The Impact of the New York Nurse Practitioner Modernization Act on the Supply of Primary Care Nurse Practitioners: a Difference in Differences Design

Grant Martsolf (grm32@pitt.edu)
University of Pittsburgh

Ryan Kandrack
Aledade

Lusine Poghosyan
Columbia University

Stephen Ferrera
Columbia University

Research Article

Keywords: nurse practitioner, primary care, workforce, state policy

Posted Date: June 6th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1654478/v1

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Abstract

Background: Expanding scope of practice (SOP) for nurse practitioners (NPs) may increase NP supply which can help meet the growing demand in primary care. We examined the impact of enacting less restrictive NP practice restrictions—NP Modernization Act—in New York State (NYS) on the overall supply of primary care NPs and supply in underserved areas.

Methods: We used longitudinal data from the SK&A outpatient database (2012-2018) to identify primary care practices in NYS and in the comparison states (Pennsylvania [PA] and New Jersey [NJ]). Using a difference-in-differences design, we compared changes in 1) the presence and 2) total counts of NPs in primary care practice in NYS and neighboring comparison states (i.e., PA and NJ) before and after the policy change.

Results: The NP Modernization Act was associated with a 1.3 percentage point lower probability of a practice employing at least one NP on average across each of the 3 post-periods (95% CI: -0.024, -0.002). NP Modernization Act was associated with 0.065 fewer NPs on average across the post-period (95% CI: -0.119, -0.011). Results were similar in underserved areas.

Conclusions: The NP supply in NYS was lower after the NP Modernization Act than would have been expected based on the experience of comparison states. The negative relationship may be explained by gains in provider efficiency which leads to reduced NP hiring. More research is needed to understand the relationship between SOP regulations, NP supply, and access to care.

Background

The nurse practitioner (NP) workforce, which has been predicted to increase by 93% between 2013 and 2025, (1) represents a valuable source of primary care providers to help the country to meet the increasing demand for primary care services. (2-5) NPs can deliver high quality primary care (6-8); however, many barriers affect NPs’ ability to use the full range of their educational preparation to deliver care to patients. One issue affecting these providers is the variability of NP scope of practice (SOP) environments across the states. Currently, 24 states and the District of Columbia allow NPs to practice to the fullest extent of their education and training (9), while the remaining states require NPs to have supervisory or collaborative relationships with physicians to deliver care or prescribe medications. (10-13)

Many advocates have argued that restrictive SOP regulations can limit the supply of primary care NPs especially in underserved areas such as rural and low-income communities, which already lack shortage of health care providers. (14) Also, NPs might be less likely to relocate to states with restrictive SOP laws as they affect NPs’ ability to deliver care according to their training and education. Furthermore, the health care organizations in restrictive SOP states might be less likely to hire NPs as the SOP restrictions limit NPs’ ability to practice and deliver care to patients and they may also increase the burden on physicians who by state law are statutorily required to collaborate with or supervise NPs. In fact, several previous studies have found that states with fewer SOP restrictions on NP practice have more NPs per
capita compared to states with more restrictive SOP regulations, and NPs are less likely to move out of state following the removal of SOP restrictions. (15-19)

While these previous studies produce valuable evidence about the potential impact of state level SOP regulations on NP workforce supply, they have significant limitations. The most significant limitation of these studies is their cross-sectional design, and therefore, they are unable to account for fixed differences across states that have and have not removed restrictive SOP regulations. For example, states with more NPs may have more active and powerful NP professional organizations. In such a case, the supply of NPs may influence states’ action on SOP regulations, but not vice-versa. Furthermore, studies have not examined specifically the impact of SOP regulations on NP supply in primary care practices despite that most NPs are trained to deliver primary care and the NP workforce has been recognized as a solution for America’s primary care crisis. (9) One recent longitudinal study used data aggregated at the county-level and found little impact of SOP regulations on overall NP supply but did not directly estimate the effect of NP SOP specifically on primary care practices or on micro-level (i.e., Zip code). (20)

Due to these limitations, the findings from these studies have had limited utility for policymakers in efforts to understand the potential impact of removing NP SOP restrictions in an effort to strengthen primary care workforce supply and improve access to primary care services. In this study, for the first time we utilized detailed practice-level longitudinal data to examine the impact of removing SOP restrictions on the supply of NPs in primary care practices and specifically those practices located within rural and low-income communities. Specifically, we examined the impact of the New York Nurse Practitioners Modernization Act (NP Modernization Act) passed April of 2014 and became effective in January 2015.

Prior to 2015, the SOP regulations in New York state required all NPs to have a written practice agreement with a physician to practice and deliver care to patients. Under the NP Modernization Act, only newly licensed NPs, defined as having practiced less than 3,600 hours, must have a written practice agreement that is signed by a physician. Experienced NPs who have practiced for more than 3,600 hours are not subject to a written practice agreement. The new law also provides flexibility during the first phase of an NP's career. Although the Act does significantly relax SOP restrictions, NPs are still required to maintain “collaborative relationships” with either a physician and/or NYS hospital. This policy change was specifically designed to address the shortage and misdistribution of primary care providers across New York state by allowing NPs to practice independently where recruiting and retaining primary care physicians has historically been challenging. (21-23) Thus, the policy change aimed to increase the supply of NPs in underserved such as rural and low-income areas and promote access to care for patients.

With this policy change, New York state provides a unique environment to assess the direct impact of relaxing SOP restrictions on primary care NP workforce supply and address the weaknesses of existing studies on NP SOP regulations. We anticipate that the implementation of NP Modernization Act and the removal of the written practice agreement requirement between NPs and physicians will lead to primary
care practices being more willing to hire NPs, especially practices located in underserved areas as a qualitative study conducted in New York state in 2016 suggested. (24)

This study examines the impact of expanded state scope of practice regulation—Nurse Practitioners Modernization Act—in New York State (NYS) on the overall supply of primary care NPs and supply in underserved areas. Using longitudinal data for the years 2012 to 2018, we conducted a robust difference-in-differences design to examine the impact of the NP Modernization Act in New York State (NYS) on the overall supply of primary care NPs as well as supply in underserved areas. Our research design addresses the important limitation in previous cross-sectional studies showing that states with less restrictive NP SOP have larger NP supply compared to states with more restrictive SOP. Policymakers and advocates often interpret these correlations as causal, arguing that NP supply will increase after states expanded SOP to NPs. However, these causal arguments are difficult to justify in cross-sectional design. In our research design, we show that after passage of the Act, NYS experienced slower than expected growth in NP supply relative to comparison states. Our findings suggest that expanded SOP does not in fact lead to growth in NP supply and may even lead to reductions in NP supply, perhaps driven by improvements in efficiency.

Conceptual framework

Nurse practitioner scope of practice regulations may theoretically impact NP employment in primary care practices several ways. (14) Particularly, NP SOP regulations may exert downward pressure on provider supply but may also impact the productive capacity of NPs. First, The SOP regulations might impact the total supply of NPs in that state. It is reasonable to assume that NPs prefer to have fewer practice restrictions and, therefore, practice in states with fewer restrictions. NPs may simply choose not to relocate to states with restrictive NP SOP regulations or registered nurses may choose not to pursue graduate education. Alternatively, NPs may decide to relocate to states or choose to practice in settings within the state such as the Veterans Affairs that have less restrictive SOP regulations. Furthermore, in states requiring collaborative agreements between NPs and physicians, there are often costs associated with these arrangements and they are even very expensive. (25, 26) NPs may prefer to work in states that do not require these expensive agreements.

At the same time, the number of NPs working in is limited by the willingness and availability of physicians in the state to enter to work in collaborative agreements. (27, 28) Altogether, these forces likely exert downward pressure on the supply of NPs in a state with restrictive regulations, and therefore, there will be fewer eligible NPs for primary care practices to hire. Alternatively, SOP regulations may not have significant impact on NPs decisions about where to locate and work. Relocation to another state requires significant personal and financial costs that may not be worth the ability to work under less restrictive regulations. Many NPs even report preferring to work under the supervision of a physician. (29)

Less restrictive NP SOP regulations might also increase the productive capacity of NPs (14). Physician collaboration and supervision likely increases the time that NPs and physicians spend performing administrative tasks unrelated to direct patient care. (30) Previous studies do suggest that NPs in states
with fewer restrictions do deliver more clinical care. (31) This might allow NPs to provide more patient care. Such a scenario could actually both increase or decrease practice demand for NPs. Because NPs are more productive, practice may hire more to increase practice revenue. At the same time, because NPs are more productive, practice may need to hire fewer to meet existing patient demand.

Methods

Study Design

Building on previous cross-sectional analyses, we used longitudinal data to examine changes in NP supply in NYS and comparison states (i.e., NY and NJ). We first examined unadjusted longitudinal trends in NYS to describe trends in NP supply in primary care practices from 2012-2018. However, these unadjusted trends cannot be interpreted causally because any increases in NP supply in NYS could have occurred independent of the NP Modernization Act as NP supply has been increasing across the United States. Therefore, we used a difference-in-differences design to compare the NP supply in primary care practice in NYS to neighboring comparison states before and after the policy change. In a difference-in-differences design, the impact of the law is estimated based on the experience in New York State before and after the policy implementation compared to what would have happened (i.e., the counterfactual) in the absence of the policy change. To establish the counterfactual, we compared changes in NP supply in primary care practices in NYS to that in neighboring states (Pennsylvania [PA] and New Jersey [NJ]) before and after implementation of the NP Modernization Act. The comparison states border NYS and have similar population and healthcare market characteristics as NYS and serve as reasonable controls for the projected increase in NP counts. We would conclude a positive impact of the law if the pre-post changes for practices in New York state were greater than the pre-post changes for practices in PA and NJ and a negative impact of the law if the pre-post changes were less than those changes in practices in PA and NJ.

Data Sources

SK&A database. We used longitudinal data from the SK&A outpatient database (2012-2018) to identify primary care practices in NYS and in the comparison states (i.e., PA and NJ). The SK&A database contains information on the population of office-based providers in the U.S. and is the most complete resource of its kind (32). It provides information on providers (e.g., NPs, physicians) including name, practice name and location, contact information, network affiliation, and National Provider Identifier (NPI). This data source has an advantage over other sources in that it also contains information about number of providers, site specialty, and practice ownership that are not available elsewhere. (32) For our study, we retained only primary care practices. We defined primary care practices as those practices that had more than half of their providers with individual specialty of Family Practitioner, General Practitioner, Geriatrician, Internal Medicine/Pediatrics, Internist, Preventive Medicine Specialist, and Pediatrics. For our analysis, we retained only practices that had observations for all seven years (2012-2018) so that we can trace the full path of changes in NP counts in those practices over the entire study period.
American Community Survey (ACS). The ACS is an annual random survey of approximately 3.5 million housing units conducted by the U.S Census Bureau. We merged these data with SK&A practice-level data to identify practices that were located in underserved (i.e., rural or low-income) Zip codes. At the Zip-code level, only 5-year average estimates are available for income.

Area Health Resource File (AHRF). We also used AHRF, which is a dataset of county-level health information assembled by the Health Resources and Services Administration. The AHRF pulls information about health professionals, facilities, and demographic information from over 50 discrete data sources. These data were used to construct market-level covariates.

Variables

Dependent Variables. Using the SK&A dataset, we calculated practice-level dependent variables. The SK&A file provides provider-level observations. We used these provider-level observations to sum the total number of NPs within a practice. We then used these counts to calculate the following variables: 1) whether a practice has at least one NP and 2) total count of NPs. In the SK&A database, some NPs are attributed to multiple primary care practices. In order to ensure that we did not double count these providers, we estimated full-time equivalent (FTE) for each NP and divided those FTEs across all primary care practice sites to which the NPs were attributed in the SK&A database. Because we did not have any data on the actual amount of time spent by each NP at each practice, we proportionally divided the NP FTEs evenly across each attributed practice. For example, if in the SK&A database an NP had three listed practices as their employment setting, each of those practices would be assigned .33 FTEs for that NP.

Independent Variable. Our primary independent variable of interest was the NY NP Modernization Act. The NP Modernization Act was implemented in January of 2015. In order to estimate the impact of the Act, we generated a binary treatment variable which took the value of “1” in NYS in the years 2015, 2016, 2017, and 2018 and “0” otherwise.

We compared the impact of the NP Modernization Act overall and separately for practices in underserved areas and those in rural areas. Using ACS data, we characterized each practice as being in an underserved area including rural and/or low-income communities. We consider practices to be in underserved areas if they were in either a rural or low-income community. A practice is considered rural if it is located in a “rural” (RUCA>4) Zip code using Rural-Urban Commuting Area Codes (RUCAs) (33, 34). We identified a practice as being in a low-income community if the median household income of the community is in the lowest quartile among other Zip codes across the study states. (35, 36)

Covariates. In the analytic models, we controlled for a number of practice- and market-level variables. For practice characteristics, we included the number of physicians in the practice to control for practice size. For market characteristics, in all regressions, we included the following AHRF-derived county characteristics in each year: the percent of population that is Medicare-eligible, Medicare Advantage penetration rate, per capita income, poverty rate, unemployment rate, number of active physicians per 100,000 population, number of hospital beds per 100,000 population, number of federally qualified health
centers (FQHCs), and number of rural health clinics. These represent time-varying patient demand and healthcare supply factors that may influence NP supply. We have used these control variables in other studies. (20)

Data Analysis

We first examined and described unadjusted trends in NP supply of NPs in primary care practices from 2012-2018 in NYS as well as comparison states. We then estimated the association between the NYS NP Modernization Act and NP supply in primary care practices using a difference-in-differences design. The difference-in-differences model is constructed as a fixed effect model which introduces a separate intercept for each practice in year. This regression specification allows us to trace within-practice changes in NP counts over time both before and after the policy change. Specifically, we used ordinary least squares regression to estimate the following model for practice i in county j and year t:

\[ Y_{ijt} = \beta_0 + \sum_{k=-3,k\neq 0}^{3} \beta_k * 1(t - 2015 = k) + X_{ijt} \beta + \delta_t + \gamma_i + \epsilon_{ijt} \]

Where Y represents the dependent variables, X represents a matrix of practice and market covariates, \( \delta \) is the year fixed effect, and \( \gamma_i \) is the practice-level fixed effect. The indicators \( \beta_k \) represent the effect of the NY Modernization Act separately in each of the 3 years leading into the policy (i.e., before 2015) and the 3 years following the policy in practices located in NY relative to practices in the comparison states. The year 2015 is omitted as the reference year in which the policy was implemented. To calculate a single overall effect of the policy, we averaged the post-2015 coefficients and used the delta method to calculate standard errors on those averages. We estimated these models for the full sample and then separately by rural and low-income areas to assess differential effects of the policy on practices located in these communities.

The primary assumption of the difference-in-differences design is parallel trends in the pre-policy period. That is, practices in NY would have experienced the same trend in outcomes as practices located in PA and NJ. While not directly testable since the assumption relates to parallel trends in potential outcomes after the policy change, we test for differential trends in the pre-period by conducting an F-test that each of the pre-period coefficients are jointly equal to zero. A lack of differences in the pre-period would raise confidence in the credibility of the research design, and in particular of using practices in PA and NJ as valid comparisons.

All models were estimated using ordinary least squares regression. The models using the binary variable of having at least one NP in the practice were estimated as linear probability models. In each regression, we clustered the standard errors by practice to account for autocorrelation within a practice. When
modeling count data, the error term is unlikely to be normally distributed and thus test statistics may be invalid. Therefore, we chose to bootstrap the standard errors. As a sensitivity check, we also re-estimated our models using the full dataset as opposed to the balanced sample (i.e. only practices that were in our dataset each year of the study). The results were the same.

Results

Table 1 compares baseline 2012 practice- and market-level characteristics of the primary care practices in the sample. There was a total of 11,808 practices that employed NPs in the balanced panel sample of which 5,517 were located in NY and 6,291 were located in the comparison states. Practices in NY had higher values on all of the dependent variables so higher levels of NP employment across the board, though physician counts were significantly lower. The differences in all of the covariates were statistically significant as shown in Table 1.
Table 1
Descriptive statistics overall and by New York State and Comparison states in 2012

<table>
<thead>
<tr>
<th>Variable</th>
<th>Overall (n = 11,808)</th>
<th>NYS (n = 5,517)</th>
<th>Comparison states, PA and NJ (n = 6,291)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent of practices with any NP</td>
<td>17.9%</td>
<td>18.71%</td>
<td>17.26%</td>
<td>.04</td>
</tr>
<tr>
<td>NP Counts among practices with any NP</td>
<td>1.37</td>
<td>0.93</td>
<td>1.44</td>
<td>1.02</td>
</tr>
<tr>
<td>Overall NP Counts</td>
<td>0.25</td>
<td>0.66</td>
<td>0.27</td>
<td>0.72</td>
</tr>
<tr>
<td><strong>Practice-level control variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Practice-level physician count</td>
<td>2.28</td>
<td>2.58</td>
<td>2.19</td>
<td>2.57</td>
</tr>
<tr>
<td><strong>County-level control variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per capita income</td>
<td>$54,954</td>
<td>$25,254</td>
<td>$59,326</td>
<td>$34,172</td>
</tr>
<tr>
<td>Poverty rate</td>
<td>13.91</td>
<td>5.98</td>
<td>15.76</td>
<td>6.19</td>
</tr>
<tr>
<td>Percent Unemployment</td>
<td>8.59</td>
<td>1.5</td>
<td>8.46</td>
<td>1.35</td>
</tr>
<tr>
<td>Percent Medicare</td>
<td>16.85</td>
<td>2.95</td>
<td>16.09</td>
<td>2.58</td>
</tr>
<tr>
<td>Percent Medicare Advantage penetration</td>
<td>30.09</td>
<td>14.45</td>
<td>32.61</td>
<td>11.93</td>
</tr>
<tr>
<td>Percent uninsured</td>
<td>12.77</td>
<td>3.25</td>
<td>12.66</td>
<td>3.24</td>
</tr>
<tr>
<td>Number of FQHCs</td>
<td>9.08</td>
<td>10.67</td>
<td>10.83</td>
<td>9.74</td>
</tr>
<tr>
<td>Number of beds</td>
<td>354.07</td>
<td>203.76</td>
<td>374.02</td>
<td>182.13</td>
</tr>
<tr>
<td>Physicians per 100,000 people</td>
<td>379.19</td>
<td>277.02</td>
<td>441.97</td>
<td>327.18</td>
</tr>
<tr>
<td>Percent rural</td>
<td>6.19</td>
<td>7.53</td>
<td>5.01</td>
<td></td>
</tr>
<tr>
<td>Percent low-income</td>
<td>25.01</td>
<td>24.92</td>
<td>25.08</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Statistical significance estimating using t-test for continuous variables and chi-squared for categorical. FQHC = federally qualified health center
Figure 1 shows trends in counts of NPs per practice from 2012–2018 in NY as well as comparison states overall as well as within rural and low-income communities. NP supply in NYS and comparison states both increased during the study period. In 2012, 19% of all primary care practices in NY had at least one NP and, in 2018, 22% of practices had at least one NP. In comparison states, 17% of practices had at least one NP in 2012 and 24% of practices had at least one NP in 2018. In NY, there were, on average, 1.44 NPs per practice among practices with at least one NP in 2012 and 1.47 in 2018. In comparison counties, there were 1.30 NPs per practice in 2012 and 1.39 in 2018. In rural counties in 2012, 40% of practices in NY had at least one NP and, in 2018, 42% of practices had at least one NP. In comparison states, 29% of practices had at least one NP in 2012 and 33% of practices had at least one NP in 2018. In NY, there were, on average, 1.3 NPs per practice among practices with at least one NP in 2012 and 1.47 in 2018. In comparison counties, there were 1.15 NPs per practice in 2012 and 1.24 in 2018. In low-income communities in 2012, 23% of practices in NY had at least one NP and, in 2018, 27% of practices had at least one NP. In comparison states, 15% of practices had at least one NP in 2012 and 22% of practices had at least one NP in 2018. In NY, there were, on average, 1.60 NPs per practice among practices with at least one NP in 2012 and 1.57 in 2018. In comparison counties, there were 1.42 NPs per practice in 2012 and 1.53 in 2018.

In Table 2, we present the coefficients representing the effect of NP Modernization Act on the probability of employing at least one NP. Across all regressions, there were no statistically significant differences in the pre-period trends, raising our confidence that the models meet the parallel trends assumption. In the overall regression, the NP Modernization Act was associated with a 1.3 percentage point lower probability of a practice employing at least one NP on average across each of the 3 post-periods (95% CI: -0.024, -0.002). The effect varied slightly over time and did not substantially decrease until 2 years after the policy change. There was a larger effect when we limited to rural communities. In these rural models, NP Modernization was associated to a 5.9 percentage point lower probability of a practice employing at least one NP on average across the 3 post-periods (95% CI: -0.106, -0.014). The effect appeared 1 year after the policy and increased in magnitude 2 years after the policy change (5.4 and 7.0 percentage point reduction, respectively). Finally, the NP Modernization Act did not have substantial effects on practices in low-income communities. Overall, the policy was associated with a 2.2 percentage point lower probability of having at least one NP for practices in low-income communities, though this was not statistically significant. Only the effect at 2-years after the policy change was statistically significant, representing a 2.6 percentage point lower probability of having at least one NP.
Table 2
Regression results for the probability of employing at least 1 NP

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>Rural communities</th>
<th>Low-income communities</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 years before</td>
<td>0.011</td>
<td>-0.022</td>
<td>-0.007</td>
</tr>
<tr>
<td></td>
<td>[-0.002,0.023]</td>
<td>[-0.072,0.028]</td>
<td>[-0.034,0.020]</td>
</tr>
<tr>
<td>2 years before</td>
<td>0.007</td>
<td>0.005</td>
<td>-0.002</td>
</tr>
<tr>
<td></td>
<td>[-0.004,0.017]</td>
<td>[-0.038,0.049]</td>
<td>[-0.024,0.021]</td>
</tr>
<tr>
<td>1 year before</td>
<td>0.007</td>
<td>-0.031</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>[-0.001,0.016]</td>
<td>[-0.070,0.008]</td>
<td>[-0.013,0.021]</td>
</tr>
<tr>
<td>1 year after</td>
<td>-0.009</td>
<td>-0.054*</td>
<td>-0.013</td>
</tr>
<tr>
<td></td>
<td>[-0.018,0.000]</td>
<td>[-0.102,-0.006]</td>
<td>[-0.033,0.006]</td>
</tr>
<tr>
<td>2 years after</td>
<td>-0.016**</td>
<td>-0.070**</td>
<td>-0.026*</td>
</tr>
<tr>
<td></td>
<td>[-0.028,-0.004]</td>
<td>[-0.121,-0.019]</td>
<td>[-0.051,0.000]</td>
</tr>
<tr>
<td>3 years after</td>
<td>-0.015*</td>
<td>-0.055</td>
<td>-0.027</td>
</tr>
<tr>
<td></td>
<td>[-0.029,-0.002]</td>
<td>[-0.111,0.000]</td>
<td>[-0.057,0.003]</td>
</tr>
<tr>
<td>Overall effect</td>
<td>-0.013*</td>
<td>-0.059*</td>
<td>-0.022</td>
</tr>
<tr>
<td></td>
<td>[-0.024,-0.002]</td>
<td>[-0.106,-0.014]</td>
<td>[-0.046,0.001]</td>
</tr>
<tr>
<td>Observations</td>
<td>82475</td>
<td>5076</td>
<td>20503</td>
</tr>
<tr>
<td>P-value from F-test of pre-policy coefficients</td>
<td>0.19</td>
<td>0.09</td>
<td>0.86</td>
</tr>
</tbody>
</table>

95% confidence intervals in brackets

* p < 0.05, ** p < 0.01, *** p < 0.001

Table 3 displays the regression results for the effect of the NP Modernization Act on the count of NPs among practices that employ at least 1 NP. As with the previous regressions, we did not find evidence of pre-period trend differences in any model, which raises our confidence in these models as meeting the parallel trend assumption. In the overall model, we find that the NP Modernization Act was associated with 0.065 fewer NPs on average across the post-period (95% CI: -0.119, -0.011). Practices responded immediately after the policy such that the number of NPs per practice was lower by 0.060 and 0.069 1 and 2 years after the policy change, respectively. The NP Modernization Act did not affect the number of
NPs in practices in rural or low-income communities. Specifically, the NP Modernization Act did not lead to statistically significant differences in the count of NPs when limiting to rural communities or low-income communities with the exception of 0.175 fewer NPs on average in rural communities 3 years after the policy (95% CI: -0.335, -0.015).

Table 3
Regression results for the count of NPs among practices that employ at least 1 NP

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>Rural communities</th>
<th>Low-income communities</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 years before</td>
<td>0.054</td>
<td>-0.038</td>
<td>0.040</td>
</tr>
<tr>
<td></td>
<td>[-0.016,0.124]</td>
<td>[-0.205,0.128]</td>
<td>[-0.111,0.191]</td>
</tr>
<tr>
<td>2 years before</td>
<td>0.040</td>
<td>-0.055</td>
<td>-0.022</td>
</tr>
<tr>
<td></td>
<td>[-0.022,0.101]</td>
<td>[-0.194,0.084]</td>
<td>[-0.160,0.115]</td>
</tr>
<tr>
<td>1 year before</td>
<td>0.035</td>
<td>0.005</td>
<td>-0.002</td>
</tr>
<tr>
<td></td>
<td>[-0.009,0.079]</td>
<td>[-0.119,0.130]</td>
<td>[-0.106,0.102]</td>
</tr>
<tr>
<td>1 year after</td>
<td>-0.060**</td>
<td>-0.082</td>
<td>-0.053</td>
</tr>
<tr>
<td></td>
<td>[-0.106,-0.015]</td>
<td>[-0.232,0.067]</td>
<td>[-0.149,0.043]</td>
</tr>
<tr>
<td>2 years after</td>
<td>-0.069*</td>
<td>-0.114</td>
<td>-0.075</td>
</tr>
<tr>
<td></td>
<td>[-0.130,-0.008]</td>
<td>[-0.268,0.039]</td>
<td>[-0.210,0.060]</td>
</tr>
<tr>
<td>3 years after</td>
<td>-0.066</td>
<td>-0.175*</td>
<td>-0.092</td>
</tr>
<tr>
<td></td>
<td>[-0.134,0.001]</td>
<td>[-0.335,0.015]</td>
<td>[-0.235,0.051]</td>
</tr>
<tr>
<td>Overall effect</td>
<td>-0.065*</td>
<td>-0.124</td>
<td>-0.073</td>
</tr>
<tr>
<td></td>
<td>[-0.119,-0.011]</td>
<td>[-0.260,0.126]</td>
<td>[-0.188,0.042]</td>
</tr>
<tr>
<td>Observations</td>
<td>17258</td>
<td>1888</td>
<td>4461</td>
</tr>
<tr>
<td>P-value from F-test of pre-policy coefficients</td>
<td>0.35</td>
<td>0.78</td>
<td>0.66</td>
</tr>
</tbody>
</table>
| 95% confidence intervals in brackets

* p < 0.05, ** p < 0.01, *** p < 0.001

Discussion
In this study, we estimated the impact of the NP Modernization Act on the supply of NPs in primary care practices and particularly within rural and low-income communities. Our study is the first of its kind to use detailed practice-level data to estimate the impact of SOP on NP employment within primary care practices. Our paper is also one of few to use robust quasi-experimental design to estimate the impact of less restrictive SOP regulations on the primary care workforce. There are a number of important findings that emerge from this work that expand the current literature on the relationship between SOP regulations and NP workforce.

Previous cross-sectional studies have found that states with less restrictive SOP regulations have more NPs per capita than states with more restrictive SOP regulations. (18, 37–39) Many policymakers and advocates have used such findings to suggest that if states pass less restrictive SOP regulations then the supply of NPs will increase in those states. However, previous studies using cross-sectional models do not account for unobserved differences across states that might be impacting NP workforce. (18, 37–39)

We aimed to improve on the existing literature by using a longitudinal design to examine the extent to which the NP Modernization Act leads to an increase in NP supply in primary care practices. We found that the NP supply in NYS did increase from 2012–2018. However, supply in our comparison states also experienced increases in NP supply, independent of changes to NP SOP. Therefore, examining only the pre-post changes in NY does not account for unobserved factors that might contribute to pre-post changes in NP supply in primary care practices that are independent of the NP Modernization Act.

Using a differences-in-differences design, we are able to directly compare the experience of NYS pre-post regulatory changes to a counterfactual of what would have happened in NYS if they had never changed the SOP regulations by using the experiences of PA and NJ. When we use a differences-in-differences design, we found that the NP Modernization Act did not lead to increases in NP supply in primary care practices. In this way, our results are similar to a recent study showing that, when using difference-in-differences models, NP SOP regulations have not lead to increases in NP supply. (20)

Alternatively, we found that the NP Modernization Act was actually negatively associated with NP supply in many primary care practices. Increases in NP primary care employment in NYS after the NP Modernization Act were actually lower than what we would have expected given the PA and NJ counterfactual. It is not clear why the act would have actually contributed to lower than expected changes in NP supply. One potential explanation for these findings is that less restrictive state SOP regulations led to improvements in efficiency for existing NPs and physicians within primary care practices. Statutory written practice agreements between NPs and physicians require added work from both the physician and NP creating non-trivial inefficiencies. Less restrictive SOP regulations may increase physicians and NP productivity due to reduced administrative or supervisory burden. Counter to popular belief that the NP Modernization Act would expand NP employment, practices instead may have effectively increased the productivity of their practice without hiring additional NPs.

These potential increases in productivity are consistent with previous studies showing that less restrictive SOP regulations have contributed to expanded access to care. (31) However, a previous study suggests
that the NP Modernization Act may have led to very small increases in access to care but those increases were negligible. (40) It may be that any increased efficiency may have been offset by reductions in NP hiring in the case of NYS. Our study was unable to directly examine practice efficiency so could not directly test this hypothesis. Our study does, however, lay a foundation for future studies to evaluate the impact of the NP SOP laws over time on workforce-related outcomes other than simple supply numbers.

The study has limitations. The NP Modernization Act was implemented in 2015 and the 3-year time period after the law change may not allow adequate time for a supply response. Although this is not a major limitation as research on state policy changes shows immediate and measurable responses to policy changes using a similar research design as the one proposed (difference in differences) (41) and suggests that dynamic responses to policy change occur rapidly (42–44). The accuracy of the dataset used to identify primary care practices is a limitation. We have not verified if the NPs in the SK&A database indeed practiced in the setting. Also, NP Modernization Act did not fully remove regulatory restrictions on NP practice. Though the Act removed written practice agreements, NPs continue to be required to have collaborative relationships either with a physician or a hospital. It may be the fact that positive impact of relaxing SOP restrictive are only operative when restrictions are lifted completely as opposed to a piecemeal manner.

**Conclusions**

Many previous cross-sectional studies have shown that state SOP regulations are correlated with overall supply of NPs. States that allow for more NP practice independence also have larger NP supply. Many policymakers and advocates have interpreted these correlations as causal, arguing that if states expand NP SOP, they will experience an increase supply of NPs. However, emerging literature suggests that these results are not robust to longitudinal designs. In this study, we evaluate the impact of the New York Nurse Practitioner Modernization Act on the supply of primary care NPs overall and within underserved communities using a robust difference-in-differences design. We found that supply in NYS was lower than would have been expected after the NP Modernization compared to the experience of comparison states. We suggest that this negative relationship between increase NP independence and NP supply may be explained by gains in provider efficiency. More research is needed to better understand the dynamic relationship between SOP regulations, NP supply, and patient access to care.

**Abbreviations**

List of abbreviations

Scope of practice (SOP)

Nurse practitioner (NP)

New York State (NYS)
Pennsylvania (PA)

New Jersey (NJ)

New York Nurse Practitioners Modernization Act (NP Modernization Act)

National Provider Identifier (NPI)

American Community Survey (ACS)

Area Health Resource File (AHRF)

Full-time equivalent (FTE)

Rural-Urban Commuting Area Code (RUCA)

Federally qualified health center (FQHC)

**Declarations**

**Ethics approval and consent to participate:**

This study was approved by the Institutional Review Board at the Columbia University. The IRB waved the need for informed consent.

**Consent for publication:** Not applicable

**Availability of data and materials**

- SK&A database: The data that support the findings of this study are available from SK&A but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. All methods were carried out in accordance with institutional guidelines and regulations.

- American Community Survey (ACS): The datasets analyzed during the current study are available in the ACS website (https://www.census.gov/programs-surveys/acs). All methods were carried out in accordance with relevant guidelines and regulations.

- Area Health Resource File (AHRF): The datasets analyzed during the current study are available in the AHRF website (https://data.hrsa.gov/topics/health-workforce/ahrf). All methods were carried out in accordance with relevant guidelines and regulations.

**Competing interest:** The authors declare that there is no financial and non-financial competing interest.

**Funding:** The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This project was supported by the National Council of State Boards of Nursing.
Authors' contribution:

Martsolf conception, design of the work, acquisition, analysis, interpretation of data, drafted the work

Kandrack analysis, interpretation of data, drafted the work or substantively revised it Ferrera interpretation of data, drafted the work or substantively revised it

Poghosyan conception, design of the work, acquisition, interpretation of data, drafted the work

All authors approve of this submitted version and are personally accountable for its contents.

Acknowledgements: Not applicable

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Figures

Figure 1

Trends in counts of nurse practitioners in primary care practices over time, 2012-2018

a) Percent of primary care practices with at least 1 NP by all, rural, and low-income practices
b) Average number of NPs among practices with at least 1 NP by all, rural, and low-income practices