3-22-2019

Technical Appendix to 'Healthcare Licensing and Liability'

Benjamin J. McMichael
University of Alabama - School of Law, bmcmichael@law.ua.edu

Healthcare Licensing and Liability
TECHNICAL APPENDIX

Benjamin McMichael

95 INDIANA LAW JOURNAL (forthcoming 2020)

TECHNICAL APPENDIX

To Accompany

Benjamin J. McMichael, *Healthcare Licensing and Liability*, 95 IND. L.J. (forthcoming 2020)

INTRODUCTION TO THE TECHNICAL APPENDIX

This Technical Appendix provides additional information that, in the interest of succinctness, was not included in the main text. Importantly, the main text stands alone in reporting and discussing the primary analysis. This appendix simply provides additional details of that analysis as well as supplementary analyses to further support the conclusions of the Article. Section I begins by providing econometric details of the empirical analysis. Section II provides more details on the primary results that are discussed in the main text. Section III reports the results of supplementary analyses that provide additional support for the main analysis. Section IV reports a series of robustness checks designed to test whether the effects of the various legal regimes reported here represent true causal effects or spurious relationships—the robustness analysis demonstrates that the effects are, indeed, true causal effects.

I. ECONOMETRIC SPECIFICATION

To examine the effect of APRN and PA SOP laws, malpractice pressure, and the interaction of the two on the provision of obstetric care, I estimate a series of difference-in-differences models. These models control for fixed, unobserved characteristics of individual states and unobserved trends over time. Throughout the analysis, I estimate the following general ordinary least squares specification:

$$\begin{aligned} Y_{ist} = \beta_1(APRN\ Independence_{st}) + (Malpractice\ Quartile_{st})'\delta_j \\ + (APRN\ Independence_{st}) \times (Malpractice\ Quartile_{st})'\gamma_j \\ + (Individual\ Controls_{ist})'\theta + \sigma_s + \tau_t + \varepsilon. \end{aligned}$$

In this specification, the dependent variable, *Y*, is a measure of one of the obstetric outcomes discussed in the main text. The indicator *APRN Independence* equals one when a state allows APRNs to both practice without physician supervision and prescribe a full range of medications. The vector *Malpractice Quartile* contains indicators for whether the birth occurred in a state that falls in the second, third, or fourth quartile of the distribution of malpractice premiums for general surgeons (with the first quartile as the omitted category). These quartiles are defined at the state-year level, so all providers in a given state and year fall into the same quartile. States can shift quartiles from year to year. Next, I include an interaction between the indicator variable for APRN independence with each malpractice quartile indicator variable. These interaction terms allow me to measure the difference in the effect of granting APRNs independence in states with different levels of malpractice pressure.

Individual Controls is a vector of variables that control for the demographics and medical history of the mother and aspects of the birth that may impact the outcomes of interest. It contains a series of indicators for whether the mother's age is between: 15 – 19, 20 –24, 25 –29, 30 – 34, 35 –39, 40 – 44, 45 – 49, and over 50 (with younger than 15 as the omitted category). Also included are indicators for whether the mother has completed: an unknown level of education, less than high school, high school, some college, or college (with more than college as the omitted category). It also includes indicators for the following maternal races: African-American or black, Asian, Native American, and Hispanic. With respect to the infant, *Individual Controls* includes an indicator for a female infant and indicators for the following multiple births: 2, 3, 4, and 5 or more (with singleton births as the omitted category).

To control for fixed, unobserved determinants of obstetric care across states and over time, I include state fixed effects, σ_s, and year fixed effects, τ_t. Throughout the analysis, standard errors are clustered at the state and year levels to correct for serial autocorrelation, consistent with the two-way clustering approach described by Cameron, Gelbach, and Miller.[1] When estimating the effect of PA autonomy, indicator variables for these laws replace the *APRN Independence* variables. In the interest of parsimony, I estimate separate models for APRN independence and PA autonomy since the pattern of adoption of these two types of SOP laws are different. However, as discussed below, estimating models with both *APRN Independence* and *PA Autonomy* (and relevant interactions) included yields similar results.

Throughout the analysis, most of the specifications include all of the observations included in the primary dataset, which consists of over 69 million observations.[2] This approach differs slightly from the Markowitz study, which examined only singleton, first births and excluded women with certain risk factors.[3] While appropriate in that context—the Markowitz team did not focus on malpractice liability—excluding these births here could potentially mask important effects of malpractice liability as APRNs and PAs gain more autonomy. Thus, I examine all births between 1998 and 2015. This approach is consistent with that of Currie and MacLeod, and as with their approach, I also separately examine high- and low-risk births (limiting the births included in the regressions as appropriate).[4] In general, high-risk pregnancies are more likely to require medical intervention, such as a C-section.[5] I supplement the analysis of high- and low-risk births with an analysis of apparently elective C-sections and medical inductions of labor similar to that provided by the Markowitz study.[6] These procedures may be more sensitive to SOP laws and malpractice pressure because they are not medically indicated and thus may be more likely to be influenced by non-medical factors.

The parameters of interest are β, δ, γ, and φ, which represent the change in various obstetric outcomes associated with changes in SOP laws across different levels of malpractice pressure. In general, β captures the causal effect of SOP laws while δ captures the equilibrium relationship between malpractice pressure and obstetric outcomes. The coefficients on the interaction terms, γ, capture the causal effect of SOP laws on obstetric outcomes across different levels of malpractice pressure, and these effects are identified through state variation in SOP laws just as the effect of these laws in general is identified. Importantly, the inclusion of interactions between SOP laws and indicators for different levels of malpractice pressure does not transform the models into triple-difference estimators—they remain difference-in-differences models.[7]

---

[1] A. Colin Cameron, Jonah B. Gelbach, & Douglas L. Miller, *Robust Inference with Multiway Clustering*, 29 J. BUS. ECON. STAT. 238, 240–49 (2011).

[2] Most models include approximately 69 million observations. The full dataset includes approximately 73 million observations, but 4.5 million observations are excluded because they lack relevant information. Almost invariably, this missing information relates to the construction of the control variables, not the outcome variables. Estimating the models with the control variables excluded and all of the observations included does not meaningfully change the results reported in the main text or appendix.

[3] Sara Markowitz et al., *Competitive effects of scope of practice restrictions: Public health or public harm?*, 55 J. HEALTH ECON. 201, 207 (2017).

[4] Janet Currie & W. Bentley MacLeod, *First Do No Harm? Tort Reform and Birth Outcomes*, 123 Q.J. ECON. 795, 813–18 (2008).

[5] *Id.*

[6] Markowitz et al., *supra* note 3, at 213.

[7] In the context of this study, a true triple difference model would include the following sets of fixed effects: state, year, (state)x(year), (state)x(malpractice pressure), and (year)x(malpractice pressure). However, throughout the analysis, malpractice pressure is defined at the state and year level. Thus, malpractice pressure is not linearly

While this appendix provides full regression results, the main text reports results in a series of figures to facilitate readability and ease of interpretation. Specifically, Figures 4 – 7 in the main text report the results of a series of regression models. Within these figures, each point represents the effect of the given SOP law within the given malpractice pressure quartile. These points are calculated from the individual coefficient estimates from a regression model that includes an indicator for the given SOP law, indicators for different malpractice pressure quartiles, and interactions between the SOP law indicator and the malpractice pressure quartile indicators.

For example, based on the general specification provided above, the effect of APRN independence in the third malpractice pressure quartile is calculated as the sum of the coefficients on the following variables: the APRN independence indicator, the indicator for the third malpractice pressure quartile, and the interaction between these two indicators. Because restricted practice is the baseline, the reported effects for this SOP law regime are simply the coefficient estimates on the relevant malpractice pressure indicator variables. All effects may be interpreted as changes from the baseline of states within the first malpractice pressure quartile that maintain restrictive SOP laws. The error bars in each figure represent the 90% confidence intervals. When a given point represents the combination of multiple coefficients, the standard error of the combination is calculated via the delta method.

II. Additional Results from the Primary Analysis

The main text includes a discussion of both summary statistics that provide context for the empirical analysis and results that are not reported in the main text in the interest of succinctness. Those statistics and results are provided here. Table A1, which is discussed in Part I.B of the main text, provides an overview of the SOP laws that are the focus of the analysis. Panel A includes a list of all states that allowed APRNs to practice independently throughout the entire period of analysis (1998–2015) and states that restricted APRN practices throughout the entire period. It also reports the states that changed their APRN SOP laws between 1998 and 2015 along with the year the change occurred. These changes represent the source of the identifying variation that make the difference-in-differences models reported throughout the analysis possible. Panel B provides a similar overview of PA SOP laws.

Part III.A of the main text discusses summary statistics that provide an overview of the final dataset and offer context for interpreting the primary results. Tables A2 and A3 report a complete set of summary statistics. Panel A of Table A2 provides information on the evolution of SOP laws and malpractice pressure over time. In general, states have consistently moved from more restrictive to less restrictive SOP laws for both APRNs and PAs over time. Malpractice pressure increased in the beginning of the study period, peaking in the mid to late 2000s before declining thereafter. However, malpractice pressure increased overall between the beginning and end of the study period. Panels B and C of Table A2 report information on labor and delivery outcomes and pregnancy and health outcomes, respectively. In general, the rate of more intensive medical interventions—C-sections and inductions—has increased over time. Pregnancy and health outcomes have remained relatively stable, though there has been a slight movement towards worse outcomes, e.g., slightly lower APGAR scores. Table A3 reports summary statistics organized by SOP law regimes to provide greater context for the primary empirical models. While these

independent of the other fixed effects required in a triple difference model, meaning such a model would not be identified.

summary statistics do not capture causal relationships, they are generally suggestive of the conclusion that relaxing SOP laws reduces the intensity of medical interventions.

Turning to the regression results, Figures A1 and A2 report the results from a series of models examining procedure choice beyond C-sections, including inductions, elective inductions, and VBACs. The results reported in these figures are discussed extensively in the main text, and, in the interest of brevity, I do not repeat that discussion here. Next, Tables A4 and A5 report the regression results that underlie Figures 4 –7 in the main text. Table A4 corresponds to Figure 4, while the individual columns across Table A5 report the results that are visualized in Figures 5 –7 and Figures A1 and A2. All of the information reported in Tables A4 and A5 is captured by the figures reported in the main text and appendix, and the implications of these results are discussed at length in the main text. Tables A4 and A5 simply report more precise estimates of the primary effects in the interest of completeness.

III. SUPPLEMENTARY ANALYSES

The primary analysis focuses on procedure choice during delivery as a means to explore the interaction between SOP laws and malpractice pressure, demonstrating that the interaction of these regimes has salient implications for the delivery of care. To test whether the effects identified in the main analysis translate into meaningful changes in the health of mothers and infants, I examine the effect of SOP laws and malpractice pressure on a series of maternal and neonatal outcomes. The results of this analysis cannot elucidate changes in provider behavior, but they can provide insight into whether the changes in behavior revealed in the main analysis ultimately improve the lives of patients.

To test whether the changes in provider behavior translate into changes in health outcomes, I collect information on a series of pregnancy and infant health outcomes from the NVSS dataset, including the length of gestation, birth weight, the five-minute APGAR score, and whether the infant suffered a birth injury. All of these outcomes are indicative of maternal or infant health. According to the American College of Obstetrics and Gynecology, infants born prior to 37 weeks gestation face significant health risks.[8] Similarly, infants born weighing less than 2500 grams face health risks, and low birthweight can be predictive of infant mortality.[9] APGAR refers to activity, pulse, grimace, appearance, and respiration. At five minutes after birth, the infant is assessed and given a score (of up to 2) for each of these five attributes, with a maximum score of 10.[10] Low APGAR scores (generally considered to be 8 or lower) are good predictors of infant mortality.[11]

In examining the effect of SOP laws and malpractice pressure on these health outcomes, I again start by focusing only on the former. I estimate the same general specification as before but replace the dependent variable with measures of the pregnancy and health outcomes described here. Table A6 reports the results from a series of regressions that examine different health outcomes.[12] The results in Panel A demonstrate that allowing APRNs to practice independently

[8] American College of Obstetrics and Gynecology, *COG Committee Opinion No 579: Definition of term pregnancy*, 122 OBSTETRICS & GYNECOLOGY 1139, 1139–1140 (2013).
[9] *Id.*
[10] Douglas Almond, Kenneth Y. Chay, & David S. Lee, *The Costs of Low Birth Weight*, 120 Q.J. ECON. 1031, 1042–45 (2005).
[11] *Id.*
[12] Based on the different ways the health outcomes are measured (number of weeks of gestation, weight in grams, etc.), the coefficient estimates across different specifications vary by several orders of magnitude. This variation

has the anticipated effects on various health outcomes. Gestation length, birth weight, and APGAR score all increase slightly, and the probability of suffering a birth injury decreases slightly. The estimated effects are relatively small, e.g., the increase in gestation is less than a day and the increase in birth weight is less than four grams. However, all of the evidence supports the conclusion that, to the extent APRN independence affects health outcomes, this effect is beneficial. The results in Panel B suggest that PA autonomy does not have the statistically significant, beneficial effects of APRN independence. However, the results provide no statistically significant evidence that allowing PAs to practice autonomously causes pregnancy- and delivery-related health outcomes to decline.

These results are consistent with prior work showing that granting APRNs and PAs more authority and autonomy either increases measurable health outcomes or leaves them unchanged.[13] Additionally, the consistent, statistically significant effects of APRN SOP laws and the consistently insignificant results for PA SOP laws are consistent with the roles these different providers play in the healthcare system. APRNs are more likely to practice in primary care specialties and provide women's healthcare than PAs, so the health outcomes that would be sensitive to these types of care should be impacted to a greater extent by APRN SOP laws than PA SOP laws.[14] Similarly, PAs are more likely to practice in surgical specialties, so changing their SOP laws should have a greater effect on surgical outcomes, such as the decision of whether to perform a C-section, than on non-surgical outcomes such as labor inductions or primary-care-sensitive health outcomes.[15]

Next, I examine the effect of SOP laws across different levels of malpractice pressure. Figures A3 and A4 report the results of a series of models focusing on the effect of APRN and PA SOP laws on four different health outcomes, and Table A7 reports the regression results that underlie Figures A3 and A4. Beginning with APRN laws and Figure A3, some evidence suggests that the effect of APRN SOP laws varies systematically as malpractice pressure increases. While the effect of these laws on gestation length does not appear to follow a clear pattern, there is some evidence of a divergence and convergence between the restricted-practice- and APRN-independence lines in the panels focusing on birth weight and APGAR scores, respectively.

However, the strongest evidence of a differential effect of APRN SOP laws across different levels of malpractice pressure appears in the panel focusing on birth injuries. At the lowest levels of malpractice pressure, APRN SOP laws clearly reduce the probability that a birth results in an injury to the infant. However, at the highest levels of malpractice pressure, birth injuries are slightly more common when APRNs can practice independently (though, the difference is not statistically significant). This pattern of results echoes those observed for the effect of APRN SOP laws on C-section rates, suggesting that the different effect APRN laws have on C-sections translates directly into different effects on birth injuries.

Turning to PA SOP laws and Figure A4, some evidence suggests that the effect of these laws varies systematically with malpractice pressure. However, the convergences and divergences observed as malpractice pressure increases are not nearly as dramatic as those observed for APRN laws. These muted effects likely stem from PAs not practicing in primary care settings to the same

(which stems only from the way the outcomes are measured) makes it infeasible to report these regression results in figure form.

[13] *See, e.g.*, Sara Markowitz et al., *Competitive effects of scope of practice restrictions: Public health or public harm?*, 55 J. HEALTH ECON. 201, 209–16 (2017) (finding similar results).

[14] Oren Berkowitz & Susan E. White, *An opportunity for PAs as obstetrical laborists*, 31 J. AM. ACAD. PHYSICIAN ASSISTANTS 40, 40 (2018).

[15] *Id.*

degree as APRNs, as discussed above, and from PA laws not creating the same degree of separation from physicians as APRN laws. Because (even at the highest levels of autonomy) PAs cannot practice fully independently (and therefore may always pass some liability onto their physicians) the variation in the effect of PA SOP laws should be more muted than the variation in the effect of APRN SOP laws. This is exactly the pattern that emerges when comparing individual panels across Figure A3 (APRN laws) and Figure A4 (PA laws).

Overall, the results reported here offer no evidence that the effects of SOP laws and malpractice pressure identified in the main analysis result in more maternal or neonatal harm. Indeed, the majority of the evidence suggests that the legal changes recommended in the main text will improve maternal and neonatal health outcomes. While the evidence of an interactive effect of SOP laws and malpractice pressure is not as strong in the health outcomes models as the procedure choice models that are the focus of the primary analysis, this could stem from the fact that the intensive procedures commonly used in the United States offer limited health benefits. This is consistent with the World Health Organization's conclusions and provides further support for relaxing SOP laws, as recommended in the main text.

IV. Robustness Checks

To test whether the results reported in the primary and supplementary analyses represent true causal effects, I conduct a series of robustness checks. First, I estimate a series of specifications to test the sensitivity of the results to the underlying econometric specification of the models. Throughout the primary and supplementary analyses, I estimate separate models for APRN SOP laws and PA SOP laws. Based on the nature of the development in these laws—APRN SOP laws and PA SOP laws are almost never changed by a state in the same year—this approach is most appropriate. However, it is possible that one set of indicator variables is simply picking up the effect of changes in the other set of SOP laws. For example, if states routinely amend their PA SOP laws soon after amending their APRN SOP laws, the effect of relaxing PA SOP laws identified in the empirical models may reflect changes in APRN SOP laws.

To test whether one set of SOP law variables is simply picking up the effect of changes in the other SOP laws, I estimate a series of models that include indicators for both APRN independence and PA autonomy. Results from these models are reported in Table A8. Comparing these results with those reported in the separate panels of Tables A4 and A6 reveals only very slight changes in the point estimates for the effects of both APRN independence and PA autonomy and no changes in the statistical significance of these effects. Thus, I find no evidence that one set of SOP law variables is picking up changes in the other SOP laws. More generally, the evidence demonstrates that APRN and PA SOP laws have separate impacts on the delivery of care. In addition to the models reported in Table A8, I re-estimate all of the models that include a complete set of interactions between the SOP law variables and the malpractice pressure indicators. In the interest of succinctness, those models are not reported, but they reveal a similar pattern of results. APRN and PA SOP laws have separate impacts, and estimating these impacts in the same model leads to little change in the results.

Next, all of the primary and supplementary models include indicator variables for different malpractice quartiles. As noted in the main text, this allows the models to pick up non-linear effects of malpractice pressure that would be masked by simply including a continuous measure of malpractice pressure (which would impose a functional form assumption on the effect of malpractice pressure). To probe the possibility that the use of quartiles is masking a potential effect

of malpractice pressure or failing to pick up important non-linearities, I estimate a series of models that divide malpractice pressure into deciles instead of quartiles. By grouping states into ten categories instead of four, it is possible to examine whether the pattern of effects that SOP laws have across different levels of malpractice pressure persist when those levels are measured at a more granular level.

Figure A5 reports the results of models with an indicator for whether the infant was delivered via C-section as the dependent variable. The model reported in Panel A explores the effect of allowing APRNs to practice independently across ten levels of malpractice pressure, and Panel B does the same for PA autonomy. While these models capture a more nuanced differential effect of APRN independence and PA autonomy than the models employing quartiles, the results of the decile models are entirely consistent with the quartile models. In the interest of succinctness, I report only models for C-sections for illustrative purposes. Models focusing on other outcomes and including deciles are similarly consistent with the quartile models that form the basis of the primary analysis.

Finally, as noted in the main text, a key assumption underlying all difference-in-differences models—including those estimated here—is that the trend in the outcome of interest is the same in the control group and treatment group. Because the models reported in all parts of my analysis rely on changes in SOP laws for identification—malpractice pressure is not the source of identification—it is important to test the assumption that the trends in the treated (states changing their SOP laws) and control (states not changing these laws) groups are the same. If these trends are statistically significantly different, that could suggest that the results of my analysis simply reflect differences in the relevant underlying trends as opposed to true effects of the legal regimes under investigation.

While there are multiple methods for testing the assumption that the pre-adoption trends in the control and treatment groups were the same, I follow the straightforward approach of estimating event study models. These models include, instead of simple indicator variables for the relevant legal regime, a series of indicator variables that equal one for specified intervals before and after the adoption of the relevant law. In particular, I replace the indicator for APRN independence (and PA autonomy in the models focusing on PA SOP laws) with indicator variables for the following timeframes: two or more years prior to the adoption of APRN independence, the year of adoption, one-year post-adoption, two years post-adoption, three years post-adoption, four years post-adoption, and five or more years post-adoption. The omitted timeframe is one-year prior to the adoption of APRN independence, and this year serves as the baseline for comparison.[16]

The results of the event-study models are reported in Figure A6—as with other robustness checks, I report only the C-section models in the interest of succinctness. Of particular interest is the coefficient estimate for the pre-trend variable, which equals one two or more years prior to the adoption of APRN independence (or PA autonomy). If this coefficient were statistically significant, that would indicate that the states in the treatment group (those that eventually adopted APRN independence or PA autonomy) differed in a statistically significant way from those states in the control group. That would suggest, in turn, that the control and treatment groups differed in meaningful ways prior to the adoption of the relevant SOP law and that the estimated effects of that law may represent differences in pre-existing trends as opposed to the causal effect of the SOP law. The coefficient on the pre-trend variable is not statistically significant in either Panel A or

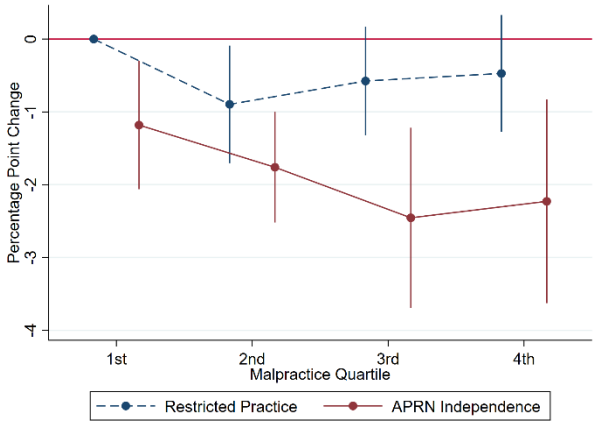
[16] This approach is consistent with the event study models reported by Frakes and Gruber. Michael D. Frakes & Jonathan Gruber, *Defensive Medicine: Evidence from Military Immunity*, 11 AM. ECON. J. ECON. POL'Y (forthcoming 2019).

Panel B, suggesting that the parallel trends assumption is not violated and that the use of difference-in-difference models throughout my analysis is appropriate.

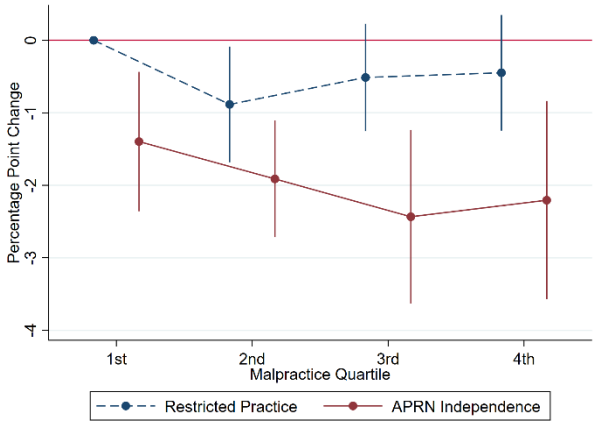
In addition to demonstrating the validity of the primary empirical models, the event-study results also elucidate the "phasing in" of the effect of relaxing SOP laws. For example, in Panel A, allowing APRNs to practice independently has a clear effect on C-section rates, but it takes several years following a change in APRN SOP laws for this effect to take hold. C-section rates decline immediately upon the adoption of laws allowing APRNs to practice independently, and this effect strengthens over time. Only four years after adoption does the effect of APRN independence lead to a statistically significant difference in C-section rates. This is not surprising, as one would expect that it would take providers of all types several years to adjust their practice patterns consistent with new APRN SOP laws. A similar pattern of temporal effects is present in the event-study model focusing on PA autonomy. The effect of allowing PAs to practice autonomously similarly phases in over time, consistent with providers needing some time to adjust their practice patterns. It is worth noting that, while PA autonomy has more of an immediate effect on C-section rates, it does not have as strong of an effect as APRN independence after five years. This suggests, consistent with expectations, that APRNs and the laws that govern them play more salient roles in obstetric care than PAs and their SOP laws.

Figure A1: Effect of APRN Scope-of-Practice Laws on Other Procedure Choices

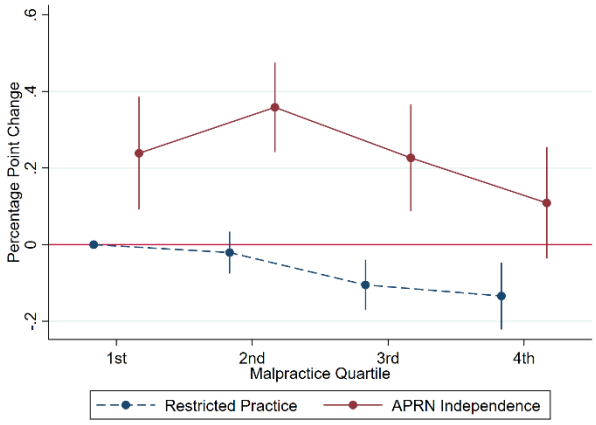
Panel A: Inductions



Panel B: Elective Inductions



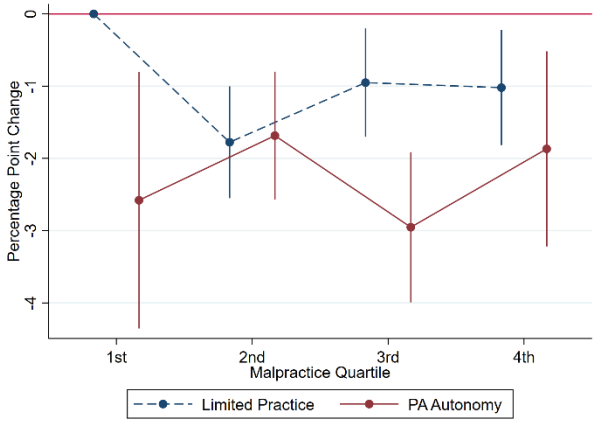
Panel C: VBAC



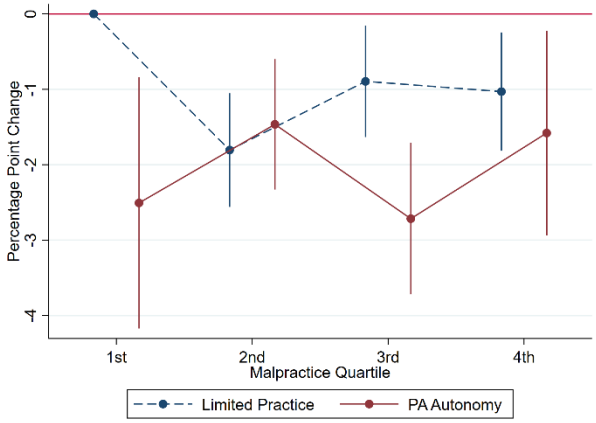
Notes: Each point represents the effect of the given SOP law within the given malpractice pressure quartile. Each point is calculated from the individual coefficient estimates from a regression model that includes a full set of control variables and state and year fixed effects. Error bars represent the 90% confidence intervals, which are based on standard errors clustered at the state and year levels.

Figure A2: Effect of PA Scope-of-Practice Laws on Other Procedure Choices

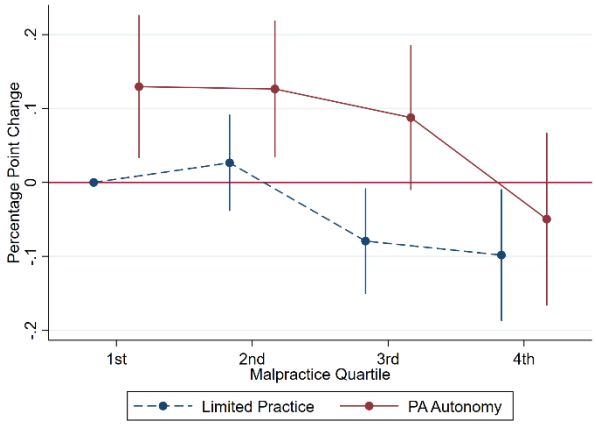
Panel A: Inductions



Panel B: Elective Inductions

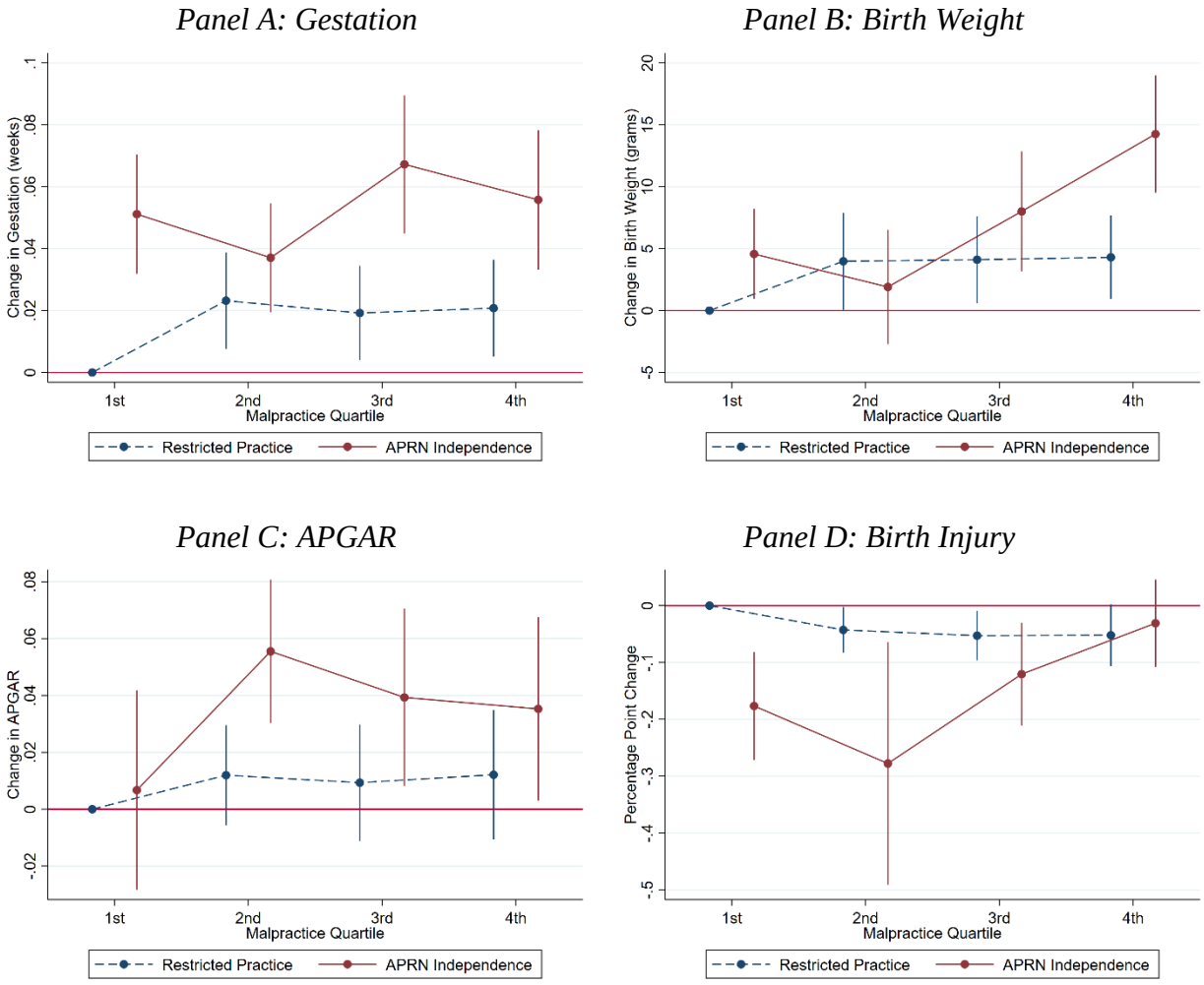


Panel C: VBAC



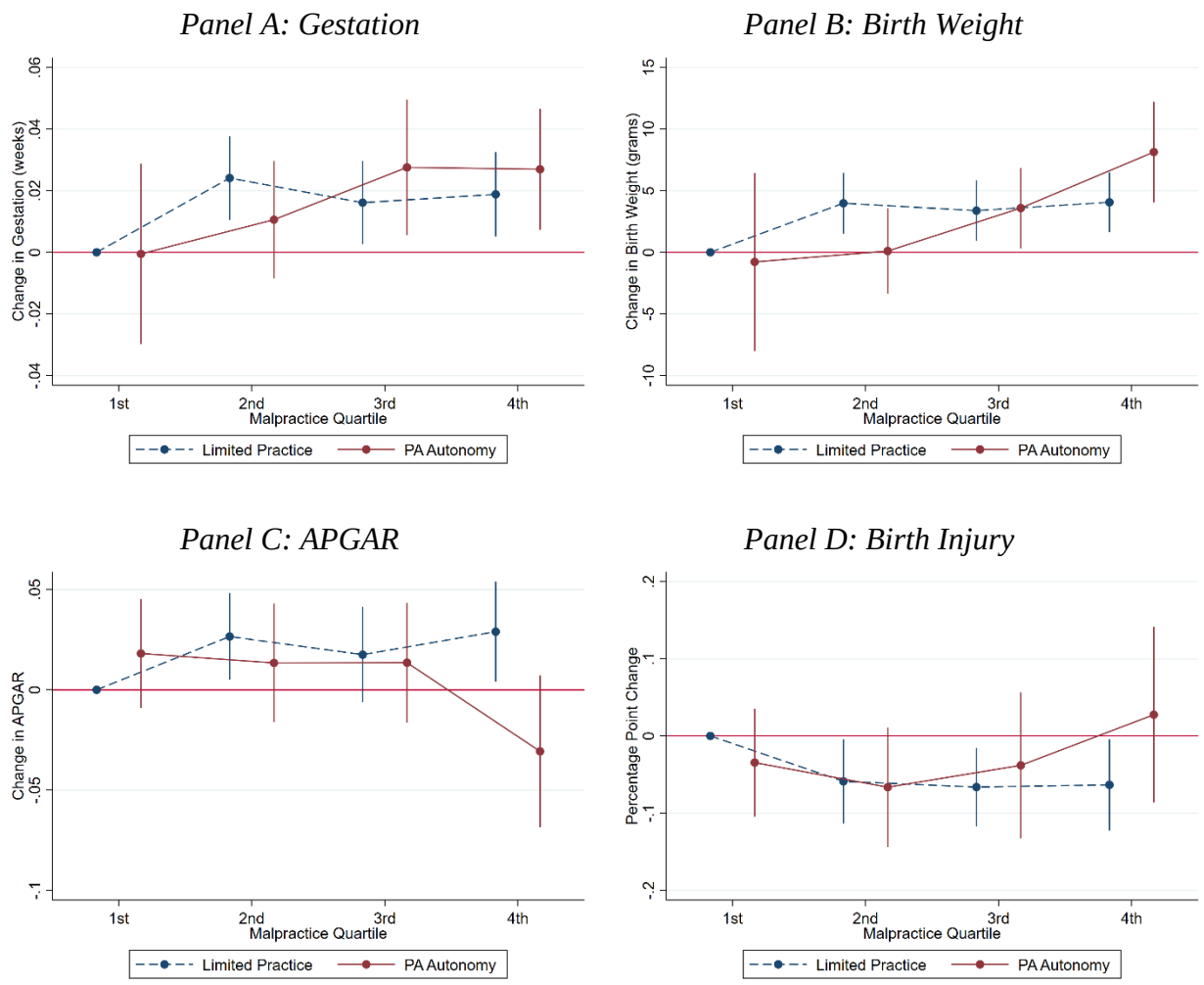
Notes: Each point represents the effect of the given SOP law within the given malpractice pressure quartile. Each point is calculated from the individual coefficient estimates from a regression model that includes a full set of control variables and state and year fixed effects. Error bars represent the 90% confidence intervals, which are based on standard errors clustered at the state and year levels.

Figure A3: Effect of APRN Scope-of-Practice Laws on Health Outcomes



Notes: Each point represents the effect of the given SOP law within the given malpractice pressure quartile. Each point is calculated from the individual coefficient estimates from a regression model that includes a full set of control variables and state and year fixed effects. Error bars represent the 90% confidence intervals, which are based on standard errors clustered at the state and year levels.

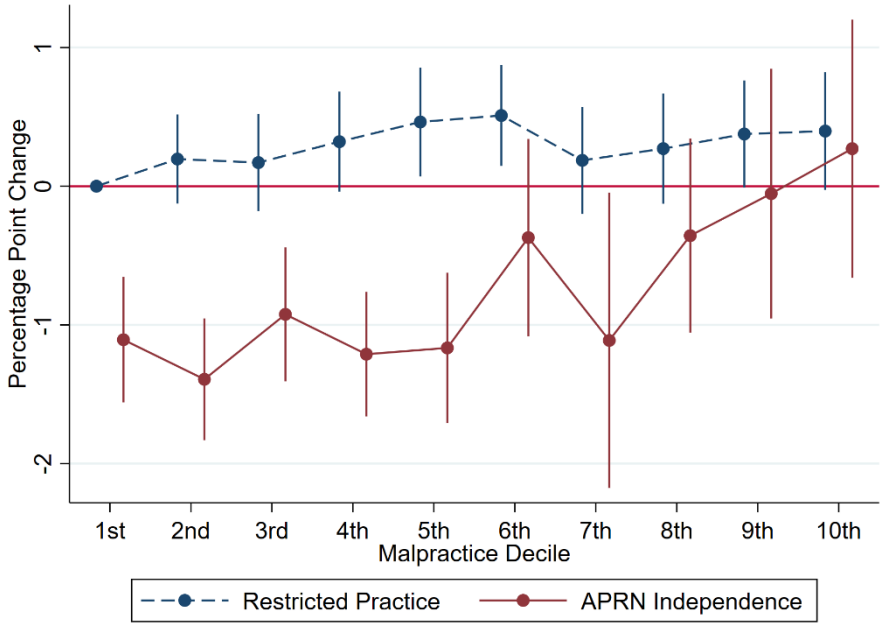
Figure A4: Effect of PA Scope-of-Practice Laws on Health Outcomes



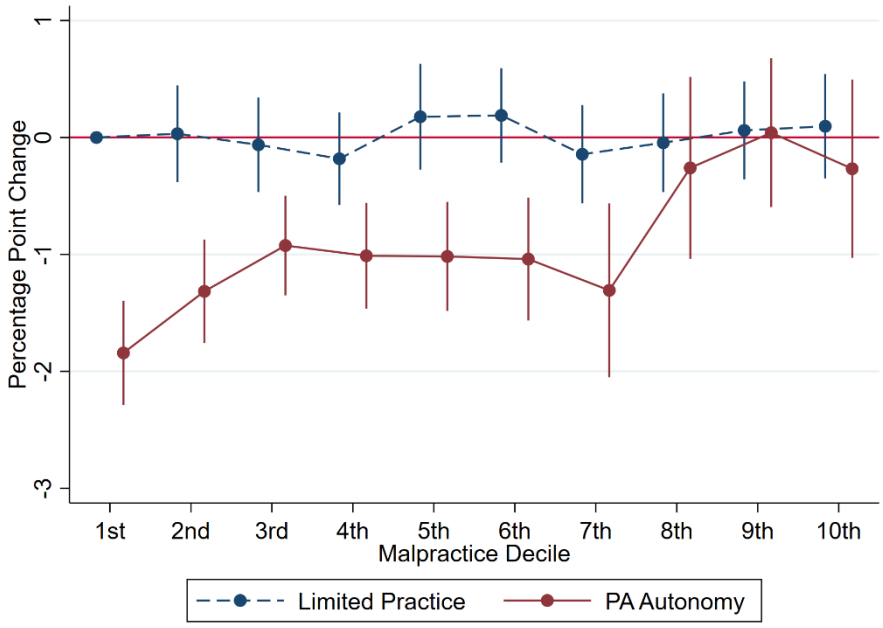
Notes: Each point represents the effect of the given SOP law within the given malpractice pressure quartile. Each point is calculated from the individual coefficient estimates from a regression model that includes a full set of control variables and state and year fixed effects. Error bars represent the 90% confidence intervals, which are based on standard errors clustered at the state and year levels.

Figure A5: Effect of Scope-of-Practice Laws on C-sections Across Malpractice Deciles

Panel B: APRN SOP Laws



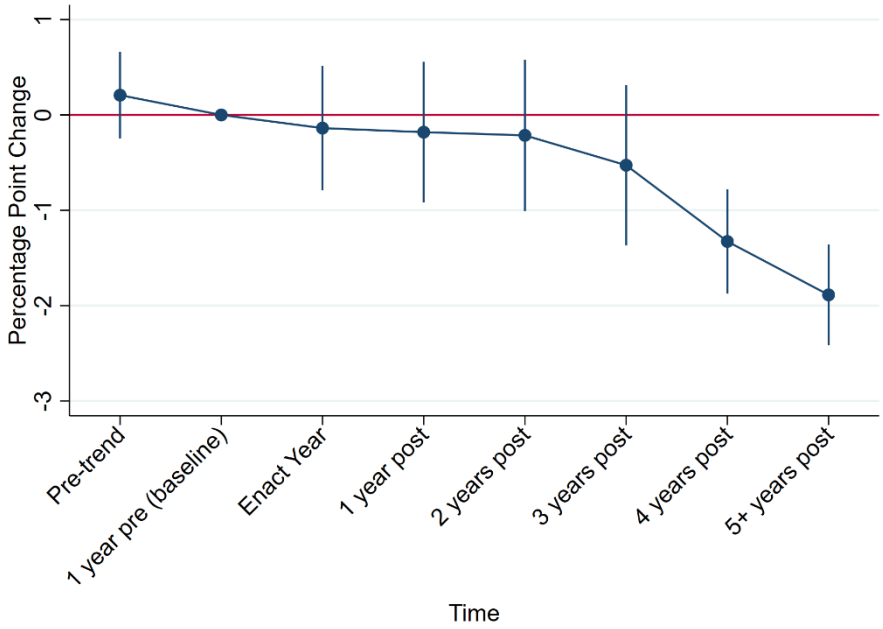
Panel B: PA SOP Laws



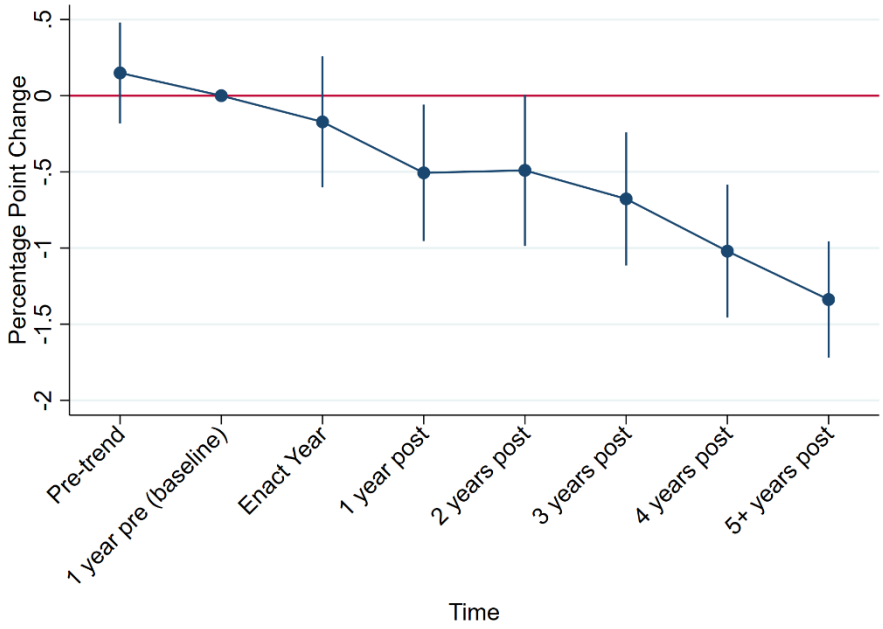
Notes: Each point represents the effect of the given SOP law within the given malpractice pressure decile. Each point is calculated from the individual coefficient estimates from a regression model that includes a full set of control variables and state and year fixed effects. Error bars represent the 90% confidence intervals, which are based on standard errors clustered at the state and year levels.

Figure A6: Event Study Results for C-sections

Panel A: APRN Scope-of-Practice Laws



Panel B: PA Scope-of-Practice Laws



Notes: The points represent the coefficients on a series of leads and lags on *APRN independence* (Panel A) or *PA autonomy* (Panel B). Error bars represent the 90% confidence intervals and are calculated based on standard errors clustered at the state and year levels. The dependent variable in each model is an indicator for whether the infant was delivered via C-section. All specifications include individual state and year fixed effects and a full set of control variables.

Table A1: Scope-of-Practice Laws: 1998–2015

Panel A: Advanced Practice Registered Nurses

Always Independence	Always Restricted Practice	Changed from Restricted Practice to Independence
AK, DC, IA, ME, MT, NH, NM	AL, AR, CA, DE, FL, GA, IL, IN, KS, KY, LA, MA, MI, MS, MO, NE, NJ, NY, NC, OH, OK, PA, SC, SD, TN, TX, VA, WV, WI	UT (2000), AZ (2000), OR (2001), WY (2002), ID (2005), WA (2009), HI (2010), CO (2010), ND (2011), VT (2011), MD (2012), NV (2013), CT (2014) RI (2014), MN (2015)

Panel B: Physician Assistants

Always Autonomy	Always Limited Practice	Changed from Limited Practice to Autonomy
MA, MN, MT, NH, VT	AL, AZ, AR, FL, GA, IL, IN, IA, KY, MS, MO, NJ, OH, OK, PA, SC, TX, VA, WA, WV	NV (1999), NC (2000), WI (2000), MD (2000), TN (2002), ID (2002), RI (2002), KS (2002), UT (2002), WY (2003), NE (2006), CO (2006), NM (2006), ME (2006), SD (2008), CT (2008), AK (2008), DC (2008), CA (2008), ND (2010), OR (2010), MI (2012), DE (2014), HI (2015), NY (2015), LA (2015)

NOTE: All reported years reflect the first year a state is coded as having the new law. If a state enacted a law in the second half of a given calendar year, it is not coded as having that new law in place until the following calendar year.

Table A2: Summary Statistics by Year

Panel A: Legal Variables

Year	% APRN Independence	% PA Autonomy	Avg. MPL Premium
1998	3.2%	4.5%	49,469
1999	3.2%	5.2%	46,581
2000	6.5%	11.6%	47,414
2001	7.7%	11.6%	51,894
2002	7.9%	16.7%	61,823
2003	7.9%	16.9%	72,733
2004	8.0%	16.9%	83,280
2005	8.6%	17.0%	88,256
2006	8.7%	20.4%	85,020
2007	8.8%	20.4%	85,575
2008	8.8%	35.4%	82,015
2009	10.8%	35.2%	78,729
2010	12.9%	36.6%	76,146
2011	13.3%	36.6%	75,264
2012	15.2%	39.5%	71,896
2013	16.1%	39.3%	70,925
2014	17.3%	39.6%	63,581
2015	19.0%	47.4%	65,483

Panel B: Labor and Delivery Variables

Year	% C-section	% C-section (high risk)	% C-section (low risk)	% C-section (elective)	% Induction	% Induction (elective)	% VBAC	% CNM Attended
1998	20.9%	36.6%	12.7%	15.9%	19.1%	18.1%	2.8%	7.0%
1999	21.8%	37.7%	13.3%	16.6%	19.6%	18.6%	2.5%	7.3%
2000	22.7%	38.9%	13.9%	17.5%	19.7%	18.8%	2.2%	7.3%
2001	24.3%	40.9%	14.7%	19.1%	20.3%	19.4%	1.8%	7.6%
2002	25.9%	42.9%	15.6%	20.6%	20.5%	19.6%	1.5%	7.6%
2003	27.4%	45.2%	16.9%	21.4%	20.5%	19.7%	1.3%	7.6%
2004	28.9%	48.0%	18.4%	22.3%	21.1%	20.3%	1.1%	7.5%
2005	30.2%	51.3%	19.6%	24.1%	22.2%	21.6%	1.1%	7.4%
2006	31.0%	53.0%	20.4%	23.5%	22.5%	21.8%	1.0%	7.4%
2007	31.7%	69.2%	21.1%	25.4%	22.6%	22.2%	1.0%	7.3%
2008	32.2%	68.9%	21.6%	25.5%	22.9%	22.3%	1.0%	7.5%
2009	32.8%	63.4%	25.3%	25.9%	23.1%	22.4%	0.8%	7.6%
2010	32.7%	63.1%	24.2%	25.2%	23.2%	22.4%	1.0%	7.8%
2011	32.7%	63.1%	23.1%	28.9%	23.1%	22.2%	1.2%	7.8%
2012	32.8%	62.8%	22.7%	28.9%	22.7%	21.8%	1.3%	7.9%
2013	32.7%	62.3%	22.1%	28.8%	23.0%	22.0%	1.4%	8.2%
2014	32.2%	63.5%	20.9%	31.7%	23.2%	22.7%	1.6%	8.3%
2015	32.0%	62.6%	20.2%	31.4%	23.8%	23.3%	1.8%	8.5%

Panel C: Pregnancy and Infant Health Variables

Year	Avg. Gestation	Avg. Birth Weight	Avg. APGAR	% Birth Injury
1998	38.8	3318.9	8.9	0.3%
1999	38.8	3316.2	8.9	0.3%
2000	38.8	3316.6	8.9	0.3%
2001	38.7	3306.1	8.9	0.3%
2002	38.7	3298.7	8.9	0.3%
2003	38.6	3291.1	8.9	0.2%
2004	38.6	3281.7	8.9	0.2%
2005	38.6	3272.3	8.9	0.2%
2006	38.5	3264.6	8.9	0.2%
2007	38.5	3262.7	8.8	0.0%
2008	38.6	3262.2	8.8	0.0%
2009	38.6	3261.9	8.8	0.1%
2010	38.6	3261.9	8.8	0.1%
2011	38.6	3265.9	8.8	0.1%
2012	38.6	3270.9	8.8	0.1%
2013	38.6	3271.6	8.8	0.1%
2014	38.7	3272.8	8.8	NA
2015	38.6	3270.1	8.8	NA

Notes: N = 73,239,023. All reported summary statistics are calculated at the individual level. Percentages represent the percentage of all births that satisfy the given criterion, e.g., the percentage of births occurring in states that allow APRNs to practice independently or the percentage of births resulting in a C-section.

Table A3: Summary Statistics by Scope-of-Practice Regime

Panel A: Labor and Delivery Outcomes

	N	% C-section	% C-section (high risk)	% C-section (low risk)	% C-section (elective)	% Induction	% Induction (elective)	% VBAC	% CNM Attended
All Observations	73,239,023	29.2%	52.1%	19.6%	24.0%	21.9%	21.1%	1.4%	7.6%
APRN SOP Laws									
Restricted Practice	65,780,848	29.6%	52.7%	19.8%	24.3%	21.7%	21.0%	1.4%	7.3%
APRN Independence	7,458,175	25.9%	46.7%	17.3%	21.6%	22.9%	22.0%	1.6%	10.6%
PA SOP Laws									
Limited Practice	54,924,452	29.1%	51.4%	19.6%	23.8%	22.0%	21.2%	1.5%	
PA Autonomy	18,314,571	29.3%	54.3%	19.5%	24.6%	21.4%	20.7%	1.4%	

Panel B: Pregnancy and Infant Health Outcomes

	N	Avg. Gestation	Avg. Birth Weight	Avg. APGAR	% Birth Injury
All Observations	73,239,023	38.6	3,281.2	8.8	0.1%
APRN SOP Laws					
Restricted Practice	65,780,848	38.6	3,278.6	8.9	0.1%
APRN Independence	7,458,175	38.7	3,304.7	8.8	0.2%
PA SOP Laws					
Limited Practice	54,924,452	38.6	3,277.7	8.9	0.1%
PA Autonomy	18,314,571	38.7	3,291.9	8.8	0.2%

Notes: All reported summary statistics are calculated at the individual level. Percentages represent the percentage of all births that satisfy the given criterion, e.g., the percentage of births resulting in a C-section

Table A4: Effect of Scope-of-Practice Laws on Labor and Delivery Procedures

Panel A: APRN Scope-of-Practice Laws

	(1) I(CNM)	(2) I(C-sect)	(3) I(C-sect | High Risk)	(4) I(C-sect | Low Risk)	(5) I(Elec C-Sect)	(6) I(Induction)	(7) I(Elec Induction)	(8) I(VBAC)
APRN Independence	0.008***	-0.010***	-0.013**	-0.009***	-0.008***	-0.015***	-0.016***	0.003***
	(0.003)	(0.002)	(0.006)	(0.003)	(0.003)	(0.004)	(0.004)	(0.001)
Observations	69,395,709	69,395,709	21,279,136	48,116,573	69,395,709	69,395,709	69,395,709	69,395,709
R-squared	0.027	0.056	0.100	0.053	0.044	0.028	0.028	0.006

Panel B: PA Scope-of-Practice Laws

	(1) I(C-sect)	(2) I(C-sect | High Risk)	(3) I(C-sect | Low Risk)	(4) I(Elec C-Sect)	(5) I(Induction)	(6) I(Elec Induction)	(7) I(VBAC)
PA Autonomy	-0.009***	-0.028***	-0.013***	-0.006**	-0.007*	-0.005	0.001***
	(0.001)	(0.006)	(0.002)	(0.003)	(0.004)	(0.004)	(0.000)
Observations	69,395,709	21,279,136	48,116,573	69,395,709	69,395,709	69,395,709	69,395,709
R-squared	0.056	0.100	0.053	0.044	0.028	0.028	0.006

Notes: Dependent variables are listed at the top of each column. All specifications include the following control variables: a series of indicators for whether the mother's age is between: 15 – 19, 20 –24, 25 –29, 30 – 34, 35 –39, 40 – 44, 45 – 49, and over 50; indicators for whether the mother has completed an unknown education level, less than high school, high school, some college, or college (with more than college as the omitted category); indicators for African-American or black, Asian, Native American, and Hispanic; an indicator for a female infant; and indicators for multiple births (with singleton births as the omitted category). All specifications include individual state and year fixed effects. Standard errors clustered at the state and year levels are reported in parentheses.

* significant at the $p < 0.1$ level

** significant at the $p < 0.05$ level

*** significant at the $p < 0.01$ level

Table A5: Effect of Scope-of-Practice Laws Across Different Levels of Malpractice Pressure

Panel A: APRN Scope-of-Practice Laws

	(1) I(CNM)	(2) I(C-sect)	(3) I(C-sect | High Risk)	(4) I(C-sect | Low Risk)	(5) I(Elec C-Sect)	(6) I(Induction)	(7) I(Elec Induction)	(8) I(VBAC)
APRN Independence	0.020***	-0.013***	-0.014*	-0.014***	-0.011***	-0.012**	-0.014**	0.002***
	(0.005)	(0.003)	(0.008)	(0.003)	(0.004)	(0.005)	(0.006)	(0.001)
Quartile 2	-0.003	0.003**	0.015**	0.001	0.004	-0.009*	-0.009*	-0.000
	(0.002)	(0.001)	(0.007)	(0.002)	(0.003)	(0.005)	(0.005)	(0.000)
Quartile 3	-0.003	0.003**	0.015**	0.005**	0.007**	-0.006	-0.005	-0.001***
	(0.002)	(0.001)	(0.008)	(0.002)	(0.003)	(0.005)	(0.004)	(0.000)
Quartile 4	-0.001	0.003**	0.007	-0.000	0.012***	-0.005	-0.004	-0.001**
	(0.002)	(0.001)	(0.009)	(0.003)	(0.003)	(0.005)	(0.005)	(0.001)
(APRN Indep)x(Q2)	-0.013**	-0.001	-0.012	0.001	-0.003	0.003	0.004	0.001*
	(0.006)	(0.003)	(0.009)	(0.003)	(0.004)	(0.006)	(0.006)	(0.001)
(APRN Indep)x(Q3)	-0.011*	0.005	-0.001	0.008*	0.002	-0.007	-0.005	0.001
	(0.006)	(0.004)	(0.010)	(0.004)	(0.005)	(0.008)	(0.008)	(0.001)
(APRN Indep)x(Q4)	-0.023***	0.010**	0.020*	0.014***	0.006	-0.006	-0.004	0.000
	(0.007)	(0.005)	(0.012)	(0.005)	(0.005)	(0.009)	(0.009)	(0.001)
Observations	69,395,709	69,395,709	21,279,136	48,116,573	69,395,709	69,395,709	69,395,709	69,395,709
R-squared	0.027	0.056	0.100	0.053	0.044	0.028	0.028	0.006

Panel B: PA Scope-of-Practice Laws

	(1) I(C-sect)	(2) I(C-sect | High Risk)	(3) I(C-sect | Low Risk)	(4) I(Elec C-Sect)	(5) I(Induction)	(6) I(Elec Induction)	(7) I(VBAC)
PA Autonomy	-0.013***	-0.035***	-0.018***	-0.011***	-0.026**	-0.025**	0.001**
	(0.002)	(0.008)	(0.002)	(0.004)	(0.011)	(0.010)	(0.001)
Quartile 2	0.000	0.010	-0.002	0.001	-0.018***	-0.018***	0.000
	(0.001)	(0.007)	(0.002)	(0.003)	(0.005)	(0.005)	(0.000)
Quartile 3	0.001	0.007	0.002	0.005	-0.010**	-0.009**	-0.001*
	(0.001)	(0.008)	(0.002)	(0.003)	(0.005)	(0.004)	(0.000)
Quartile 4	0.001	0.002	-0.003	0.011***	-0.010**	-0.010**	-0.001*
	(0.001)	(0.010)	(0.003)	(0.003)	(0.005)	(0.005)	(0.001)
(PA Auton)x(Q2)	0.004**	0.003	0.005*	0.005	0.027***	0.028***	-0.000
	(0.002)	(0.010)	(0.002)	(0.005)	(0.010)	(0.009)	(0.001)
(PA Auton)x(Q3)	0.004	0.020*	0.006*	0.006	0.006	0.007	0.000
	(0.003)	(0.010)	(0.003)	(0.005)	(0.011)	(0.010)	(0.001)
(PA Auton)x(Q4)	0.010***	0.022*	0.016***	0.004	0.017	0.020*	-0.001
	(0.003)	(0.013)	(0.004)	(0.005)	(0.012)	(0.011)	(0.001)
Observations	21,279,136	48,116,573	69,395,709	69,395,709	69,395,709	69,395,709	69,395,709
R-squared	0.100	0.053	0.044	0.028	0.028	0.006	0.056

Notes: Dependent variables are listed at the top of each column. All specifications include the following control variables: a series of indicators for whether the mother's age is between: 15 – 19, 20 –24, 25 –29, 30 – 34, 35 –39, 40 – 44, 45 – 49, and over 50; indicators for whether the mother has completed an unknown education level, less than high school, high school, some college, or college (with more than college as the omitted category); indicators for African-American or black, Asian, Native American, and Hispanic; an indicator for a female infant; and indicators for multiple births (with singleton births as the omitted category). All specifications include individual state and year fixed effects. Standard errors clustered at the state and year levels are reported in parentheses.

* significant at the $p < 0.1$ level

** significant at the $p < 0.05$ level

*** significant at the $p < 0.01$ level

Table A6: Effect of Scope-of-Practice Laws on Health Outcomes

Panel A: APRN Scope-of-Practice Laws

	(1) Gestation	(2) Birth Weight	(3) APGAR	(4) I(Injury)
APRN Independence	0.038***	3.998**	0.030***	-0.001**
	(0.008)	(1.667)	(0.011)	(0.001)
Observations	69,006,250	69,324,461	61,678,637	61,620,766
R-squared	0.082	0.140	0.023	0.003

Panel B: PA Scope-of-Practice Laws

	(1) Gestation	(2) Birth Weight	(3) APGAR	(4) I(Injury)
PA Autonomy	-0.005	-1.755	-0.017	0.000
	(0.009)	(1.543)	(0.012)	(0.000)
Observations	69,006,250	69,324,461	61,678,637	61,620,766
R-squared	0.082	0.140	0.023	0.003

Notes: Dependent variables are listed at the top of each column. All specifications include the following control variables: a series of indicators for whether the mother's age is between: 15 – 19, 20 –24, 25 –29, 30 – 34, 35 –39, 40 – 44, 45 – 49, and over 50; indicators for whether the mother has completed an unknown education level, less than high school, high school, some college, or college (with more than college as the omitted category); indicators for African-American or black, Asian, Native American, and Hispanic; an indicator for a female infant; and indicators for multiple births (with singleton births as the omitted category). All specifications include individual state and year fixed effects. Standard errors clustered at the state and year levels are reported in parentheses.

* significant at the $p < 0.1$ level

** significant at the $p < 0.05$ level

*** significant at the $p < 0.01$ level

Table A7: Effect of Scope-of-Practice Laws on Health Outcomes Across Different Levels of Malpractice Pressure

Panel A: APRN Scope-of-Practice Laws

	(1) Gestation	(2) Birth Weight	(3) APGAR	(4) I(Injury)
APRN Independence	0.051***	4.566**	0.007	-0.002***
	(0.012)	(2.213)	(0.021)	(0.001)
Quartile 2	0.023**	3.981*	0.012	-0.000*
	(0.009)	(2.379)	(0.011)	(0.000)
Quartile 3	0.019**	4.108*	0.009	-0.001**
	(0.009)	(2.130)	(0.012)	(0.000)
Quartile 4	0.021**	4.301**	0.012	-0.001
	(0.009)	(2.047)	(0.014)	(0.000)
(APRN Indep)x(Q2)	-0.037***	-6.641**	0.037*	-0.001
	(0.014)	(2.932)	(0.022)	(0.001)
(APRN Indep)x(Q3)	-0.003	-0.668	0.023	0.001*
	(0.015)	(2.720)	(0.024)	(0.001)
(APRN Indep)x(Q4)	-0.016	5.389**	0.016	0.002***
	(0.015)	(2.661)	(0.026)	(0.001)
Observations	69,006,250	69,324,461	61,678,637	61,620,766
R-squared	0.082	0.140	0.023	0.003

Panel B: PA Scope-of-Practice Laws

	(1) Gestation	(2) Birth Weight	(3) APGAR	(4) I(Injury)
PA Autonomy	-0.001	-0.781	0.018	-0.000
	(0.018)	(4.394)	(0.017)	(0.000)
Quartile 2	0.024***	3.983***	0.027**	-0.001*
	(0.008)	(1.502)	(0.013)	(0.000)
Quartile 3	0.016**	3.382**	0.018	-0.001**
	(0.008)	(1.496)	(0.014)	(0.000)
Quartile 4	0.019**	4.059***	0.029*	-0.001*
	(0.008)	(1.465)	(0.015)	(0.000)
(PA Auton)x(Q2)	-0.013	-3.100	-0.031*	0.000
	(0.019)	(4.620)	(0.017)	(0.001)
(PA Auton)x(Q3)	0.012	0.988	-0.022	0.001
	(0.020)	(4.541)	(0.018)	(0.001)
(PA Auton)x(Q4)	0.009	4.856	-0.078***	0.001*
	(0.020)	(5.017)	(0.023)	(0.001)
Observations	69,006,250	69,324,461	61,678,637	61,620,766
R-squared	0.082	0.140	0.023	0.003

Notes: Dependent variables are listed at the top of each column. All specifications include the following control variables: a series of indicators for whether the mother's age is between: 15 – 19, 20 –24, 25 –29, 30 – 34, 35 –39, 40 – 44, 45 – 49, and over 50; indicators for whether the mother has completed an unknown education level, less than high school, high school, some college, or college (with more than college as the omitted category); indicators for African-American or black, Asian, Native American, and Hispanic; an indicator for a female infant; and indicators for multiple births (with singleton births as the omitted category). All specifications include individual state and year fixed effects. Standard errors clustered at the state and year levels are reported in parentheses.
* significant at the $p < 0.1$ level
** significant at the $p < 0.05$ level
*** significant at the $p < 0.01$ level

Table A8: Effect of Scope-of-Practice Laws on Obstetric Care and Outcomes

	(1) I(C-sect)	(2) I(C-sect | High Risk)	(3) I(C-sect | Low Risk)	(4) I(Elec C-Sect)	(5) I(Induction)	(6) I(Elec Induction)	(7) I(VBAC)	(8) Gestation	(9) Birth Weight	(10) APGAR	(11) I(Injury)
NP Independence	-0.009***	-0.010*	-0.008***	-0.008***	-0.015***	-0.016***	0.003***	0.039***	4.138**	0.032***	-0.001**
	(0.002)	(0.006)	(0.003)	(0.003)	(0.004)	(0.004)	(0.001)	(0.008)	(1.714)	(0.011)	(0.001)
PA Autonomy	-0.008***	-0.028***	-0.013***	-0.006**	-0.007*	-0.005	0.001**	-0.006	-1.869	-0.019	0.000
	(0.001)	(0.006)	(0.002)	(0.003)	(0.004)	(0.004)	(0.000)	(0.009)	(1.524)	(0.013)	(0.000)
Observations	69,395,709	21,279,136	48,116,573	69,395,709	69,395,709	69,395,709	69,395,709	69,006,250	69,324,461	61,678,637	61,620,766
R-squared	0.056	0.100	0.053	0.044	0.028	0.028	0.006	0.082	0.140	0.023	0.003

Notes: Dependent variables are listed at the top of each column. All specifications include the following control variables: a series of indicators for whether the mother's age is between: 15 – 19, 20 –24, 25 –29, 30 – 34, 35 –39, 40 – 44, 45 – 49, and over 50; indicators for whether the mother has completed an unknown education level, less than high school, high school, some college, or college (with more than college as the omitted category); indicators for African-American or black, Asian, Native American, and Hispanic; an indicator for a female infant; and indicators for multiple births (with singleton births as the omitted category). All specifications include individual state and year fixed effects. Standard errors clustered at the state and year levels are reported in parentheses.

* significant at the $p < 0.1$ level

** significant at the $p < 0.05$ level

*** significant at the $p < 0.01$ level