and looks at a much broader set of health care outcomes.

3. Data

3.1. New data on health care providers and regulations

A huge barrier to research on NPs and PAs has been a lack of data on the number of these providers at the sub-national level over time. To fill this gap, in collaboration with Deborah Sampson from Boston College School of Nursing, I assembled a new dataset containing the number of licensed nurse practitioners and physician assistants at the county level annually for the years 1990–2008 using individual licensing records obtained from relevant state agencies. The years for which data is available varies across states, so our county panel is unbalanced: NP and PA supply data is available for 23 states covering 52% of the U.S. population in 1996, but increases to 35 states covering 80% in 2008.[11] Data on the number of primary care physicians was obtained from the Area Resource File. Throughout I refer to all general practice, family practice, generalist pediatric, general internal medicine, and general obstetrician/gynecologist physicians as "primary care" and include only these providers in our measures of physician supply.

Occupational regulations in each state are characterized in two ways. First, I quantify the overall practice environment for NPs and PAs in the state at a single point in time (2000) using an index constructed by the Health Services Resource Administration (HRSA, 2004). This index ranks states separately for NPs and PAs along three dimensions: (1) legal standing and requirement for physician oversight/collaboration on diagnosis and treatment; (2) prescriptive authority (type of drugs, requirements for MD oversight); (3) reimbursement policies (e.g. Medicaid reimbursement rates and requirements for private insurers). These three dimensions are then combined into a single index with a possible range from zero to one.[12] This time-invariant index is used to assess whether outcomes are more responsive to NP and PA supply in areas with more favorable environments for these providers. To be able to assess the direct effect of regulation on outcomes (rather than the indirect effect via supply responsiveness), as a second measure I also constructed indicators for whether NPs and PAs are permitted to write prescriptions for any controlled substances in a given state and year. Prescriptive authority is one aspect of provider regulation that has seen considerable change over the past two decades and is also cleanly measured across years in my sample period.

3.2. Outcomes

I study the health care experience of participants in thirteen waves of the Household Component of the Medical Expenditure Panel Survey (MEPS) from 1996 to 2008. The MEPS is a 2 year panel of households drawn from the National Health Interview Survey, which I treat as a repeated cross-section in each year. Characteristics of respondents' county and state were merged onto the MEPS files using individuals' state and county FIPS codes.[13] Since historical data on NP and PA supply could only be constructed for some states and for some years, the final dataset has 293,100 person-year observations (compared to 404,400 for all state-years), though the analysis sample is slightly smaller due to missing values for some key covariates.

Basic characteristics of the sample are presented in Table 1, with more detailed summary statistics included in Appendix B. On average, individuals in the sample live in counties with 90 primary care physicians, 30 NPs, and 17 PAs per 100,000 population. Seventy-nine (seventy-three) percent live in states that permit NPs (PAs) to write prescriptions for controlled substances. On average they make 2.8 office-based health care visits per year, with 62% having at least one. Approximately half of these visits are for primary care whose total expenditure (from all payers) is $153 per year (in 2010 dollars, including those with zero expenditure).[14] Similar to the national trend, the NP and PA to population ratios for my sample more than doubled from 1996 to 2008. Despite these extreme changes in the health care workforce, there has been

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[9] Using cross-sectional approaches, White (1978), Adams et al. (2003), and Sass and Nichols (1996) find mixed effects of scope-of-practice laws on wages and utilization of several different health professions.

[10] Several studies suggest that a favorable practice environment is correlated with the supply of non-physician clinicians, including NPs and PAs. See Sekscenski et al. (1994), Cooper et al. (1998a), and US DHHS (2004) for cross-sectional evidence. In a longitudinal study, Kalist and Spurr (2004) found that more favorable state laws do encourage more people to enter advance practice nursing in the 1990s.

[11] Appendix A describes the data collection in more detail.

[12] The weights for the three components differ slightly by provider type. NP index = 35% legal, 35% reimbursement, 30% prescribing. PA index = 35% legal, 25% reimbursement, 40% prescribing. The total indices range from 0.43 (South Carolina) to 0.94 (New Mexico) for NPs and 0.37 (Ohio) to 0.94 (North Carolina) for PAs. Appendix A describes these indices in more detail.

[13] Geographic identifiers are not part of the public-use MEPS files, so this merging was performed by AHRQ and all subsequent analysis was conducted under security protocols at the Michigan Census Research Data Center. Reported sample sizes are rounded to the nearest hundred to conform to Census Research Data Center confidentiality protocols.

[14] All dollar variables have been adjusted for inflation using the CPI-U and are in 2010 dollars.

Table 1
Summary statistics.

	Analysis sample $n = 293,100$		Full dataset $n = 404,400$	
	Mean	SD	Mean	SD
Panel A. Person sample				
Provider supply and regulation				
MD per population (×100,000)	89.619	44.211	88.879	46.38
NP per population (×100,000)	30.166	20.629	N/A	
PA per population (×100,000)	17.082	10.979	N/A	
NP practice index (2000)	0.744	0.134	0.738	0.129
PA practice index (2000)	0.772	0.107	0.737	0.141
NPs can prescribe controlled substances in state × year	0.790	0.408	0.724	0.447
PAs can prescribe controlled substances in state × year	0.733	0.442	0.674	0.469
Health care utilization and expenditure				
Office-based visits > 0	0.623	0.485	0.631	0.483
Number of office-based visits	2.781	5.517	2.831	5.479
Number of primary care office-based visits	1.456	2.702	1.47	2.674
Number of non-primary care office-based visits	1.325	3.373	1.362	3.376
Total amount paid for primary care office-based visits	152.84	365.66	151.34	356.82
Have usual source of care	0.780	0.414	0.788	0.409
Flu shot in last 12 months	0.272	0.445	0.276	0.447
Blood pressure check in last 12 months	0.773	0.419	0.782	0.413
Pap smear in last 12 months	0.569	0.495	0.568	0.495
Breast exam in last 12 months	0.615	0.487	0.617	0.486
Cholesterol check in last 12 months	0.526	0.499	0.523	0.499
	Analysis sample $n = 803,200$		Full dataset $n = 1,114,900$	
	Mean	SD	Mean	SD
Panel B. Office-based visits sample				
No condition associated with visit	0.20	0.40	0.20	0.40
Predicted likelihood that visit is primary care	0.51	0.10	0.51	0.10
Visit category = checkup or well-child	0.29	0.46	0.29	0.45
Visit category = diagnosis/treatment	0.54	0.50	0.54	0.50
Visit category = emergency	0.01	0.09	0.01	0.09
Visit category = followup	0.12	0.33	0.12	0.33
Visit category = shots	0.04	0.20	0.04	0.20
Total amount paid for visit (all sources)	118.76	152.44	116.79	151.52
Total charges for visit	218.84	356.19	213.16	351.57

Note: Sample sizes rounded to nearest 100. Person analysis sample includes all individuals living in counties for which physician, nurse practitioner, and physician assistant supply data is available in their survey year. Provider supply measures are calculated at the county level. Physician supply only includes non-federal office-based physicians in family/general practice, general pediatrics, general internal medicine, and general ob/gyn. The office-based visits sample includes only visits for which provider was doctor, registered nurse or nurse practitioner, or physician assistant. Also excludes visits categorized as mental health, maternity, eye exam, laser eye surgery, and other. Analysis sample further restricted to visits by individuals living in counties for which physician, nurse practitioner, and physician assistant supply data is available in their survey year.

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

surprisingly little change in most measures of office-based health care utilization during this time period.

To assess the price impact of workforce and regulatory changes, I pool the MEPS office-based medical provider visits files from 1996 to 2008. The visits files contain a separate observation for each visit, call, or interaction with office-based health care providers by MEPS participants during the survey period. I restrict the sample to visits to physicians, nurse or nurse practitioners, or physician assistants and also exclude visits categorized as for mental health, maternity, eye exam, laser eye surgery, or other reasons.[15] After these restrictions, my analysis sample includes 803,200 visits by individuals living in counties for which physician, nurse practitioner, and physician assistant supply data is available in the survey year.

One limitation of the MEPS visits data is that visits to NPs and PAs are often classified as physician visits due to question framing and misreporting and physician specialty is only available since 2002.[16] Therefore I do not look extensively at visit provider type as reported in MEPS, and instead focus on market-level effects across all provider types. In order to identify visits that are potentially most affected by NP and PA supply growth and regulation, for each visit I construct a measure of the predicted likelihood that the visit would be to a primary care provider, given observed individual and visit-level characteristics. The most common high likelihood visits includes flu shots, no condition checkups, and visits for a sore throat.[17]

Twenty percent of visits are unrelated to a specific medical condition and relatively few include any specific treatment or service. The vast majority of visits are categorized as general check-ups, well-child exams, or for the diagnosis/treatment of a specific condition. I estimate that the average visit has a 51% likelihood of being to

[15] Maternity and mental health visits are excluded, as these are rarely provided by NPs and PAs in the MEPS data.

[16] As described by Morgan et al. (2007), the MEPS underreports care by NPs and PAs because only visits during which a physician is not ever seen are further categorized by type of non-physician (NPs or PAs) and because respondents tend to over report the presence of physicians at visits.

[17] Appendix A describes this procedure in more detail.

a primary care provider which implies that in expectation, slightly more than half of office-based visits are for primary care. I examine two measures of visit price: total charges and total amount paid by all sources. Since amount paid is largely dictated by reimbursement rates set by Medicare and other insurers, it may not take competitive pressures or provider availability into account, limiting observed price responsiveness; charges may be more responsive to market forces. On the other hand, charges are an imperfect measure of resource-allocating price since they are not fully paid.[18] The average amount paid for a visit was $119 across all years, with visit charges approximately $100 more.

4. Empirical approach

4.1. Fixed effects specification

To estimate the causal effect of NP and PA supply and its interaction with the regulatory environment on health care access, utilization, and expenditure, I estimate the following regression model using OLS:

$$y_{ijt} = \beta_1 NP_{jt} + \beta_2 PA_{jt} + \beta_x X_{ijt} + \beta_z Z_{jt} + \delta_j + \delta_t + \varepsilon_{ijt} \quad (1)$$

where y_{ijt} is an outcome (number of visits, total expenditure, have usual source of care, etc.) for individual i in county j at time t.[19] As measures of provider concentration (NP_{jt} and PA_{jt}) I use the log of the number of NPs and PAs per 100,000 population in area j at time t.[20] Fixed and time varying factors at the individual level, such as income category, age, race, insurance type, and self-reported health status are controlled for with X_{ijt}. To control for fixed unobserved determinants of outcomes across areas and over time that may be correlated with NP/PA concentration or practice indices, I also include county and year fixed effects δ_j and δ_t. The vector Z_{jt} controls for time-varying factors at the county level that may be correlated with both provider supply and outcomes. In this vector, most specifications control for the number of primary care physicians per capita, to account for the possible crowd-out of physicians by greater NP and PA presence. In practice, I find little evidence of crowd-out or crowd-in, so the results are insensitive to whether physician supply is included. My preferred specification also controls for state-specific linear time trends and a host of time-invariant county characteristics (measured at baseline) interacted with linear time trends. Some specifications also control for the predicted number of non-primary-care doctor visits made by an individual in the survey year. ε_{ijt} is an error term that is assumed to be uncorrelated with all the right hand side variables.[21]

The key parameters of interest are β_1 and β_2, the change in outcome y associated with a one unit increase in NP or PA concentration, holding the included control variables constant. In order to quantify the effect of state regulation on the responsiveness of outcomes to supply, I let these parameters vary with the state practice index in state s in 2000. The coefficients on the index interaction terms represent differences in outcome response to increased provider supply between states that are fully supportive of NP and PA independent practice and those whose regulatory environment is completely restrictive.[22]

To estimate effects on the prices of basic health care services, I estimate a similar regression model using OLS:

$$y_{mijt} = \beta_1 NP_{jt} + \beta_2 PA_{jt} + \beta_Q Q_{mijt} + \beta_x X_{ijt} + \beta_z Z_{jt} + \delta_j + \delta_t + \varepsilon_{mijt} \quad (2)$$

where y_{mijt} is the log price of visit m made by individual i in county j at time t. In addition to the control variables used in (1), some specifications also include visit-specific characteristics, Q_{mijt}, such as indicators for specific treatments or services provided during the visit, fixed effects for conditions (if any) associated with the visit, or the predicted likelihood that a visit is primary care. ε_{mijt} is an error term that is assumed to be uncorrelated with all the right hand side variables. In order to permit the price response to additional supply to vary between types of visits and with the state practice environment, I also interact provider supply with predicted likelihood of primary care, the state practice index, and with both simultaneously. If NPs and PAs have a greater (negative) price effect on visits that are the most substitutable for primary care physicians or in states permitting greater autonomy of NPs and PAs, then the coefficients on these interactions should be negative.

To examine the direct effect of occupational regulations on outcomes, rather than the indirect effect that operates through provider supply, I also estimate OLS regressions of the form:

$$y_{ijt} = \beta_1 NPLaw_{st} + \beta_2 PALaw_{st} + \beta_x X_{ijt} + \beta_z Z_{jt} + \delta_j + \delta_t + \varepsilon_{ijt} \quad (3)$$

where most variables are defined as before, but now $NPLaw_{st}$ ($PALaw_{st}$) is an indicator variable that equals one if state s permits NPs (PAs) to prescribe any controlled substances in year t. Identification of the parameters of interest now comes from changes in laws within states over time. Since changes in laws may also correlate with provider supply growth, some specifications also include the log of the number of NPs and PAs per 100,000 population in area j at time t.

4.2. Identification challenges with fixed effects specification

The first concern with the OLS approach described above is that changes in NP or PA supply or laws may be correlated with other determinants of health care outcomes, causing biased estimates of β. Table 2 identifies the observable factors that predict variation in provider supply across areas and over time. Cross-sectional variation in provider supply is much more highly correlated with observable county characteristics than provider growth. In fact, several of the strongest predictors of the level of provider density (number of MDs, HMO penetration, and industry mix) are not predictive of NP or PA supply growth. Nonetheless, provider growth

[18] Since charges and amount paid for each visit obtained from the household survey of MEPS participants are often incomplete, MEPS also collects this information directly from participants' medical providers, prioritizing information from providers whenever possible.

[19] Medical expenditure and utilization is right skewed with a long right tail and a large mass at zero, which can cause simple OLS estimates to be miss-specified and imprecise (Jones, 2000). I separately analyze the extensive and intensive margins of utilization and expenditure using OLS, taking the log of right-skewed outcomes and omitting persons with zero visits from the intensive margin analysis. Marginal effects and standard errors are nearly identical when binary outcomes are estimated using a logit model (instead of OLS) and results are qualitatively very similar if the intensive and extensive margins of utilization are estimated together using a Poisson or negative binomial count model.

[20] This log specification imposes heterogeneity of treatment effect by treatment intensity. For instance, counties whose NP/pop ratio increases from 1 to 2 are assumed to have a larger change in the outcome than a county whose NP/pop ratio increases from 40 to 41.

[21] To allow for the possibility of correlated errors among people sharing a similar regulatory regime, standard errors are clustered by state in all analysis. Clustering by county produces standard errors that are comparable.

[22] An alternative interpretation of index interaction terms, which I cannot rule out, is response heterogeneity by baseline provider supply level as areas with more favorable NP and PA practice environments also tend to have more of these providers (Sekscenski et al., 1994).

Table 2
Time-invariant county characteristics that correlate with provider density and growth.

	(1) log(NP per population)		(2) log(PA per population)	
	Main effect	Interaction with time	Main effect	Interaction with time
log(MDs per population) (in 1995)	0.310***	0.003	0.309***	0.000
	(0.057)	(0.005)	(0.054)	(0.005)
HMO penetration (1998)	0.725***	−0.001	−0.293*	0.018
	(0.150)	(0.013)	(0.150)	(0.014)
Log of population density (1992)	−0.046**	0.003*	−0.023	0.007***
	(0.020)	(0.002)	(0.018)	(0.002)
% persons in poverty (1989)	1.290*	−0.198***	−1.476**	0.003
	(0.751)	(0.063)	(0.725)	(0.079)
Median household income ($1000, 1990)	0.018***	−0.001***	−0.004	−0.000
	(0.005)	(0.000)	(0.006)	(0.000)
Infant mortality rate (1988)	0.004	−0.003**	0.012	−0.000
	(0.013)	(0.001)	(0.012)	(0.001)
% workforce in health (1990)	4.431***	0.083	3.999***	−0.039
	(1.139)	(0.099)	(1.082)	(0.114)
% workforce in manufacturing (1990)	−1.553***	−0.019	−0.948***	0.003
	(0.325)	(0.028)	(0.304)	(0.026)
Unemployment rate (1990)	−0.019*	−0.004***	0.022*	0.000
	(0.011)	(0.001)	(0.011)	(0.001)
% White (1990)	1.141***	−0.045*	0.438*	0.055***
	(0.264)	(0.024)	(0.258)	(0.020)
% Hispanic (1990)	−0.856***	0.014	0.008	0.050**
	(0.165)	(0.015)	(0.205)	(0.022)
% high school or greater	0.375	−0.177***	0.998**	0.032
	(0.387)	(0.034)	(0.416)	(0.043)
PAs can prescribe controlled drugs in state (in 1995)	−0.228***	0.021***	−0.029	0.016***
	(0.047)	(0.004)	(0.049)	(0.004)
NPs can prescribe controlled drugs in state (in 1995)	0.132***	−0.001	0.319***	−0.012***
	(0.043)	(0.003)	(0.047)	(0.004)
Constant	0.201	0.296***	0.310	−0.049
	(0.624)	(0.055)	(0.534)	(0.044)
F-test for coefficients on above variables = 0 (excluding constant and linear time trend)	50.84	10.17	22.56	7.01
Observations	17,235		17,235	
R-squared	0.537		0.418	

Note: Robust standard errors in parentheses, clustered by county. Time is normalized to zero in 2002 so main effects can be interpreted as the average in the mid-point of the sample period. Provider density ratios are per 100,000 population. Sample includes 1695 counties for 13 years (1996–2008), but data is not available for all years so the panel is unbalanced. Observations are weighted by county population in all specifications.
* Significance at the $p < 10\%$ level.
** Significance at the $p < 5\%$ level.
*** Significance at the $p < 1\%$ level.

did occur differentially between areas with different demographics and economic circumstances. For this reason, the preferred specification includes separate linear trends for each state and linear trends that vary with these time-invariant county characteristics. These linear trends eliminate bias resulting from areas with, for example, high poverty rates having lower utilization growth and lower NP growth. It should be noted that time-invariant area characteristics – such as the high concentration of NPs and PAs in rural areas which may have low prices – are not a source of bias when county fixed effects are included in the model, though this basic source of bias is present is most of the previous work discussed earlier. More problematic for my approach is if changes in provider supply or laws are correlated with unobservable, time-varying factors, such as latent health care demand. The fixed effects model addresses this source of bias in so far as the presence of observed medical conditions (which is controlled for) is associated with increased demand, but I am not able to rule out the contribution of changes in unobserved demand factors.

Legislative endogeneity is a specific form of time-varying omitted variable bias when looking at the direct effect of practice environment via Eq. (3). Fixed effects will absorb any fixed differences between states that correlate with the timing of adoption, such as the tendency of states with high demand for health care to pass prescribing laws earlier in the sample period. However, if prescribing laws are changed as a consequence of time-varying factors within states, such as increased political power of nurse groups or atypical health care needs, then the model may be picking up the consequences of these trending factors rather than changes in the laws themselves. I cannot rule this possibility out, but I will note that many of these legislative changes are the end result of a long series of political battles fought between groups over many years or decades (Iglehart, 2013) and so the precise timing of passage is likely driven by idiosyncratic political factors rather than specific health care needs.

Measurement error in provider supply is a second concern. Some research suggests that county may not be the best geographic level to measure the number of health care providers (Rosenthal et al., 2005). Classical measurement error will attenuate estimates toward zero. The main results are robust to using workforce supply and fixed effects at the Health Service Area level (an aggregation of counties in the same state) rather than county. Unfortunately the MEPS does not contain geographic information below the county level, so I am unable to explore more localized measures of provider availability. Error may also be present in the measure of physician density, as reporting errors and delays are common in the AMA Masterfile, the source of physician data in the Area Resource File (Staiger et al., 2009; Freed et al., 2006). Thus changes in physician density may not be adequately controlled for in the analysis.

Finally, specifications that interact provider supply with practice indices assume that these indices are uncorrelated with other determinants of the responsiveness of demand to provider supply. This assumption would be violated if states with the most pent up demand (which are likely to be highly responsive to provider supply) are more likely to grant autonomy to NPs and PAs. I am unable to test for pent-up demand, but this source of bias would cause me to overstate the effect of NP and PA autonomy on responsiveness to supply.

4.3. Instrumental variables specification

To address some of these concerns, I also exploit cross-sectional variation in NP_{jt} and PA_{jt} induced by proximity to historical relevant training infrastructure in a two stage least squares (2SLS) framework. I instrument for NP_{jt} and PA_{jt} using the number of bachelor's RN programs in the county in 1963 and the number of PA programs in the county in 1975 per 100,000 current population as excluded instruments. Two conditions must hold for 2SLS to provide consistent estimates of β_1 and β_2. First, the excluded instruments must affect provider supply (the "relevance" condition), which is testable and discussed later. Second, provider supply must be the only channel through which the instruments affect (or are correlated with) the outcomes (the "exclusion" assumption). While not testable, I argue that this assumption is plausible in this setting. A bachelor's RN degree is a prerequisite for NP training, though most RN training programs only granted diplomas in the early 1960s and subsequent demand for nurses was primarily met through Associates degree programs. While the demand for healthcare may be correlated with the presence of *any* RN training program, there is little reason to believe that it should be correlated with the specific type of RN training program given that graduates of all programs take the same licensure test and jobs upon graduation. The PA instrument is analogous to comparing counties that were the earliest to train PAs with other counties, since the first wave of PA programs were nationally certified in the early 1970s.[23] The 2SLS specification exploits a completely different source of variation in provider supply than the fixed effects specification and also possibly eliminates attenuation bias caused by provider supply measurement error.

5. Impact of provider supply and interaction with regulation

5.1. Utilization

Table 3 examines the relationship between provider supply and utilization. I first examine total provider supply, before distinguishing by provider type. Though total provider supply is weakly positively correlated with the likelihood of having any office-based visits, this correlation is diminished somewhat (and loses statistical significance) once individual characteristics, fixed county characteristics, and linear time trends are controlled for in column (2). Separating physicians from non-physician providers (column 3) and separating all three types of providers (column 4) gives a qualitatively similar result: provider supply has minimal relationship with office-based health care utilization, either on the extensive or intensive margin. The point estimates from the preferred specification (4) suggests that a 10% increase in the NP to population ratio is associated with a 0.03 percentage point decrease in the fraction of individuals having at least one office-based provider visit. The precision of the estimates permits me to rule out positive effects greater than 0.75 percentage points associated with even a large 50% increase in NP density (i.e. moving from the sample average of 62.30 to 63.05%) or effects larger than 1.12 percentage points for a similar increase in PA density. On the intensive margin, the point estimates imply an elasticity of office-based visits with respect to provider supply of 0.001 for NPs and 0.03 for PAs, with the confidence interval ruling out elasticities greater than 0.032 and 0.076, respectively.[24]

Columns (5) and (6) examine the robustness to different sets of controls. Column (5) only includes individual person-level controls and county fixed effects. Results are similar in magnitude, precision, and fit to the model with extensive time trends, suggesting my null results are not driven by over-controlling for temporal variation.[25] Column (6) does not control for physician supply. One channel through which changes to NP and PA supply could operate is though a displacement effect on physician supply. In fact, the point estimates on NP and PA supply are nearly identical with or without controlling for physician supply, so physician displacement does not appear to be important.

To address the possibility of omitted variable bias due to time-varying area characteristics and measurement error attenuation bias, column (7) presents two-stage least squares (2SLS) estimates that exploit cross-sectional variation in provider supply induced by proximity to the historical training infrastructure. Greater bachelors RN program density in the 1960s is associated with greater NP supply (but not PA supply) today, while the opposite is true for the density of PA schools in 1975.[26] It is reassuring that cross-instrument effects are minimal (e.g. bachelors RN program density does not correlate with PA supply), which would be the case if latent healthcare demand was correlated with both RN and PA school location and provider supply. For both measures of utilization, the 2SLS point estimates for NP supply are larger (and more positive) and less precise than the fixed effects estimates, though they are never significantly different from zero or from the fixed effects estimates. For PA supply, the 2SLS point estimates are negative and never significantly different from zero or from the fixed effects estimates. The point estimates imply that a 10% increase in the NP to population ratio is associated with a 0.4 percentage point increase in the fraction of individuals having at least one office-based provider visit (95% CI: −0.08 to +0.89 percentage points) and an intensive-margin elasticity of 0.051 (−0.061 to +0.163).

Critics of current state practice laws argue that a restrictive practice environment limits the ability of non-physician providers to practice to the fullest extent of their training, limiting the substitutability between physician and non-physician care. Tables 4 and 5 address this issue by examining the importance of regulatory environment to the relationship between utilization and provider supply. Positive point estimates on the supply-index interactions

[23] The first program was started at Duke University in North Carolina in the 1960s as a means to integrate returning navy corpsman with medical experience into the civilian healthcare system.

[24] Marginal effects implied by Poisson and Negative Binomial count models are similar, as are the elasticities implied by OLS estimates from a model using total number of visits (including zeros) as the outcome variable. These results are presented in Table B5 in Appendix B.

[25] Additional specifications that introduce different sets of controls progressively for different ways of aggregating provider supply are presented in Table B6 in Appendix B. Results from these specifications are qualitatively similar, suggesting that the null finding is not driven by co linearity between provider supply and the extensive controls.

[26] Table B7 in Appendix B presents the first stage relationships between provider supply and these instruments. The *F*-statistics on the excluded instruments are 8.8 and 11.5 for NP and PA supply, respectively. As the NP F-statistic is not above the rule-of-thumb value of 10, some caution is warranted. Controlling for physician supply weakens the relationship further and reduces the F-statistics such that 2SLS estimates may be biased due to weak instruments. However, physician supply may control for unobserved determinants of demand that happen to correlate with training infrastructure (making the exclusion assumption more plausible). Given that the fixed effect analysis showed no relationship between physician supply and outcomes, the preferred specification omits physician supply. Results are qualitatively similar when controls for contemporaneous physician supply and the historical presence of other types of RN programs are included (presented in Appendix B, Table B8).

Table 3
OLS estimates of provider density on number of office-based visits.

	No controls	Full controls			Individual controls, county FE	Full controls	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A. Dept variable: have at least one office-based visit during year							
log(MD + NP + PA per population)	0.029**	0.025					
	(0.013)	(0.020)					
log(NP + PA per population)			0.006				
			(0.011)				
log(NP per population)				−0.003	0.003	−0.004	0.041
				(0.011)	(0.012)	(0.011)	(0.025)
log(PA per population)				0.008	0.003	0.008	−0.009
				(0.010)	(0.011)	(0.010)	(0.030)
log(MD per population)			0.016	0.013	0.0002		
			(0.019)	(0.020)	(0.022)		
N (rounded)	292,500	290,900	289,200	281,500	282,800	281,500	281,500
Adjusted *R*-squared	0.001	0.159	0.159	0.160	0.159	0.160	0.155
Panel B. Dept variable: log(number of office-based visits in year)							
log(MD + NP + PA per population)	0.001	−0.027					
	(0.014)	(0.026)					
log(NP + PA per population)			0.022				
			(0.019)				
log(NP per population)				0.001	−0.001	0.002	0.051
				(0.016)	(0.019)	(0.016)	(0.057)
log(PA per population)				0.031	0.026	0.029	−0.040
				(0.023)	(0.023)	(0.023)	(0.076)
log(MD per population)			−0.023	−0.035**	−0.027*		
			(0.016)	(0.017)	(0.014)		
N (rounded)	182,200	181,100	180,100	175,100	176,000	175,100	175,100
Adjusted *R*-squared	0.0004	0.195	0.195	0.195	0.195	0.195	0.190

Note: Robust standard errors clustered by state in parentheses, Specification (1) includes year fixed effects only. Individual controls include male, age, age squared, dummies for race/ethnicity, dummies for four income categories, dummies for public, private, or no insurance, and dummies for three self-reported health categories. Specifications (2)-(4) and (6) also include state × time linear trends and time-invariant county characteristics interacted with linear time trends. Time-invariant county characteristics that are interacted with time (linearly) include the fraction of persons in poverty (1989), infant mortality rate (1988), fraction of workforce in health (1990), fraction of workforce in manufacturing (1990), unemployment rate (1990), fraction white (1990), fraction with high school education (1990), fraction Hispanic (1990), population density (1992), and HMO penetration rate (1998). Excluded instruments in 2SLS estimates are the number of BA RN programs in 1963 in county per population and the number of PA programs in 1975 in county per population. See text for further explanation.

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

Table 4
OLS Estimates of interaction between provider density and regulatory environment index on utilization.

		Log(number of office-based visits)				
	At least one office-based visit during year	All visits	Primary care visits		Non-primary care	
	(1)	(2)	(3)	(4)	(5)	(6)
log(NP per population)	−0.069	−0.217**	0.001	−0.255***	−0.017	−0.037
	(0.069)	(0.100)	(0.017)	(0.075)	(0.020)	(0.103)
log(PA per population)	−0.088*	−0.093	0.020	−0.038	0.034*	−0.058
	(0.046)	(0.128)	(0.018)	(0.117)	(0.019)	(0.133)
log(NP per population) × NP index	0.089	0.295**		0.348***		0.026
	(0.104)	(0.143)		(0.099)		(0.140)
log(PA per population) × PA index	0.132*	0.170		0.079		0.125
	(0.069)	(0.167)		(0.149)		(0.171)
log(MD per population)	0.014	−0.034*	−0.027	−0.027	−0.011	−0.009
	(0.020)	(0.018)	(0.020)	(0.019)	(0.016)	(0.017)
Controls	Full	Full	Full	Full	Full	Full
N (rounded)	281,500	175,100	160,700	160,700	114,500	114,500
Adjusted *R*-squared	0.160	0.195	0.115	0.115	0.196	0.196
F-test for provider supply coefficient = 0 when practice index = 1 (100%)						
Nurse practitioners (*p*-value)	0.601	0.115		0.001		0.800
Physician assistants (*p*-value)	0.089	0.099		0.267		0.127

Note: Robust standard errors clustered by state in parentheses. All specifications include year fixed effects, individual controls, state × time linear trends, and time-invariant county characteristics interacted with linear time trends. Individual controls include male, age, age squared, dummies for four income categories, dummies for race/ethnicity, dummies for public, private, or no insurance, and dummies for three self-reported health categories. Time-invariant county characteristics that are interacted with time (linearly) include the fraction of persons in poverty (1989), infant mortality rate (1988), fraction of workforce in health (1990), fraction of workforce in manufacturing (1990), unemployment rate (1990), fraction white (1990), fraction with high school education (1990), fraction Hispanic (1990), population density (1992), and HMO penetration rate (1998). Number of primary and non-primary care visits was estimated by predicting whether each individual office visit was to a primary care provider based on broad visit category, the individual characteristics listed above, and the medical condition (if any) associated with the visit. See text for further explanation.

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

Table 5
OLS estimates of provider density and interaction with components of regulatory index on utilization.

		Component-specific index		
	Overall index	Reimbursement	Legal	Prescribing
Panel A. log(total number of visits)				
log(NP per population)	−0.217**	−0.021	−0.119	−0.135***
	(0.100)	(0.077)	(0.075)	(0.044)
log(PA per population)	−0.093	0.172**	−0.028	−0.030
	(0.128)	(0.083)	(0.065)	(0.038)
log(NP per population) × NP index	0.295**	0.026	0.171	0.196**
	(0.143)	(0.095)	(0.113)	(0.075)
log(PA per population) × PA index	0.170	−0.163*	0.078	0.095
	(0.167)	(0.093)	(0.086)	(0.060)
NPxHigh P-val	0.115	0.853	0.243	0.142
PAxHigh P-val	0.099	0.717	0.143	0.049
Panel B. log(number of primary care visits)				
log(NP per population)	−0.219**	−0.007	−0.132*	−0.155***
	(0.084)	(0.054)	(0.075)	(0.033)
log(PA per population)	−0.033	0.200***	0.083**	−0.047*
	(0.084)	(0.047)	(0.033)	(0.027)
log(NP per population) × NP index	0.291**	0.001	0.180	0.217***
	(0.129)	(0.073)	(0.119)	(0.058)
log(PA per population) × PA index	0.055	−0.220***	−0.102**	0.082*
	(0.109)	(0.053)	(0.046)	(0.041)
NPxHigh P-val	0.138	0.885	0.346	0.068
PAxHigh P-val	0.466	0.061	0.339	0.110

Note: All specifications include year fixed effects, log(MD per population), individual controls, county fixed effects, state × time linear trends, and time-invariant county characteristics interacted with linear time trends. Primary care specifications also include log(number of non-primary care visits). Robust standard errors clustered by state in parentheses. Individual controls include male, age, age squared, dummies for race/ethnicity, dummies for four income categories, dummies for public, private, or no insurance, and dummies for three self-reported health categories. Time-invariant county characteristics that are interacted with time (linearly) include the fraction of persons in poverty (1989), infant mortality rate (1988), fraction of workforce in health (1990), fraction of workforce in manufacturing (1990), unemployment rate (1990), fraction white (1990), fraction with high school education (1990), fraction Hispanic (1990), population density (1992), and HMO penetration rate (1998). Number of primary and non-primary care visits was estimated by predicting whether each individual office visit was to a primary care provider based on broad visit category, the individual characteristics listed above, and the medical condition (if any) associated with the visit. See text for further explanation.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

do suggest that utilization is more (positively) responsive to provider supply in more NP and PA-friendly states. However, at the extensive margin (column (1)), neither interaction is significant at the 5% level and I cannot reject that the extensive margin response to supply is equal to zero even in the most favorable practice environments. On the intensive margin (column (2)), the estimates imply an elasticity of 0.08 for both NP and PA supply in states with the most favorable environments. Columns (3) and (4) examine the determinants of primary care visits. This variable is constructed by summing the predicted likelihood that each visit is a primary care visit across all visits made by each individual. The estimated total number of non-primary care visits, analyzed in columns (5) and (6), is constructed similarly. Across all areas, the average response of both types of visit to provider supply is minimal. However, the number of primary care visits is more responsive to NP supply in states that permit NPs greater autonomy than those with restrictive environments (column (4)). Since we may expect that additional providers have a greater impact for certain patient segments, I also examined utilization separately by type of insurance coverage. I find no evidence that provider supply is more important for the two groups most likely to face access problems (Medicaid recipients and the uninsured), though practice environment estimates are imprecise.[27] For most of these subpopulations, the conditional correlation between provider supply and utilization is small and statistically insignificant, as are the coefficients on the practice environment interactions.

Table 5 presents estimates that separate the practice index into its three components: reimbursement policies, legal restrictions on practice, and prescriptive authority. These specifications replace the overall index (a weighted average of these three components) with the component-specific indices one-by-one. Positive coefficients on the interactions between NP supply and the prescriptive authority and legal standing indices suggest these are the components of the NP index (rather than reimbursement parity) that explain its importance to NP supply effects. The patterns for the components of the PA index are broadly consistent, though all these results should be interpreted cautiously, as estimates are imprecise.

Estimates suggest that provider concentration – whether NPs or PAs – has minimal impact on utilization (both extensive and intensive margin) once time-invariant area characteristics and linear time trends are controlled for. The estimates are sufficiently precise that I can rule out increases in the likelihood of having at least one visit of 0.75 (1.12) percentage points associated with a 50% increase in NP (PA) supply and an elasticity of 0.03 (0.08) on the intensive utilization margin. However, utilization does appear to be more responsive to NP supply changes in states that permit these non-physician clinicians greater autonomy, particularly in the realm of prescriptive authority.

5.2. Prices

Theory predicts that an expansion of the supply and autonomy of NPs and PAs should reduce prices in the market for services for which they provide the greatest substitute for physician care. Table 6 reports estimates of Eq. (2) where log of visit price is the dependent variable. Visit prices and provider supply are very weakly positively correlated in the raw data (column 1). However, if NPs and PAs have expanded in areas with rising demand for care due to increased health needs, then this could create a

[27] See Table B9 in Appendix B for these results.

Table 6
OLS estimates of provider density and interaction with regulatory environment index on visit prices.

	log(total charges)			log(total paid)	log(total charges)				log(total charges)	log(total paid)
					Exclude Medicare and Medicaid	Check-up: no condition	Well child exam: no condition	2SLS		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
log(NP per population)	0.009	0.036	−0.017	−0.042**	0.001	−0.019	0.005	−0.011	−0.092	−0.041
	(0.020)	(0.031)	(0.030)	(0.020)	(0.028)	(0.026)	(0.056)	(0.063)	(0.179)	(0.089)
log(PA per population)	0.007	0.004	−0.009	−0.009	0.004	−0.030	0.001	0.055	0.012	0.038
	(0.022)	(0.023)	(0.016)	(0.019)	(0.025)	(0.023)	(0.063)	(0.064)	(0.077)	(0.088)
log(NP per population) × predicted primary care			0.042*	0.042*	0.048*				0.022	0.035
			(0.025)	(0.022)	(0.024)				(0.041)	(0.034)
log(PA per population) × predicted primary care			−0.038*	−0.005	−0.047*				−0.016	0.034
			(0.022)	(0.018)	(0.023)				(0.060)	(0.058)
log(NP per population) × NP index									0.105	0.003
									(0.223)	(0.122)
log(PA per population) × PA index									−0.030	−0.069
									(0.096)	(0.106)
log(NP per population) × predicted primary care × NP index									0.024	0.005
									(0.036)	(0.033)
log(PA per population) × predicted primary care × PA index									−0.029	−0.044
									(0.060)	(0.058)
Predicted likelihood of primary care		−0.513***	−0.548***	−0.495***	−0.561***				−0.541***	−0.499***
		(0.015)	(0.073)	(0.061)	(0.079)				(0.070)	(0.056)
Additional controls										
Individual, MD density, procedures, county FE	No	Yes	Yes	Yes	Yes	Yes	Yes	See	Yes	Yes
State × time, county characteristics × time	No	No	Yes	Yes	Yes	Yes	Yes	Notes	Yes	Yes
F-test for provider supply coefficient = 0 when primary care = 1 (100%) and practice index = 1 (100%)										
Nurse practitioners (*p*-value)			0.381	0.999	0.082				0.263	0.975
Physician assistants (*p*-value)			0.011	0.405	0.053				0.019	0.129
Adjusted *R*-squared	0.026	0.113	0.114	0.077	0.124	0.053	0.122	0.105	0.114	0.077
Rounded *N*	762,500	761,300	756,900	734,600	527,300	96,100	13,100	756,900	756,900	734,600

Note: All specifications include year fixed effects. Robust standard errors clustered by state in parentheses. Individual controls include male, age, age squared, dummies for four income categories, dummies for public, private, or no insurance, and dummies for three self-reported health categories. Time-invariant county characteristics that are interacted with time (linearly) include the fraction of persons in poverty (1989), infant mortality rate (1988), fraction of workforce in health (1990), fraction of workforce in manufacturing (1990), unemployment rate (1990), fraction white (1990), fraction with high school education (1990), fraction Hispanic (1990), and HMO penetration rate (1998). Predicted likelihood of being a primary care visit was estimated by predicting whether each individual office visit was to a primary care provider based on broad visit category, the individual characteristics listed above, and the medical condition (if any) associated with the visit. Excluded instruments in 2SLS estimates are the number of BA RN programs in 1963 in county per population and the number of PA programs in 1975 in county per population. 2SLS specifications include year and state fixed effects, individual controls, and time-invariant county characteristics, the predicted likelihood that a visit is primary care, and procedure dummies. See text for further explanation.

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

positive omitted variable bias between visit prices and NP or PA concentration. Column (2) controls for individual characteristics, indicators for 20 different treatments or procedures performed during the visit, and the estimated likelihood that the visit is to a primary care provider, based on person demographics, the type of visit, and associated conditions. The estimates suggest that primary care visits are predicted to cost 40% less than visits that can only be performed by specialists. This control has little effect on the estimated price elasticities, which remain small and insignificant.[28]

Since many visits are to specialist physicians, we may not expect there to be large price impacts of greater availability of nurse practitioners and physician assistants, who work largely in primary care. We would expect to see the largest price effects on visits for which NP and PA care is the most substitutable for physician care. Specification (3) explores this possibility by interacting NP and PA supply with the estimated likelihood that a given visit is primary care. Negative point estimates on these interactions would suggest that the prices respond more (negatively) to expanded provider supply for visits that are more likely to be to a primary care (rather than specialist) provider. This pattern is not seen in the data. Greater NP supply is associated with a *positive* price change for visits that are likely to be primary care, compared to an insignificant zero or negative change for non-primary care visits. Point estimates for PA supply are indeed negative and approaching statistical significance in some specifications, though still very small. The pattern is unchanged regardless of whether total charges or total amount paid (column 4) is used as the measure of price. Fig. 3 applies this approach even more flexibly. I estimate Eq. (2) separately for twenty quantiles of predicted probability of primary care. There is no obvious relationship between the estimated price elasticity and predicted likelihood of being a primary care visit. At all ranges of visit types, from general check-ups (high likelihood of being primary care) to cancer diagnosis (low likelihood), the estimated price elasticity bounces around zero. This is true both for NP and PA supply and regardless of how price is measured. Columns (5)–(8) probe the robustness of this null result. Column (5) excludes respondents with Medicare or Medicaid insurance coverage, whose prices may be less subject to market forces, as reimbursement rates are set by the Medicare and Medicaid programs. These results are indistinguishable from the preferred specification in column (3). Columns (6) and (7) examine two common types of visits expected to be easily performed by NPs and PAs: regular check-ups and well-child exams with no associated medical conditions. Again, provider supply has minimal association with price. Column (8) presents 2SLS estimates that exploit cross-sectional variation in provider supply induced by proximity to the historical training infrastructure. The 2SLS results are very consistent with the fixed effects estimates: provider supply has minimal effect on visit prices overall, though the 2SLS estimates are much less precise.[29]

The final two columns of Table 6 permit the price elasticity to vary with predicted likelihood of being primary care, state practice environment index, and their interaction. If there is to be any significant price effect, we may expect to find it among visits for which provider type is highly substitutable and state laws are the least restrictive. Even for this specific group of visits, the estimated price elasticity is wrong-signed or very small: +0.06 for NP supply and −0.06 for PA supply, though the latter is statistically significant. Overall, it appears that provider supply has minimal impact on visit price, even for services expected to be easily shifted from physician to non-physician care.

5.3. Expenditure on office-based visits

Table 7 examines the impact of NP and PA supply on health care expenditure for total office-based provider visits.[30] Expenditure tends to be positively (though insignificantly) correlated with provider supply, even after the preferred set of controls (individual characteristics, physician supply, linear time trends, county fixed effects) are included. Across all individuals and areas, the point estimates imply an (insignificant) 0.032% increase in expenditure associated with a 1% increase in PA supply and an (insignificant) 0.003% increase associated with a similarly sized expansion of NP supply. Point estimates of expenditure elasticities are largest for NP supply and Medicaid recipients and PA supply and the uninsured. Though most of the practice index interactions are positive, none of the elasticities implied by the point estimates for the most NP- and PA-favorable states are significant at conventional levels.

5.4. Qualitative measures of access, preventive care, and health

Even if broad measures of utilization and expenditure are unresponsive to expanded NP and PA supply and scope-of-practice, it is possible that these changes alter individuals' interaction with the health system or the nature of the care they receive. Table 8 presents OLS estimates of Eq. (1) with an indicator for several other health care and health outcomes as the dependent variables. Columns (1) and (2) examine whether the individual has a "usual source of care," the one qualitative measure of access that was consistently assessed in the MEPS through the entire analysis period. Twenty-two percent of my sample does not have a usual source of care. When only year fixed effects are controlled for, a greater number of providers of either type is associated with an increased likelihood of have having a usual source of care. However, this pattern seems to be driven by county and individual characteristics that differ across areas, since this relationship is greatly diminished with controls. Specification (2) controls for changes in population characteristics that may be correlated both with provider concentration and access, fixed county characteristics, and linear time trends by state and county characteristic. The point estimates are also small in magnitude: I can rule out an increase in the likelihood of having a usual source of care of 0.3 percentage points associated with a 10% increase in NP or PA supply.

Columns (3)–(8) examine the relationship between provider supply and several important preventive care outcomes. Greater availability of non-physician clinicians, particularly nurse practitioners, may expand the use of preventive care services both due to greater provider availability to perform low-value (e.g. poorly reimbursed) services and also because nurse practitioners' training emphasize prevention. Estimates suggest that a greater supply of non-physician clinicians is not associated with a greater likelihood of getting a flu shot, checking blood pressure or cholesterol, having a breast exam, or having a pap smear in the past 12 months. The final column examines whether respondents report being in very good or excellent health. The relationship between this measure of health and provider supply is positive, but very weak and insignificant.[31]

[28] Including fixed effects for one of 600 clinical conditions (or none) associated with the visit instead of the predicted likelihood the visit is primary care produces similar results.

[29] I also constructed 2SLS estimates separately by quintile of predicted likelihood of being made to a primary care provider. Even for visits that NPs and PAs would be expected to be the most substitutable for physician care, there is no evidence of price impacts of greater NP or PA supply. See Appendix B, Table B10.

[30] Extensive margin effects are very similar to those reported in Table 3 for total visits.

[31] In results not reported here, I also find that the coefficients on interactions between provider supply and NP and PA state practice indices are insignificant

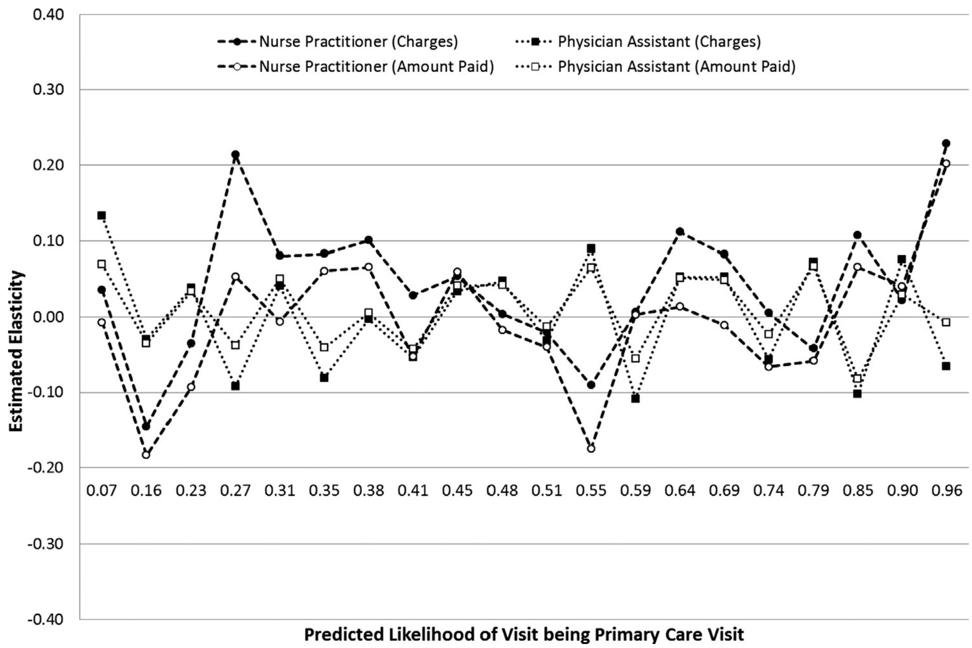

Fig. 3. Estimated elasticity of price with respect to change in provider supply, by likelihood of visit being primary care.

Table 7
OLS estimates of provider density and interaction with regulatory environment index on total office-based visit expenditure.

	Dependent variable = log(total amount paid)									
	All individuals		Medicare		Medicaid		Private		Uninsured	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
log(NP per population)	0.003	−0.287*	−0.006	−0.443*	0.052	−0.554	0.010	0.074	−0.004	−0.869*
	(0.026)	(0.148)	(0.046)	(0.261)	(0.092)	(0.371)	(0.033)	(0.213)	(0.055)	(0.441)
log(PA per population)	0.032	−0.085	0.015	−0.217	−0.035	−0.507***	0.047*	−0.013	0.186**	0.607
	(0.027)	(0.128)	(0.063)	(0.272)	(0.049)	(0.180)	(0.028)	(0.174)	(0.086)	(0.383)
log(NP per population) × NP index		0.393*		0.591		0.826		−0.087		1.188*
		(0.212)		(0.378)		(0.519)		(0.272)		(0.607)
log(PA per population) × PA index		0.160		0.316		0.648**		0.083		−0.580
		(0.167)		(0.342)		(0.277)		(0.221)		(0.558)
log(MD per population)	−0.069**	−0.068**	−0.037	−0.033	−0.082	−0.072	−0.059**	−0.057**	−0.208	−0.238
	(0.026)	(0.028)	(0.043)	(0.043)	(0.062)	(0.061)	(0.024)	(0.024)	(0.148)	(0.148)
Adjusted R-squared	0.173	0.173	0.096	0.096	0.196	0.196	0.149	0.149	0.108	0.108
Rounded N	171,300	171,300	30,300	30,300	41,100	41,100	108,700	108,700	14,000	14,000
F-test for provider supply coefficient = 0 when practice index = 1 (100%)										
Nurse practitioners (p-value)		0.140		0.265		0.143		0.848		0.085
Physician assistants (p-value)		0.129		0.307		0.180		0.220		0.891

Note: All specifications include year fixed effects, individual characteristics, county fixed effects, linear time trends for each state, and linear time trends by time-invariant county characteristics. Robust standard errors clustered by state in parentheses. Individual controls include male, age, age squared, dummies for four income categories, dummies for public, private, or no insurance, and dummies for three self-reported health categories. Time-invariant county characteristics that are interacted with time (linearly) include the fraction of persons in poverty (1989), infant mortality rate (1988), fraction of workforce in health (1990), fraction of workforce in manufacturing (1990), unemployment rate (1990), fraction white (1990), fraction with high school education (1990), fraction Hispanic (1990), and HMO penetration rate (1998).

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

6. Direct impact of regulation

This paper is primarily concerned with how the regulatory environment moderates the effect of increases in NP and PA supply on various outcomes. Though provider supply has a relatively weak association with utilization and access, I do find that provider supply is more positively correlated with utilization in states that permit NPs to be more substitutable for physicians. That is, there is some evidence that this form of occupational regulation weakly impacts the healthcare market by moderating the effects of provider supply. It is also possible that the regulatory environment has a direct impact on these same outcomes. The previous analysis controlled for the direct effect of states' regulatory environment (at a point in time) through the inclusion of county fixed effects. In order to quantify the direct impact of the regulatory environment while still controlling for cross-sectional differences between areas that may be correlated with

for all these outcomes. The direct and interactive effects are also small and insignificant for all insurance subgroups for the likelihood of having a usual source of care. Lastly, 2SLS estimates of these outcomes are all insignificant with mixed signs (some positive, some negative), though much less precise than the fixed effects estimates reported here.

Table 8
OLS Estimates of provider density and interaction with regulatory environment index on usual source of care, preventative outcomes, and health (linear probability model).

	Have usual source of care		Had the following in the previous 12 months						
			Flu shot	Blood pressure check	Cholesterol check	Pap smear (women 18+)	Breast exam (women 18+)	Average of 5 preventive outcomes	Health is very good or excellent
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
log(NP per population)	0.041**	0.007	−0.008	−0.010	0.009	0.018	0.020	0.000	0.008
	(0.018)	(0.014)	(0.016)	(0.009)	(0.009)	(0.012)	(0.012)	(0.008)	(0.020)
log(PA per population)	0.015*	0.009	0.013	0.011	0.015	0.002	0.001	0.006	0.022
	(0.009)	(0.009)	(0.010)	(0.010)	(0.015)	(0.018)	(0.019)	(0.011)	(0.014)
log(MD per population)		0.032	0.006	0.011	0.004	−0.010	0.012	0.010	0.008
		(0.022)	(0.013)	(0.017)	(0.015)	(0.020)	(0.039)	(0.013)	(0.010)
Controls	None	Full	Full	Full	Full	Full	Full	Full	Full
N (rounded)	265,500	264,200	172,600	171,400	166,000	90,500	90,800	175,300	281,500
Adjusted *R*-squared	0.006	0.191	0.209	0.159	0.230	0.089	0.072	0.230	0.110

Note: All specifications include year fixed effects, individual characteristics, county fixed effects, linear time trends for each state, and linear time trends by time-invariant county characteristics. Robust standard errors clustered by state in parentheses. Individual controls include male, age, age squared, dummies for four income categories, dummies for race/ethnicity, dummies for public, private, or no insurance, and dummies for three self-reported health categories (except (9)). Time-invariant county characteristics that are interacted with time (linearly) include the fraction of persons in poverty (1989), infant mortality rate (1988), fraction of workforce in health (1990), fraction of workforce in manufacturing (1990), unemployment rate (1990), fraction white (1990), fraction with high school education (1990), fraction Hispanic (1990), population density (1992), and HMO penetration rate (1998).

* $p < 0.1$.
** $p < 0.05$.
** $p < 0.01$.

regulation and health care outcomes, I exploit changes in one component of regulation – prescriptive authority – within states over time.

Table 9 presents estimates of models that regress health care utilization, access, prices, and expenditure on time-varying indicators for whether NPs and PAs are permitted to write prescriptions for controlled substances, controlling for state fixed effects and individual characteristics. Since information about prescriptive authority is available for all states and years, these models use nearly the entire sample of individuals in the MEPS. The even rows additionally control separately for the log of number of NPs, PAs, and primary care physicians. Changes in provider supply may be part of the causal effect of changes in practice environment (Kalist and Spurr, 2004), so these specifications isolate any effects that operate through other channels (and could reduce bias if the correlation between provider supply and laws is spurious). When examining price of individual visits, these models also include controls for all procedures and treatments provided during the visit and indicators for one of 600 conditions associated with the visit (including none).

I find that granting NPs the ability to prescribe has a very modest impact on the intensive utilization margin: NP prescriptive authority is associated with 3% more visits conditional on having at least one. For PAs, the opposite is true: granting PAs the ability to prescribe is actually associated with 5% fewer visits conditional on having at least one, though this result is sensitive to whether supply is controlled for. Expansive NP prescriptive authority is positively associated with increases in the likelihood of having at least one visit, but this is statistically insignificant. NP prescriptive authority is modestly associated with greater visit charges, though this does not translate into greater prices paid. PA prescriptive authority is not associated with changes in visit prices by either measure. Thus, permitting NPs and PAs to do more also does not appear to create price pressure on office-based visits. Given the minimal price impact of the regulation, the patterns for expenditure follow those for utilization pretty closely. There is a positive, though modest, association between NP prescriptive authority and expenditure (both on the extensive and intensive margin). Together these results suggest that changes in NP and PA prescriptive authority – one key component of the overall regulatory environment – have only modest impact on the market for health care services.

7. Discussion and conclusion

This paper is the first to assess the output market effects of the enormous increase in supply of nurse practitioners and physician assistants, the interaction of this growth with occupational restrictions, and an expansion of these providers' scope-of-practice. My findings suggest that, across all areas, greater supply of NPs and PAs has had minimal impact on utilization, access, preventative health services, and prices. However, primary care utilization is moderately responsive to NP provider supply in areas that grant non-physician clinicians the greatest autonomy to practice independently. I find no evidence that increases in provider supply decreases prices, even for visits most likely to be affected by NPs and PAs: primary care visits in states with a favorable regulatory environment for NP and PAs. I also find that expansions in prescriptive authority for NPs are associated with modest increases in utilization and expenditure, though no consistent pattern emerges for expansions to PA prescriptive authority. Neither change appears to consistently reduce visit prices.

The results of this paper suggest that even considerable changes in the nature of who is providing health care can result in only modest changes in important outcomes such as access, overall utilization, prices, and expenditure. There is also suggestive evidence that occupational regulation may play some role in input substitutability and thus moderate the relationship between input availability and the aggregate supply of primary health care. An important implication is that licensing laws – which determine the division of labor and thus how labor inputs translate to services – may be as important as policies that expand supply directly. My results call for a reconsideration of the nature of federal healthcare workforce efforts, which have mostly focused on supply expansion rather than altering how existing labor is used.

Why a greater number of providers have not significantly altered the healthcare market remains an unanswered question. One possibility is that existing providers – physicians, NPs, and PAs – reduce their work hours in response to provider expansion, limiting the effective supply increase to less than the number of

Table 9
OLS Estimates of NP and PA prescriptive authority on various outcomes.

		Coefficient on		Control for supply	Level of fixed effects	*N* (rounded)
		NP prescribe	PA prescribe			
Utilization (individuals)						
Office-based provider visit > 0	(1)	0.005	0.004	N	State	400,500
		(0.006)	(0.006)			
	(2)	0.013*	0.001	Y	County	282,800
		(0.007)	(0.009)			
log(office-based provider visits)	(3)	0.019	−0.009	N	State	272,600
		(0.013)	(0.013)			
	(4)	0.031**	−0.053***	Y	County	189,400
		(0.013)	(0.014)			
Have usual source of care	(5)	−0.002	0.002	N	State	371,100
		(0.006)	(0.005)			
	(6)	−0.002	−0.010	Y	County	265,500
		(0.007)	(0.007)			
Visit prices (visits)						
log amount paid (check-up visits)	(7)	0.014	0.005	N	State	313,100
		(0.011)	(0.010)			
	(8)	−0.002	0.004	Y	County	218,300
		(0.013)	(0.018)			
log amount paid (diagnose/treat visits)	(9)	0.017	−0.007	N	State	573,100
		(0.015)	(0.013)			
	(10)	−0.004	−0.005	Y	County	395,100
		(0.013)	(0.011)			
log total charges (check-up visits)	(11)	0.035***	0.010	N	State	321,800
		(0.013)	(0.011)			
	(12)	0.029*	−0.015	Y	County	224,300
		(0.016)	(0.018)			
log total charges (diagnose/treat visits)	(13)	0.035*	−0.005	N	State	590,300
		(0.019)	(0.016)			
	(14)	0.005	−0.014	Y	County	406,900
		(0.020)	(0.012)			
Expenditures (individuals)						
Office-based expenditure > 0	(15)	0.007	0.004	N	State	400,500
		(0.006)	(0.005)			
	(16)	0.015**	0.000	Y	County	282,800
		(0.007)	(0.008)			
log(office-based expenditure)	(17)	0.043**	−0.010	N	State	267,300
		(0.021)	(0.017)			
	(18)	0.027*	−0.065***	Y	County	185,700
		(0.015)	(0.014)			

Note: Each row is a separate regression of the outcome on indicators for whether NPs and PAs were permitted to prescribe controlled substances in that state-year, controlling for male, age, age squared, dummies for four income categories, dummies for public, private, or no insurance, dummies for three self-reported health categories, and either state or county fixed effects. Even rows additionally control separately for the log of number of NPs, PAs, and primary care physicians. Models for visit-level prices also include indicators for all procedures and treatments provided on the visit and indicators for one of 600 conditions associated with the visit. Robust standard errors clustered by state in parentheses.

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

providers would suggest. There is evidence that physicians reduce the number of hours spent on patient care in response to public health insurance expansions (Garthwaite, 2012), so it is reasonable to expect a similar response to a greater number of providers. Understanding how changes in provider supply and regulation alter work hours and earnings of existing providers is an important topic to be explored, albeit with different data.

A second possibility is that current reimbursement policies – which create incentives for physician involvement in services provided by NPs and PAs in order to bill at a higher rate – limit efficient substitution between providers, preventing cost (and price) reductions and utilization increases from materializing. While I do not observe a differential response in states with greater reimbursement parity between physicians, NPs, and PAs, the test is admittedly weak. Related, a lack of direct billing by lower-cost NPs and PAs may combine with rigid insurance payment schemes (particularly by the Medicare and Medicaid programs) to make prices unresponsive to provider supply. Minimal price effects are seen when looking at visit charges (which are not directly dictated by insurance plans) and when excluding people with public insurance, but reimbursement-driven rigidity in price-setting is one plausible explanation for minimal price response.

A third possibility is that the number of providers may be less important than the organizational structure in which their services are delivered. Community health clinics (CHCs) have been shown to have substantial effects on healthcare access and health outcomes (Bailey and Goodman-Bacon, 2012), but isolated provider supply expansions absent the outreach and other services provided by CHCs may be less effective. A related possibility is that physicians and non-physicians still have very different views about the role of the latter in health care delivery, limiting gains from provider supply despite recent legislative changes. Donelan et al. (2013) find that MDs and NPs still possess very different views on hospital admitting privileges, equal pay, and quality of care provided by NPs and that 8 out of 10 NPs work in a practice with an MD. Scope-of-practice laws expand the frontier of what NPs and PAs can do, but do not require that practices take full advantage of this frontier. Finally, it is possible that patients' interactions with the healthcare system have been altered in ways that that are not easily captured by overall measures of utilization and prices. For instance, greater NP and PA supply may facilitate the provision of team-based care and task specialization that improves the quality of and patients' satisfaction with care without altering the overarching patterns of utilization. Changes in task specialization are one explanation proposed for the modest economic impacts observed for immigration (Peri and Sparber, 2009). All of these are fruitful areas for further exploration, with important implications for the design and implementation of healthcare workforce policy.

Appendix A. Data appendix

Nurse practitioner and physician assistant supply data

In collaboration with Deborah Sampson from Boston College School of Nursing, I assembled a new dataset containing the number of licensed nurse practitioners, physician assistants, and physicians (by specialty) at the county level annually for the years 1990–2008. This data was constructed from individual licensing records obtained from state Boards of Nursing, Medicine, Health, Commerce and other relevant state licensing agencies. The typical license record includes the provider's name, mailing address (typically home), license number, license type, issue date, expiration date, and status. We aggregated these individual records to construct total counts of the number of active PA and NP licenses in each county in each year for as many years as possible.[32] Data on the number of physicians (by specialty) was obtained from the Area Resource File.

Our aggregation currently makes three main assumptions. First, only licensees' current (or most recent, if the license is expired) address is kept on file, so we have applied this address to all years of license activity.[33] Second, licenses with out-of-state addresses are assumed not to be actively practicing in the state. Many providers are licensed in multiple states, though primarily practice in only one. Since address information was less complete for out-of-state licenses and there is more uncertainty about county of practice, we do not include out-of-state licenses in our county counts. This likely understates the number of providers, particularly for border counties and small states. This undercounting will not bias our estimates if it remains fixed over time since our analysis includes county fixed effects. Lastly, our measures reflect active licenses not necessarily actively practicing practitioners. It is possible that providers will maintain an active license even if they are not actively practicing. If this pattern changes over time, our trends may over or understate the true trends in provider supply.

We successfully collected at least some historical license data on both NPs and PAs from 35 states. We found that many states did not retain or would not provide records on inactive/expired licenses, or these licenses were missing key fields (e.g. address or issue date). Our sample is geographically diverse, with representation from most parts of the country. Our weakest coverage is in the upper mountain/plains states and the lower Mississippi River states. The years for which data is available varies across states, so our county panel is unbalanced: NP and PA supply data is available for 23 states covering 52% of the U.S. population in 1996, but increases to 35 states covering 80% in 2008.

Comparing our estimates of NP and PA supply to other sources is difficult because there are no definitive sources for NP supply nationally or subnational. The implied NP to population ratio for our sample in 2008 (40 NPs per 100,000 people) is just slightly less than that implied by the National Survey Sample of Registered Nurses in 2008. In that survey (which is used to construct Fig. 1), there are 158,348 nurses who have received NP preparation, or 52 per 100,000 people in the U.S in 2008. Of these, only 141,286 are employed in nursing (46 per 100,000 people) and 131,678 (43 per 100,000 people) are employed in nursing and have either a national certification or recognition as an NP from a State Board of Nursing (which is what they would need to be included in our sample). The implied PA to population ratio for our sample in 2007 (22 PAs per 100,000 people) is similar to that implied by the number of PAs actively practicing in the U.S. (68,000 or 22 per 100,000 people) as estimated by AAPA and reported by Morgan and Hooker (2010). So we interpret our NP and PA supply estimates to be comparable to national figures, but with the benefit of providing subnational estimates over time.

NP and PA practice index

An overall index of the professional practice environment for NPs and PAs in each state in 2000 was obtained from the Health Services Resource Administration (HRSA, 2004). This index ranks states separately for NPs and PAs along three dimensions: (1) legal standing and requirement for physician oversight/collaboration on diagnosis and treatment; (2) prescriptive authority; and (3) reimbursement policies. These three dimensions are then combined into a single index for each profession with a possible range from zero to one. For each of the three indices, the legislation and policies of each state are scored along many specific criteria. For instance, the "legal" index (35% of total for NPs, 35% for PAs) includes components related to whether autonomous practice is possible, the required type of practice agreements with physicians, rules regulating review by physicians, and board oversight, among others. While the specific components and weights differ between NPs and PAs, collectively they all measure the extent of autonomy the two professions have from physician oversight and control. The prescriptive authority index (30% for NPs, 40% for PAs) includes measures of the type of drugs NPs and PAs can prescribe, the requirements for physician oversight, whether the NP or PA uses their own DEA number, and whether they sign the prescription or can sign for samples, among others. The reimbursement index (35% for NPs, 25% for PAs) includes points based on Medicaid reimbursement rates and requirements for private insurers to reimburse for NP or PA services. A detailed listing of the score of each state along every specific criteria can be found in HRSA (2004).

State laws on prescriptive authority

We also constructed indicators for whether nurse practitioners and physician assistants are permitted to write prescriptions (any, some controlled substances, levels V through II controlled substances) in a given state and year. Prescriptive authority was coded from various issues of the journal *Nurse Practitioner* and from *Abridged State Regulation of Physician Assistant Practice*, distributed by the American Academy of Physician Assistants.

Data on nursing and PA schools

Data on all current and closed PA schools and programs, including their location, opening and closing dates was obtained from the

[32] For several states we obtained number of active licensed providers by county over time directly from annual summary reports published by the states, rather than individual license records.

[33] For instance, if a licensed NP lived in Washtenaw County (MI) from 1990 to 2002 and Wayne County (MI) from 2003 to present, they would be counted in the total for Wayne County for the entire 1990-present time period. This no-mobility assumption is more problematic for years further back in time or far from the license expiration date.

Physician Assistant Education Association and the Accreditation Review Committee on Education for the Physician Assistant (ARC-PA). Information on the location of basic RN training programs in 1963, by type (diploma, Associates, Bachelors) was obtained from State Approved Schools of Professional Nursing, 1963 (National League for Nursing).

Predicting likelihood of primary care

For each visit in the MEPS office-based visits files I construct a measure of the predicted likelihood of seeing a primary care provider, given observed individual and visit-level characteristics. Specifically, I estimate the following equation using a probit model using data from 2002 to 2008:

$$PrimaryCare_{imjt} = VisitCategory_{imjt} + Condition_{imjt} + \beta_x X_{ijt} + \varepsilon_{imjt}$$

The outcome, *PrimaryCare*, is an indicator for whether the visit was to a family practice, general practice, or internal medicine physician, pediatrician, nurse or nurse practitioner, or physician assistant. *VisitCategory* is a set of dummy variables for each of five types of visits: general check-up or well-child visit, diagnosis or treatment, emergency, post-op follow-up visit, or shots (the baseline category). *Condition* is a set of 600 dummy variables for the condition associated with the visit (including none). Individual factors such as income category, age, education, and health risks are included in X_{ijt}. Estimates for this model are presented in the third column of Table B4 in Appendix B. The model is then used to predict the likelihood that each individual visit (in all years) would be to a primary care provider based on these characteristics. Importantly, this predicted value does not depend on provider supply. For instance, all "check-ups" not associated with any specific condition by 40 year old men with the same income and insurance will have the same predicted likelihood of being primary care, regardless of the NP and PA supply in their county in the year of the visit. The most common high likelihood visits includes flu shots, no condition checkup, and sore throat.

Appendix B. Additional tables

Tables B1–B10.

Table B1
Summary statistics, person sample.

	Analysis sample		Full dataset	
	Mean	SD	Mean	SD
Provider supply and regulation				
MD per population (×100,000)	89.619	44.211	88.879	46.38
NP per population (×100,000)	30.166	20.629	N/A	
PA per population (×100,000)	17.082	10.979	N/A	
NP practice index (2000)	0.744	0.134	0.738	0.129
PA practice index (2000)	0.772	0.107	0.737	0.141
NPs can prescribe controlled substances in state × year	0.790	0.408	0.724	0.447
PAs can prescribe controlled substances in state × year	0.733	0.442	0.674	0.469
Individual characteristics				
Male	0.477	0.499	0.477	0.499
Age	33.682	22.261	34.038	22.358
Income category 1 (lowest)	0.258	0.437	0.253	0.435
Income category 2	0.171	0.376	0.167	0.373
Income category 3	0.294	0.456	0.297	0.457
Income category 4 (highest)	0.277	0.448	0.283	0.45
Have private insurance	0.587	0.492	0.603	0.489
Have public insurance	0.246	0.431	0.238	0.426
Have no insurance	0.167	0.373	0.158	0.365
Health very good	0.603	0.489	0.599	0.49
Health good	0.247	0.431	0.245	0.43
Health bad	0.117	0.321	0.121	0.326
Hispanic	0.316	0.465	0.258	0.437
Non-Hispanic white	0.48	0.500	0.530	0.499
Non-Hispanic black	0.145	0.352	0.158	0.365
Other race	0.059	0.235	0.054	0.227
Health very good	0.603	0.489	0.599	0.49
Health good	0.247	0.431	0.245	0.43
Health bad	0.117	0.321	0.121	0.326
Hispanic	0.316	0.465	0.258	0.437
Non-Hispanic white	0.48	0.500	0.530	0.499
Non-Hispanic black	0.145	0.352	0.158	0.365
Other race	0.059	0.235	0.054	0.227
Health care utilization and expenditure				
Office-based visits > 0	0.623	0.485	0.631	0.483
Number of office-based visits	2.781	5.517	2.831	5.479
Primary care office-based visits > 0	0.572	0.495	0.575	0.494
Number of primary care office-based visits	1.456	2.702	1.47	2.674
Charges for primary care office-based visits > 0	0.571	0.495	0.573	0.495
Total charges for primary care office-based visits	274.24	1035.25	268.60	972.92
Amount paid for primary care office-based visits > 0	0.561	0.496	0.563	0.496
Total amount paid for primary care office-based visits	152.84	365.66	151.34	356.82
Have usual source of care	0.780	0.414	0.788	0.409
Flu shot in last 12 months	0.272	0.445	0.276	0.447
Blood pressure check in last 12 months	0.773	0.419	0.782	0.413
Pap smear in last 12 months	0.569	0.495	0.568	0.495
Breast exam in last 12 months	0.615	0.487	0.617	0.486

Table B1 (*Continued*)

	Analysis sample		Full dataset	
	Mean	SD	Mean	SD
Cholesterol check in last 12 months	0.526	0.499	0.523	0.499
County characteristics				
% in poverty (1989)	13.819	7.07	13.989	7.339
Median income (1989)	31,167	7830	30,551	8173
Infant mortality rate (1989)	9.98	2.364	10.165	2.449
% workforce in health industry (1990)	8.065	2.06	8.152	2.093
% workforce in manufacturing (1990)	16.971	7.351	17.586	7.662
Unemployment rate	5.793	2.88	5.864	2.784
% white	77.934	14.416	79.111	15.108
% education HS+	74.525	9.218	74.147	9.518
% Hispanic ethnicity	15.194	17.574	12.266	16.542
HMO penetration (1998)	0.307	0.171	0.285	0.175
Population density (1992)	2082	6060	1893	5488
# PA schools in 1975/100,000 population	0.012	0.045	0.015	0.09
# BA RN schools in 1963/100,000 population	0.047	0.126	0.05	0.133
# AA RN schools in 1963/100,000 population	0.032	0.094	0.027	0.107
# Diploma RN schools in 1963/100,000 population	0.268	0.472	0.286	0.503
Sample size (rounded to 100)	293,100		404,400	

Note: Analysis sample includes all individuals living in counties for which physician, nurse practitioner, and physician assistant supply data is available in their survey year. Provider supply measures are calculated at the county level. Physician supply only includes non-federal office-based physicians in family/general practice, general pediatrics, general internal medicine, and general ob/gyn.

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

Table B2
Summary statistics, office-based visit sample.

	Analysis sample		Full dataset	
	Mean	SD	Mean	SD
No condition associated with visit	0.20	0.40	0.20	0.40
Predicted likelihood that visit is primary care	0.51	0.10	0.51	0.10
Visit category = checkup or well-child	0.29	0.46	0.29	0.45
Visit category = diagnosis/treatment	0.54	0.50	0.54	0.50
Visit category = emergency	0.01	0.09	0.01	0.09
Visit category = followup	0.12	0.33	0.12	0.33
Visit category = shots	0.04	0.20	0.04	0.20
See doctor	0.92	0.27	0.92	0.27
Provider was RN/NP	0.07	0.25	0.07	0.26
Provider was PA	0.01	0.11	0.01	0.10
Chemotherapy	0.01	0.07	0.01	0.07
Drug treatment	0.00	0.06	0.00	0.06
IV Therapy	0.00	0.05	0.00	0.05
Kidney dialysis	0.02	0.12	0.02	0.12
Occupational therapy	0.00	0.04	0.00	0.04
Physical therapy	0.03	0.16	0.03	0.16
Psycho therapy	0.01	0.11	0.01	0.11
Radiation therapy	0.00	0.06	0.00	0.07
Received shot	0.02	0.13	0.02	0.14
Speech therapy	0.00	0.02	0.00	0.02
Anesthesia	0.00	0.07	0.00	0.07
EEG	0.00	0.04	0.00	0.04
EKG	0.02	0.15	0.02	0.15
Lab tests	0.25	0.44	0.25	0.44
Mammogram	0.01	0.08	0.01	0.07
MRI	0.01	0.09	0.01	0.09
Other services	0.12	0.33	0.12	0.32
Received vaccine	0.03	0.17	0.03	0.17
Sonogram	0.01	0.12	0.01	0.11
X-rays	0.06	0.23	0.06	0.23
Total amount paid for visit (all sources)	118.76	152.44	116.79	151.52
Total charges for visit	218.84	356.19	213.16	351.57
Sample size (rounded to 100)	803,200		1,114,900	

Note: Only office-based visits for which provider was doctor, registered nurse or nurse practitioner, or physician assistant are included. Also excludes visits categorized as mental health, maternity, eye exam, laser eye surgery, and other. Analysis sample further restricted to visits by individuals living in counties for which physician, nurse practitioner, and physician assistant supply data is available in their survey year.

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

Table B3
Summary statistics by year, person sample.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Provider supply and regulation													
MD per population (×100,000)	81.04	92.08	89.383	87.693	87.774	89.922	88.167	90.479	91.52	90.322	89.127	90.298	92.137
NP per population (×100,000)	17.16	22.578	22.596	25.276	26.674	27.791	28.812	29.982	31.68	32.965	34.838	36.855	39.643
PA per population (×100,000)	9.326	11.979	12.2	12.863	13.74	14.88	15.916	17.074	18.247	19.121	20.459	21.957	23.909
NPs can prescribe controlled substances in state × year	0.328	0.760	0.624	0.629	0.699	0.747	0.756	0.747	0.894	0.901	0.902	0.936	0.928
PAs can prescribe controlled substances in state × year	0.638	0.488	0.678	0.655	0.617	0.718	0.71	0.712	0.749	0.749	0.744	0.936	0.928
Individual characteristics													
Male	0.476	0.473	0.478	0.479	0.478	0.48	0.478	0.475	0.474	0.475	0.475	0.48	0.479
Age	33.16	33.691	33.103	33.352	33.581	33.972	33.567	33.013	33.388	33.606	34.243	34.683	33.912
Income category 1 (lowest)	0.257	0.254	0.245	0.222	0.21	0.214	0.239	0.281	0.289	0.284	0.283	0.257	0.277
Income category 2	0.162	0.159	0.167	0.158	0.166	0.17	0.173	0.177	0.176	0.176	0.172	0.171	0.173
Income category 3	0.294	0.308	0.308	0.316	0.312	0.317	0.307	0.285	0.274	0.277	0.276	0.292	0.288
Income category 4 (highest)	0.286	0.279	0.28	0.304	0.312	0.299	0.282	0.257	0.261	0.263	0.269	0.28	0.262
Have private insurance	0.647	0.643	0.606	0.655	0.646	0.64	0.604	0.554	0.555	0.545	0.541	0.55	0.545
Have public insurance	0.181	0.205	0.22	0.191	0.194	0.2	0.233	0.273	0.273	0.283	0.29	0.279	0.278
Have no insurance	0.172	0.152	0.174	0.155	0.159	0.16	0.163	0.173	0.172	0.172	0.169	0.171	0.176
Health very good	0.614	0.624	0.617	0.633	0.624	0.619	0.601	0.591	0.587	0.578	0.578	0.596	0.617
Health good	0.233	0.232	0.236	0.238	0.245	0.238	0.255	0.253	0.255	0.26	0.258	0.25	0.231
Health bad	0.118	0.115	0.119	0.099	0.098	0.112	0.113	0.122	0.12	0.125	0.128	0.12	0.111
Hispanic	0.303	0.264	0.337	0.337	0.325	0.3	0.309	0.33	0.325	0.326	0.317	0.302	0.328
Non-Hispanic white	0.55	0.562	0.5	0.504	0.502	0.527	0.494	0.462	0.468	0.455	0.453	0.458	0.394
Non-Hispanic black	0.104	0.132	0.127	0.123	0.138	0.133	0.138	0.143	0.141	0.152	0.165	0.163	0.185
Other race	0.044	0.041	0.036	0.036	0.035	0.04	0.059	0.065	0.066	0.066	0.065	0.077	0.093
Health care utilization and expenditure													
Office-based visits > 0	0.622	0.624	0.611	0.613	0.621	0.637	0.635	0.63	0.621	0.62	0.624	0.62	0.612
Number of office-based visits	2.797	2.841	2.726	2.603	2.724	2.882	2.892	2.828	2.845	2.8	2.783	2.756	2.58
Primary care office-based visits > 0	0.571	0.571	0.56	0.557	0.564	0.584	0.584	0.58	0.572	0.573	0.574	0.57	0.563
Number of primary care office-based visits	1.499	1.509	1.445	1.373	1.413	1.514	1.508	1.495	1.469	1.461	1.439	1.41	1.376
Non-primary care office-based visits > 0	0.411	0.411	0.397	0.397	0.414	0.426	0.419	0.408	0.407	0.401	0.412	0.409	0.387
Number of non-primary care office-based visits	1.298	1.332	1.281	1.23	1.311	1.368	1.385	1.334	1.375	1.339	1.344	1.346	1.204
Charges for primary care office-based visits > 0	0.567	0.57	0.558	0.556	0.563	0.583	0.583	0.579	0.571	0.572	0.572	0.568	0.561
Total charges for primary care office-based visits	198.36	205.25	211.37	206.49	228.73	264.60	284.13	276.66	302.45	302.76	310.70	316.76	325.36
Amount paid for primary care office-based visits > 0	0.559	0.557	0.547	0.548	0.55	0.569	0.573	0.569	0.563	0.562	0.563	0.559	0.553
Total amount paid for primary care office-based visits	131.78	129.27	129.39	125.50	135.85	156.52	165.19	159.87	162.62	162.11	162.08	160.10	160.27
Have usual source of care	0.790	0.810	0.787	0.783	0.794	0.797	0.782	0.771	0.777	0.771	0.781	0.773	0.763
Flu shot in last 12 months	0.247	0.262	0.258	N/A	0.252	0.263	0.264	0.292	0.206	0.265	0.293	0.312	0.323
Blood pressure check in last 12 months	0.748	0.772	0.764	N/A	0.78	0.781	0.777	0.772	0.777	0.771	0.774	0.777	0.765
Pap smear in last 12 months	0.571	0.605	0.599	N/A	0.611	0.599	0.587	0.567	0.559	0.539	0.542	0.546	0.553
Breast exam in last 12 months	0.602	0.635	0.636	N/A	0.653	0.644	0.631	0.611	0.604	0.592	0.597	0.602	0.607
Cholesterol check in last 12 months	0.453	0.494	0.497	N/A	0.524	0.516	0.514	0.517	0.52	0.532	0.545	0.568	0.563
Sample size (rounded to 100)	12,300	18,400	15,700	16,200	17,000	24,700	30,000	26,300	27,000	26,900	27,400	24,800	26,500

Note: Analysis sample includes all individuals living in counties for which physician, nurse practitioner, and physician assistant supply data is available in their survey year. Provider supply measures are calculated at the county level. Physician supply only includes non-federal office-based physicians in family/general practice, general pediatrics, general internal medicine, and general ob/gyn.

* $p < 0.1$.

** $p < 0.05$.

*** $p < 0.01$.

Table B4
Determinants of whether a visit was to a primary care provider (Probit model).

	Dept variable: provider was primary care provider		
	(1)	(2)	(3)
Broad visit category (omitted = "shots")			
Check-up	−0.33993***	−0.31285***	−0.32029***
	(0.004)	(0.004)	(0.004)
Diagnose or treat	−0.42432***	−0.38006***	−0.38165***
	(0.003)	(0.004)	(0.004)
Emergency	−0.27555***	−0.26050***	−0.20946***
	(0.007)	(0.007)	(0.008)
Follow-up	−0.47956***	−0.43636***	−0.41842***
	(0.002)	(0.003)	(0.003)
Individual characteristic			
Male		0.03145***	0.03117***
		(0.001)	(0.001)
Age		−0.01596***	−0.01476***
		(0.000)	(0.000)
Age squared		0.00012***	0.00011***
		0.000	0.000
Poverty category 1		0.09324***	0.10206***
		(0.002)	(0.002)
Poverty category 2		0.09016***	0.09674***
		(0.002)	(0.002)
Poverty category 3		0.06067***	0.06160***
		(0.002)	(0.002)
Private insurance		−0.09580***	−0.09402***
		(0.003)	(0.003)
Public insurance		−0.07239***	−0.06270***
		(0.003)	(0.003)
Health very good		0.01898***	0.02247***
		(0.002)	(0.002)
Health good		0.00305*	0.0022
		(0.002)	(0.002)
Condition associated with visit			
No condition		0.05408***	0.20927
		(0.002)	(0.135)
Condition fixed effects	No	No	Yes
Observations (rounded)	672,200	668,400	666,800
Psuedo-R^2	0.029	0.107	0.198

Note: All specifications include year fixed effects. Robust standard errors clustered by state in parentheses. Sample includes only observations from 2002 to 2008, for which specialty of physician seen is available. Primary care provider includes general and family practice physician, internal medicine physician, pediatrician, nurse or nurse practitioner, and physician assistants. Reported coefficients are marginal effects.

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

Table B5
Estimates of provider density on number of office-based visits, alternative models.

	Dependent variable: number of office-based provider visits								
	OLS			Poisson			Negative binomial		
	$X > 0$ (1)	$\ln X$ (2)	$E[X]$ (3)	$X > 0$ (4)	$\ln X$ (5)	$E[X]$ (6)	$X > 0$ (7)	$\ln X$ (8)	$E[X]$ (9)
log(NP per population)	−0.003	0.001	−0.130	−0.008	−0.036	−0.100	−0.009	−0.050	−0.143
	(0.011)	(0.016)	(0.095)	(0.007)	(0.032)	(0.090)	(0.008)	(0.040)	(0.115)
log(PA per population)	0.008	0.031	0.152	0.012	0.054	0.149	0.009	0.048	0.138
	(0.010)	(0.023)	(0.107)	(0.008)	(0.037)	(0.102)	(0.007)	(0.036)	(0.105)
N (rounded)	281,500	175,100	281,500		281,500			281,500	
Adjusted *R*-squared	0.163	0.201	0.142						
−Log likelihood					−835,663			−559,007	

Note: Robust standard errors clustered by state in parentheses. All models include the full controls described in previous tables. Columns (1)–(3) represent three different regressions. Column (3) uses total number of office visits (including zero) as the dependent variable. Columns (4)–(6) depict different marginal effects for a single Poisson count model and columns (7)–(9) represent different marginal effects for a single negative binomial count model. No point estimates are significantly different from zero at conventional levels.

Table B6
OLS Estimates of provider density on number of office-based visits, alternative controls.

	Dept variable: have at least one office-based visit in year				Dept variable: log(number of office-based visits in year)				Dept variable: have usual source of care			
	No controls	Individual controls, county FE	Individual controls, county FE, log(MD)	Full controls	No controls	Individual controls, county FE	Individual controls, county FE, log(MD)	Full controls	No controls	Individual controls, county FE	Individual controls, county FE, log(MD)	Full controls
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A. NP and PA supply combined												
log(NP + PA per population)	0.047***	0.005	0.005	0.006	0.042**	0.019	0.021	0.022	0.047**	−0.009	−0.007	−0.010
	(0.015)	(0.013)	(0.012)	(0.011)	(0.017)	(0.025)	(0.026)	(0.019)	(0.020)	(0.010)	(0.010)	(0.009)
log(MD per population)			0.0029	0.016			−0.0182	−0.023			0.0128	0.026
			(0.022)	(0.019)			(0.013)	(0.016)			(0.022)	(0.021)
N (rounded)	291,000	291,000	290,700	289,200	181,400	181,400	181,100	180,100	273,200	273,200	272,900	271,500
Adjusted *R*-squared	0.003	0.159	0.159	0.159	0.001	0.195	0.195	0.195	0.004	0.189	0.189	0.190
Panel B. NP and PA supply disaggregated												
log(NP per population)	0.032**	0.003	0.003	−0.003	0.031	0.001	−0.001	0.001	0.041**	0.004	0.006	0.007
	(0.014)	(0.013)	(0.012)	(0.011)	(0.019)	(0.018)	(0.019)	(0.016)	(0.018)	(0.010)	(0.011)	(0.014)
log(PA per population)	0.023	0.003	0.003	0.008	0.021	0.025	0.026	0.031	0.015*	0.003	0.002	0.009
	(0.015)	(0.012)	(0.011)	(0.010)	(0.020)	(0.023)	(0.023)	(0.023)	(0.009)	(0.010)	(0.009)	(0.009)
log(MD per population)			0.0002	0.013			−0.027*	−0.035**			0.019	0.032
			(0.022)	(0.020)			(0.014)	(0.017)			(0.023)	(0.022)
N (rounded)	282,800	282,800	282,800	281,500	176,000	176,000	176,000	175,100	265,500	265,500	265,500	264,200
Adjusted *R*-squared	0.003	0.159	0.159	0.160	0.001	0.195	0.195	0.195	0.006	0.190	0.190	0.191

Note: Robust standard errors clustered by state in parentheses. Specification (1) includes year fixed effects only. Individual controls include male, age, age squared, dummies for race/ethnicity, dummies for four income categories, dummies for public, private, or no insurance, and dummies for three self-reported health categories. "Full controls" additionally includes state × time linear trends and time-invariant county characteristics interacted with linear time trends. Time-invariant county characteristics that are interacted with time (linearly) include the fraction of persons in poverty (1989), infant mortality rate (1988), fraction of workforce in health (1990), fraction of workforce in manufacturing (1990), unemployment rate (1990), fraction white (1990), fraction with high school education (1990), fraction Hispanic (1990), population density (1992), and HMO penetration rate (1998).

* $p < 0.1$.

** $p < 0.05$.

*** $p < 0.01$.

Table B7
Relationship between historical educational infrastructure and provider density (first stage).

	Individual-level regressions						Visit-level regressions					
	log(NP per population)			log(PA per population)			log(NP per population)			log(PA per population)		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
# BA RN schools in 1963/100,000 population	0.627***	0.355**	0.362**	0.081	−0.135	−0.146	0.693***	0.364**	0.377**	0.127	−0.106	−0.117
	(0.211)	(0.145)	(0.145)	(0.207)	(0.198)	(0.200)	(0.209)	(0.165)	(0.163)	(0.233)	(0.226)	(0.229)
# PA schools in 1975/100,000 population	0.384	−0.072	−0.083	1.242***	0.976***	0.967***	0.266	−0.167	−0.176	1.294***	1.037***	1.021***
	(0.342)	(0.276)	(0.277)	(0.367)	(0.322)	(0.323)	(0.341)	(0.290)	(0.288)	(0.425)	(0.392)	(0.393)
# AA RN schools in 1963/100,000 population			−0.294**			0.016			−0.287*			−0.044
			(0.140)			(0.173)			(0.147)			(0.186)
Diploma RN schools in 1963/100,000 population			−0.038			0.034			−0.050			0.027
			(0.046)			(0.050)			(0.042)			(0.049)
log(MD per population)		0.489***	0.500***		0.350***	0.341***		0.479***	0.493***		0.350***	0.344***
		(0.065)	(0.065)		(0.066)	(0.067)		(0.066)	(0.066)		(0.070)	(0.071)
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Predicted likelihood visit is primary care	N/A	N/A	N/A	N/A	N/A	N/A	Yes	Yes	Yes	Yes	Yes	Yes
Procedure dummies	N/A	N/A	N/A	N/A	N/A	N/A	Yes	Yes	Yes	Yes	Yes	Yes
F-test for excluded instrument	8.839	5.993	6.265	11.45	9.206	8.95	10.94	4.87	5.329	9.28	7.00	6.74
Adjusted *R*-squared	0.692	0.742	0.743	0.632	0.661	0.662	0.704	0.750	0.752	0.631	0.661	0.661
Rounded *N*	286,100	286,100	286,100	286,100	286,100	286,100	781,300	781,200	781,200	778,100	777,300	777,300

Note: All specifications include year and state fixed effects. Robust standard errors clustered by county in parentheses. Individual controls include male, age, age squared, dummies for four income categories, dummies for race/ethnicity, dummies for public, private, or no insurance, and dummies for three self-reported health categories. Time-invariant county controls include the fraction of persons in poverty (1989), infant mortality rate (1988), fraction of workforce in health (1990), fraction of workforce in manufacturing (1990), unemployment rate (1990), fraction white (1990), fraction with high school education (1990), fraction Hispanic (1990), population density, and HMO penetration rate (1998).

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

Table B8
2SLS estimates of provider density on utilization, expenditure, and access.

	Total visits		Primary care visits	Non-primary care visits	Total primary care amount paid	Have usual source of care	Flu shot	Blood pressure check	Pap smear	Breast exam	Chol. check
	>0	log( )	log( )	log( )	log( )						
	(1)	(2)	(4)	(5)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Panel A. fixed effects estimates											
log(NP per population)	−0.003	0.001	−0.005	−0.017	−0.007	0.007	−0.008	−0.010	0.018	0.020	0.009
	(0.011)	(0.016)	(0.027)	(0.020)	(0.009)	(0.014)	(0.016)	(0.009)	(0.012)	(0.012)	(0.009)
log(PA per population)	0.008	0.031	0.007	0.03369*	0.009	0.009	0.013	0.011	0.002	0.001	0.015
	(0.010)	(0.023)	(0.013)	(0.019)	(0.014)	(0.009)	(0.010)	(0.010)	(0.018)	(0.019)	(0.015)
Panel B. 2SLS Estimates: first and second stage do not control for log(MD per population)											
log(NP per population)	0.041	0.051	0.046	0.050	0.049	−0.034	0.036	0.027	−0.011	0.004	−0.055
	(0.025)	(0.057)	(0.048)	(0.055)	(0.076)	(0.039)	(0.034)	(0.020)	(0.039)	(0.039)	(0.045)
log(PA per population)	−0.009	−0.040	−0.082	−0.026	−0.088	−0.006	−0.020	0.002	0.024	0.018	0.015
	(0.030)	(0.076)	(0.072)	(0.076)	(0.085)	(0.040)	(0.031)	(0.034)	(0.049)	(0.040)	(0.042)
Panel C. 2SLS estimates: first and second stage control for log(MD per population)											
log(NP per population)	0.066	0.089	0.040	0.096	0.012	−0.074	0.047	0.065	−0.012	0.006	−0.109
	(0.053)	(0.111)	(0.093)	(0.110)	(0.139)	(0.089)	(0.065)	(0.046)	(0.077)	(0.074)	(0.093)
log(PA per population)	0.001	−0.022	−0.085	−0.004	−0.104	−0.023	−0.015	0.019	0.024	0.019	−0.008
	(0.040)	(0.096)	(0.093)	(0.094)	(0.105)	(0.056)	(0.037)	(0.049)	(0.062)	(0.048)	(0.059)
Panel D. 2SLS estimates: first and second stage control for AA and diploma RN programs per population in 1963 and for log(MD per population)											
log(NP per population)	0.066	0.091	0.038	0.100	0.007	−0.080	0.053	0.066	0.008	0.029	−0.103
	(0.052)	(0.112)	(0.093)	(0.111)	(0.140)	(0.091)	(0.063)	(0.046)	(0.076)	(0.072)	(0.091)
log(PA per population)	0.003	−0.020	−0.085	−0.002	−0.111	−0.029	−0.013	0.021	0.029	0.026	−0.008
	(0.041)	(0.098)	(0.095)	(0.096)	(0.109)	(0.058)	(0.038)	(0.050)	(0.066)	(0.053)	(0.060)
N (rounded)	281,500	175,100	160,700	114,500	157,500	264,200	172,600	171,400	90,500	90,800	166,000

Note: Excluded instruments in 2SLS estimates are the number of BA RN programs in 1963 in county per population and the number of PA programs in 1975 in county per population. Fixed effects estimates include year and county fixed effects, log(MD per population), individual controls, county characteristics interacted with linear time trends, and state-specific linear time trends. 2SLS specifications include year and state fixed effects, individual controls, and time-invariant county characteristics. Robust standard errors clustered by county in parentheses. Individual controls include male, age, age squared, dummies for four income categories, dummies for race/ethnicity, dummies for public, private, or no insurance, and dummies for three self-reported health categories. Time-invariant county characteristics include the fraction of persons in poverty (1989), infant mortality rate (1988), fraction of workforce in health (1990), fraction of workforce in manufacturing (1990), unemployment rate (1990), fraction white (1990), fraction with high school education (1990), fraction Hispanic (1990), population density (1992), and HMO penetration rate (1998).

* $p < 0.1$.

** $p < 0.05$.

*** $p < 0.01$.

Table B9
OLS estimates of provider density and interaction with regulatory environment index on utilization, by insurance type.

	Have at least one office-based visit				log(total office-based visits in year)				log(primary care office-based visits in year)			
	Medicare (1)	Medicaid (2)	Private (3)	Uninsured (4)	Medicare (5)	Medicaid (6)	Private (7)	Uninsured (8)	Medicare (9)	Medicaid (10)	Private (11)	Uninsured (12)
Panel A. No interactions with regulatory environment												
log(NP per population)	−0.015	−0.002	−0.007	−0.008	0.000	0.020	0.001	−0.028	0.022	0.001	−0.003	−0.077
	(0.017)	(0.031)	(0.008)	(0.015)	(0.034)	(0.073)	(0.020)	(0.070)	(0.039)	(0.068)	(0.033)	(0.054)
log(PA per population)	0.024*	0.018	0.009	−0.006	0.023	−0.007	0.035	0.090	0.005	0.009	0.000	0.026
	(0.014)	(0.019)	(0.016)	(0.027)	(0.043)	(0.037)	(0.024)	(0.072)	(0.028)	(0.029)	(0.019)	(0.040)
Panel B. Interactions with regulatory environment												
log(NP per population)	0.044	−0.302	−0.091	0.067	−0.248	−0.456	−0.023	−0.225	−0.103	−0.476	−0.179	−0.237
	(0.085)	(0.189)	(0.066)	(0.075)	(0.218)	(0.314)	(0.104)	(0.293)	(0.189)	(0.288)	(0.130)	(0.262)
log(PA per population)	−0.059	−0.032	−0.091	0.007	−0.135	−0.362**	−0.037	0.433	0.089	−0.206	−0.017	0.121
	(0.042)	(0.075)	(0.064)	(0.121)	(0.188)	(0.163)	(0.157)	(0.340)	(0.112)	(0.163)	(0.101)	(0.190)
log(NP per population) × NP index	−0.081	0.409	0.112	−0.104	0.336	0.649	0.032	0.267	0.170	0.647	0.239	0.223
	(0.110)	(0.263)	(0.088)	(0.100)	(0.286)	(0.395)	(0.126)	(0.458)	(0.282)	(0.387)	(0.196)	(0.341)
log(PA per population) × PA index	0.112	0.070	0.137	−0.019	0.214	0.488*	0.099	−0.476	−0.113	0.299	0.023	−0.131
	(0.067)	(0.095)	(0.085)	(0.156)	(0.249)	(0.243)	(0.205)	(0.494)	(0.144)	(0.210)	(0.129)	(0.260)
F-test for provider supply coefficient = 0 when practice index = 1 (100%)												
Nurse practitioners (*p*-value)	0.226	0.199	0.415	0.203	0.266	0.070	0.775	0.820	0.499	0.146	0.406	0.886
Physician assistants (*p*-value)	0.064	0.184	0.102	0.801	0.310	0.141	0.262	0.801	0.596	0.096	0.864	0.905
N (rounded)	34,800	64,100	162,000	47,100	30,400	42,200	110,000	15,400	26,100	18,400	67,400	6600

Note: All specifications include year fixed effects, county fixed effects, log(MD per population), individual controls, state × time linear trends, and time-invariant county characteristics interacted with linear time trends. Primary care specifications also include log(number of non-primary care visits). Robust standard errors clustered by state in parentheses. Individual controls include male, age, age squared, dummies for four income categories, dummies for race/ethnicity, dummies for public, private, or no insurance (when not collinear), and dummies for three self-reported health categories. Time-invariant county characteristics that are interacted with time (linearly) include the fraction of persons in poverty (1989), infant mortality rate (1988), fraction of workforce in health (1990), fraction of workforce in manufacturing (1990), unemployment rate (1990), fraction white (1990), fraction with high school education (1990), fraction Hispanic (1990), population density (1992), and HMO penetration rate (1998). Number of primary and non-primary care visits was estimated by predicting whether each individual office visit was to a primary care provider based on broad visit category, the individual characteristics listed above, and the medical condition (if any) associated with the visit. See text for further explanation. No point estimates are significantly different from zero at conventional levels.

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

Table B10
2SLS estimates of provider density on visit prices.

	Log(total charges)						Log(amount paid)					
		Quintile of predicted likelihood that visit is primary care						Quintile of predicted likelihood that visit is primary care				
	All visits (1)	Lowest (2)	2nd (3)	3rd (4)	4th (5)	Highest (6)	All visits (7)	Lowest (8)	2nd (9)	3rd (10)	4th (11)	Highest (12)
Panel A. Fixed effects estimates												
log(NP per population)	0.036						−0.012					
	(0.031)						(0.025)					
log(PA per population)	0.004						0.010					
	(0.023)						(0.017)					
Panel B. 2SLS estimates: first and second stage do not control for log(MD per population)												
log(NP per population)	−0.011	0.037	−0.052	−0.021	−0.052	0.062	0.019	0.010	−0.012	0.033	−0.026	0.089
	(0.063)	(0.110)	(0.143)	(0.075)	(0.071)	(0.081)	(0.051)	(0.107)	(0.103)	(0.066)	(0.066)	(0.087)
log(PA per population)	0.055	0.011	0.211	0.064	0.061	−0.043	0.003	0.035	0.085	−0.027	0.018	−0.040
	(0.064)	(0.116)	(0.177)	(0.094)	(0.072)	(0.087)	(0.055)	(0.126)	(0.112)	(0.106)	(0.063)	(0.088)
Panel C. 2SLS estimates: first and second stage control for log(MD per population)												
log(NP per population)	0.025	0.054	0.023	0.106	−0.043	0.086	0.048	0.048	0.009	0.172	−0.026	0.108
	(0.127)	(0.202)	(0.269)	(0.200)	(0.129)	(0.170)	(0.102)	(0.190)	(0.180)	(0.194)	(0.116)	(0.181)
log(PA per population)	0.071	0.020	0.250	0.127	0.064	−0.033	0.017	0.055	0.096	0.044	0.017	−0.033
	(0.084)	(0.153)	(0.228)	(0.162)	(0.085)	(0.114)	(0.073)	(0.166)	(0.145)	(0.182)	(0.072)	(0.113)
Panel D. 2SLS estimates: first and second stage control for AA and diploma RN programs per population in 1963 and for log(MD per population)												
log(NP per population)	0.034	0.029	0.034	0.148	−0.027	0.096	0.057	0.059	0.030	0.197	−0.024	0.109
	(0.127)	(0.197)	(0.260)	(0.225)	(0.132)	(0.171)	(0.103)	(0.193)	(0.171)	(0.209)	(0.118)	(0.180)
log(PA per population)	0.078	−0.004	0.258	0.170	0.065	−0.034	0.020	0.051	0.108	0.068	0.012	−0.036
	(0.087)	(0.159)	(0.232)	(0.183)	(0.084)	(0.115)	(0.075)	(0.171)	(0.148)	(0.193)	(0.072)	(0.114)
N (rounded)	756,900	150,000	151,000	151,800	151,400	152,700	734,600	147,000	147,200	147,500	146,000	147,100

Note: Excluded instruments in 2SLS estimates are the number of BA RN programs in 1963 in county per population and the number of PA programs in 1975 in county per population. Fixed effects estimates include year and county fixed effects, log(MD per population), individual controls, county characteristics interacted with linear time trends, and state-specific linear time trends. 2SLS specifications include year and state fixed effects, individual controls, and time-invariant county characteristics. All specifications include the predicted likelihood that a visit is primary care and procedure dummies. Robust standard errors clustered by state in parentheses. Individual controls include male, age, age squared, dummies for four income categories, dummies for race/ethnicity, dummies for public, private, or no insurance, and dummies for three self-reported health categories. Time-invariant county characteristics include the fraction of persons in poverty (1989), infant mortality rate (1988), fraction of workforce in health (1990), fraction of workforce in manufacturing (1990), unemployment rate (1990), fraction white (1990), fraction with high school education (1990), fraction Hispanic (1990), population density (1992), and HMO penetration rate (1998). Predicted likelihood of being a primary care visit was estimated by predicting whether each individual office visit was to a primary care provider based on broad visit category, the individual characteristics listed above, and the medical condition (if any) associated with the visit. See text for further explanation.

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