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Associations between State Scope of Practice Laws and US Physician Assistant Wages from 1997–2017: A Longitudinal Analysis

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Associations between State Scope of Practice Laws and US Physician Assistant Wages from 1997–2017: A Longitudinal Analysis

ABSTRACT

Objective

The purpose of this study is to determine whether, and to what degree, variation in Physician Assistant (PA) state scope of practice (SOP) laws across states are associated with 1) PA median wage over time, and 2) if a specific SOP key element has a greater impact on PA median wage than others. We hypothesize that expanded SOP laws would be associated with higher PA wage.

Design

Longitudinal analysis from 1997 to 2017.

Setting

Fifty states and the District of Columbia.

Participants

Employed PAs from 1997 to 2017.

Methods

Four national data sets were combined to allow for longitudinal analysis of state level annual PA wage with state SOP laws. We used linear regression models to explore the predicting effect of SOP elements on PA wage in 5-year intervals and individual growth models to assess the change in PA annual wage over the study period.

Results

There was a 220% increase in weighted PA annual wage over two-decades. There was a positive linear correlation between annual wage and age in 2012 and 2017 ($r=0.52$, $P<0.01$; $r=0.29$, $P=0.04$, respectively). The adjusted R^2 for individual SOP elements in the selected years were all small (Range: 0.0-0.29), with no appreciable pattern across time for any SOP element. In 1997, several SOP laws show association with median wage but this impact disappears over time.

Conclusions

PA median wage has risen over two-fold in the past two decades with the rise in PA wage mainly explained by time and the age of providers. In 1997 some SOP elements were associated with increased average wage, however, the impact of this increase diminished over time in all such instances. Future research needs to realize the impact specialty practice has on wage as we look to fill the gaps in our health care system.

Key Words

Physician assistant, annual wage, scope of practice laws, health policy, organization of health services

Strengths and Limitations

- Data from the Bureau of Labor and Statistics (BLS) provided employed Physician Assistants (PAs) census data for all employed PAs from 1997 to 2017 for all 50 states and the District of Columbia.
- Comprehensive state legislative SOP data from the American Academy of Physician Assistants (AAPA) was cross referenced and verified for each state and each year and then combined with the annual wage data from the BLS.
- This is the first study analysing two decades of national PA wage data for all 50 states and the District of Columbia longitudinally to describe the effect of state SOP laws on wage.
- The analysis did not include other possible confounding variables that may impact PA wage including PA specialty, physician or nurse practitioner employment numbers, or state and federal healthcare legislative policies.

Associations between State Scope of Practice Laws and US Physician Assistant Wages from 1997–2017: A Longitudinal Analysis

INTRODUCTION

Despite the increase in supply of Physician Assistants (PAs) over the last twenty years, PA salaries have continued to rise.[1, 2] The number of employed PAs has risen from 13,500 in 1992 to 140,000 in 2019.[3, 4] Meanwhile, the median salary has continued to rise to a reported $105,000 in 2019.[5] Nonetheless, demand remains strong with an estimated five job postings per PA graduate.[1] Due to this demand, a survey of 26 academic medical centers reported a range of 3.5 to 63 weeks to fill an open PA position.[6]

This high employer demand continues to draw large numbers of students to the PA profession, with a reported 2.95 applicants per 1 PA program seat.[7] An analysis of American Academy of Physician Assistants (AAPA) student surveys indicated that upon entering PA school, a majority of students expect to amass student loan debt of $75,000–$124,999 and earn salaries between $80,000 and $89,999.[8] Prior research on PA wages indicates that wage is impacted by gender, specialty, geographic region, years of practice, cost of living, local economy, and population density.[2] An analysis by Morgan et al. demonstrated that a higher ratio of PAs to MDs was correlated with higher salaries, suggesting that restrictions around practice ratios may have an impact on salaries.[9] Higher PA salaries have also been correlated with larger number of PAs employed in high-paid specialties.[1, 2] Together, these prior studies suggest that scope of practice (SOP) may be associated with PA wages, however this relationship remains largely unexplored.[1, 10, 11]

Prior research has demonstrated that there is an inverse relationship between the supply of PAs and NPs and the level of restrictiveness of scope of practice laws.[12-17] An analysis of 2018 AAPA Salary Report data found a statistically significant difference in PA salary in states that passed the following three scope of practice (SOP) key elements: scope determined at practice site; adaptable supervision requirements; and no chart co-signature requirement.[18] Despite the legislative work at the state level over the decades, there remains wide variation in PA SOP laws in the United States (US), ranging from restrictive to permissive.[17] The purpose of this study is to determine whether, and to what degree, variation in PA state SOP laws across states are associated with 1) PA median wage over time, and 2) if a specific SOP key element has a greater impact on PA median wage than others. We hypothesize that expanded PA scope of practice would be associated with higher PA wage.

METHODS

Data

Data were obtained from the Bureau of Labor and Statistics (BLS), AAPA census, and the AAPA database on PA legislative history. Census data were obtained from the U.S. Census Bureau to estimate

PA/population ratio by state.[19-22] These four datasets were linked to allow for evaluation of annual PA demographics, SOP laws by state, and wage data from all 50 U.S. states and the District of Columbia (DC) during the 21-year period from 1997 to 2017. The combined state/year dataset included number of employed PAs and median wage in each state annually from the BLS, PA demographics from the AAPA census, state SOP laws from AAPA legislative history, and PA/population ratio by state from the U.S. Census Bureau.

Independent Variables (IV), Dependent Variable (DV), and Covariates

Scope of Practice (IV): The AAPA established the ideal PA practice act which includes the 6 Key Elements of a Modern PA Practice Act: 1) licensure as a regulatory term, 2) full prescriptive authority, 3) scope of practice determined at the practice level, 4) adaptable collaboration requirements, 5) co-signature requirements determined at the practice level, and 6) number of PAs a physician may collaborate with determined at the practice level.[23] Data from AAPA included which six key elements were approved in each state by year. From this, the total number of key elements in a given state in a given year was calculated. There were no missing data for the number of key elements.

Annual Wage Estimates (DV): In the BLS occupational employment statistics (OES) survey, annual wage estimates are defined as straight-time, gross pay, exclusive of premium pay. Included in the collection of OES wage data are base rate, cost-of-living allowances, guaranteed pay, hazardous-duty pay, incentive pay including commissions and production bonuses, on-call pay, and tips. Excluded from the wage data are back pay, jury duty pay, overtime pay, severance pay, shift differentials, nonproduction bonuses, and tuition reimbursements.[24]

Covariates: The AAPA census provided mean age and percent female gender for each state by year. There were no missing data for mean age or gender.

Statistical Analysis

We used descriptive statistics to summarize PA and states demographics. We conducted multiple linear regression models to explore the predicting effect of SOP elements in PA wage change in the selected years of 1997, 2002, 2007, 2012, and 2017. Multiple linear regression models were adjusted for age and percent female PA, and weighted for the PA population size in each state. To assess the change in PA annual wage over years 1997 to 2017, individual growth analyses were applied at the level of the state to examine the impact of presence or absence of a key element on wage growth over time. All growth models were adjusted for year, and the time-varying covariates of mean PA age, and percent female PAs within the state. As in our linear regression models, our individual growth models were additionally weighted for the PA population size in each state.

Missing Data: State-level missing values on the time-varying variables of PA annual wage (n=9, 0.8%), number of employed PAs (n=28, 2.6%), and PA age and percent female PAs (n=204, 19% per variable)

were imputed with the average of the state's last known and next known observations. In case of 2 missing values in a row (i.e. PA age and percent female PAs in years 2011 and 2012 for all states and DC), the last observation carried forward (LOCF) and the next observation carried backward (NOCB) techniques were used, respectively. In two cases of 3 missing values in a row for employed PAs (Hawaii and Arkansas), after replacing the LOCF and NOCB for the 1st and 3rd missing values, respectively, the average of these replaced values was used for the middle (2nd) missing value.

All analyses were conducted using SAS version 9.4.

RESULTS

We analyzed 1,071 PA annual wage records from 50 states and DC over 21 years. **Table 1** summarizes cross-sectional demographics of U.S. employed PAs, and states demographics for selected years of 1997, 2002, 2007, 2012, and 2017 (5-year intervals). Overall, weighted PA annual wage increased steadily with the minimum wage earned seen in Mississippi for all years measured except 1997. The median age of sampled PAs was stable across time at between 40 and 41 years. The median percent of female PAs showed a constant increase over the study timeframe, growing from 49% in 1997 to 69% in 2017. There was a positive linear correlation between annual wage and age in 2012 and 2017 ($r=0.52$, $P<0.01$; $r=0.29$, $P=0.04$, respectively). The negative linear correlation between annual wage and percent female PAs was only statistically significant in 2012 ($r=-0.41$, $P<0.01$) (**Supplementary Table 1**). The weighted PA median ratio per 100,000 population increased monotonically from 23.4 PA in 1997 to 33.2 PA per 100,000 population in 2017. Likewise, the median number of PA SOP laws also increased monotonically over the study period, from 2 in 1997 to 4 in 2017. **Figure 1** demonstrates the 220% increase in weighted PA annual wage over the observation period, from a median of $47,060 in 1997 to $103,480 in 2017. The number of states with adoption of each of the six AAPA Key Elements is displayed with Licensure accepted early by all states and PA to physician ratio determined at the practice level least adopted by states.

Table 1 Physician Assistant and State Demographics and Median Wage in 1997, 2002, 2007, 2012, and 2017

	Year				
	1997	**2002**	**2007**	**2012**	**2017**
Physician Assistants Demographics					
Age[a]					
Mean (SD)	40.9 (1.8)	41.2 (1.8)	39.7 (2.1)	40.8 (2.1)	39.7 (2.1)
Median (IQR)	41 (3)	41 (2)	41 (3)	41 (3)	40 (2)
Minimum (state)	36 (NJ)	37 (NJ)	37 (NJ)	34 (DC)	33 (AR)
Maximum (state)	46 (AR)	48 (NM)	47 (AK, NM)	47 (WY)	47 (WY)
Percent female[a]					
Mean (SD)	48.2 (8.6)	58.4 (7.0)	63.9 (6.0)	67.0 (6.0)	69.2 (5.8)
Median (IQR)	49 (11)	60 (11)	64 (7)	68 (6)	69 (6)
Minimum (state)	20 (MS)	18 (MS)	38 (UT)	40 (WY)	44 (HI)
Maximum (state)	75 (ND)	75 (ND)	79 (ND)	77 (ND)	78 (IL, PA, WI)
Annual wage (USD)[ab]					
Mean (SD)	44,921 (8,315)	63,546 (9,545)	77,843 (7,231)	92,451 (7,579)	104,760 (7,886)
Median (IQR)	47,060 (12,250)	67,520 (11,270)	79,240 (5,560)	92,150 (10,800)	103,480 (12,150)
Minimum (state, # scope of practice laws)	22,700 (AR, 1)	37,490 (MS, 1)	42,160 (MS, 2)	50,200 (MS, 2)	70,190 (MS, 2)
Maximum (state, # scope of practice laws)	77,210 (DE, 3)	78,900 (AR, 4)	91,010 (CT, 2)	112,250 (RI, 6)	120,200 (WA, 3)
State Demographics					
Population density/square mile[c]					
Mean (SD)	245.4 (470.9)	253.4 (469.5)	257.1 (462.2)	266.3 (513.3)	274.2 (565.7)
Median (IQR)	173.5 (195.8)	177.2 (195.8)	187.2 (189.8)	200.1 (185.3)	210.8 (177.3)
Minimum (state)	1.1 (AK)	1.1 (AK)	1.2 (AK)	1.3 (AK)	1.3 (AK)
Maximum (state)	9,307.2 (DC)	9,396.0 (DC)	9,416.5 (DC)	10,408.6 (DC)	11,391.9 (DC)
Number of scope of practice laws[d]					
Mean (SD)	2.2 (1.4)	2.6 (1.4)	2.8 (1.4)	3.3 (1.4)	3.7 (1.4)
Median (IQR)	2 (2)	2 (2)	3 (2)	3 (2)	4 (2)
Minimum (state)	0 (MS,NV,OH,PA,SC,VA,WI)	0 (OH,PA)	0 (OH)	0 (OH)	1 (AL,IA,SC)
Maximum (state)	5 (ME, NC)	6 (RI)	6 (NM, RI)	6 (ND, NM, RI)	6 (ND,NM,MA,MI,MN,RI)
PA ratio/100,000 population[e]					
Mean (SD)	24.7 (7.6)	26.2 (11.4)	26.2 (10.8)	31.9 (12.6)	38.5 (14.0)
Median (IQR)	23.4 (9.5)	25.5 (19.8)	23.5 (14.7)	32.9 (21.9)	33.2 (20.5)
Minimum (state)	8.8 (RI)	3.2 (MS)	4.6 (AR)	4.4 (MS)	8.4 (MS)
Maximum (state)	47.9 (DE)	52.6 (SC)	80.1 (DC)	75.3 (AK)	72.0 (DC)

SD: Standard Deviation; IQR: Interquartile Range; USD: United States Dollar
For the states name, we used two-letter states abbreviations.
[a] Weighted by states' PA population
[b] See supplementary Table 1 for -linear correlation of PA annual wage with age and percent female PA in the respective year
[c] Densities of 50 States + DC per square mile, weighted by the population of states and DC (state population in year/state area in square mile)[19-22]
[d] PA scope of practice laws are the 6 Key Elements of a Modern PA Practice Act [23]
[e] (employed PA in year/state population in that year) * 100,000, weighted by states' PA population

Supplementary Table 2 shows the adoption of SOP laws in the US for selected years of 1997, 2002, 2007, 2012, and 2017 (5-year intervals). SOP elements follow a similar pattern of increased adoption over time, including: scope of practice (71% in 2017 versus 49% in 1997); full prescriptive authority (65% in 2017 versus 25% in 1997); co-signature requirements (61% in 2017 versus 39% in 1997); adaptable collaboration requirements (55% in 2017 versus 35% in 1997); and number of PAs a physician may collaborate with (24% in 2017 versus 18% in 1997). There is also significant heterogeneity in SOP element adoption by state. For example, Alabama, Iowa, and South Carolina had adopted only one, while six states (North Dakota, New Mexico, Massachusetts, Michigan, Minnesota, and Rhode Island) had adopted all six key elements as of 2017 (**Table 1, Supplementary Table 2**).

In general, SOP elements did not appear to be significantly associated with PA wage within the selected years (**Supplementary Table 2)**. While some significant associations were found (i.e., Adaptable Collaboration and Co-signature in 2002; Licensure in 2007; Adaptable Collaboration in 2017) there is no overall pattern within any SOP element over time. Likewise, the adjusted R^2 in regression models for individual SOP elements in the selected years were all small (Range: 0.0-0.29), with no appreciable pattern across time for any SOP element. This indicates that these variables do not explain a large amount of heterogeneity in the PA wage within the selected years.

Table 2 presents the results of our individual growth models showing the associations between the presence of individual SOP elements and PA wage over time. Model 3 shows that states with full prescriptive authority in 1997 had predicted annual wage of $5,238 (CI $2,794, $7,682) higher than in states without this law. Each year since 1997 was associated with a mean wage growth of $3,049, however, the wage growth over time among states with full prescriptive authority grew $319 less (CI $-522, $-116) per year than in states without this SOP element. A similar pattern is observed in Model 6 where SOP at the practice level in 1997 had wages $3,094 (CI $388, $5,800) higher compared to states without this SOP element. Each year since 1997 was associated with a mean wage growth of $3,090, but wage growth was $251 less among these states compared to those without SOP at the practice level (CI $-448, $-54). Interestingly, states with the Adaptable Collaboration SOP element had no significant difference in wage in 1997

(p=0.647), but again saw a decrease in wage growth over time compared to states without this element (β: $286, 95% CI $-485, $-87).

Table 2 Associations between Mean U.S. PA Annual Wage (US$) Growth and Presence of Individual Scope of Practice Laws Over Time (1997–2017) [a, b, c]

Models	Parameter Estimate	Standard Error	Lower 95% CI	Upper 95% CI	p
Model 1					
Intercept (year 1997)	45,644	1,465	42,702	48,587	<0.0001
Licensure	742	1,082	-1381	2,865	0.4931
Year	3,081	104	2,873	3,289	<0.0001
Mean age	565	143	285	845	<0.0001
Percent female	16	15	-13	45	0.2871
Licensure*year	-142	93	-325	41	0.1272
Model 2					
Intercept (year 1997)	46,132	1,301	43,519	48,744	<0.0001
PA to physician collaboration ratio	296	1,963	-3,557	4,149	0.8803
Year	2,946	76	2,794	3,098	<0.0001
Mean age	631	138	361	901	<0.0001
Percent female	11	15	-17	40	0.4352
Ratio*year	76	130	-180	332	0.5598
Model 3					
Intercept (year 1997)	44,538	1,260	42,007	47,069	<0.0001
Full prescriptive authority	5,238	1,246	2,794	7,682	<0.0001
Year	3,049	87	2,874	3,223	<0.0001
Mean age	526	139	254	797	0.0002
Percent female	19	15	-10	48	0.2065
Prescription*year	-319	103	-522	-116	0.0021
Model 4					
Intercept (year 1997)	45,819	1,386	43,036	48,602	<0.0001
Adaptable collaboration	722	1,577	-2,373	3,817	0.6472
Year	3,086	87	2,912	3,260	<0.0001
Mean age	514	139	242	786	0.0002
Percent female	15	14	-13	43	0.2932
Collaboration*year	-286	102	-485	-87	0.0050
Model 5					
Intercept (year 1997)	45,469	1,372	42,712	48,226	<0.0001
Co-signature	1,541	1,428	-1,262	4,344	0.2810
Year	3,136	87	2,961	3,312	<0.0001
Mean age	476	141	198	753	0.0008
Percent female	13	14	-15	41	0.3743
Co-signature*year	-358	99	-552	-163	0.0003
Model 6					

Intercept (year 1997)	44,660	1,416	41,816	47,505	<0.0001
SOP at practice level	3,094	1,379	388	5,800	0.0251
Year	3,090	90	2,909	3,272	<0.0001
Mean age	587	139	314	859	<0.0001
Percent female	14	15	-15	43	0.3378
SOP*year	-251	100	-448	-54	0.0125

CI: Confidence Interval

[a] Models were adjusted for PA mean-age and percent female PA. Weighted by PA number.

[b] Linear mixed models were used to generate least square means.

[c] See Supplementary Tables 3–9 for per state coefficients per SOP laws. All these models are weighted and adjusted by age and percent female.

DISCUSSION

Over the 20-year study period PA wages increased 2.2-fold with the change in wage primarily explained by time and not specific state scope of practice laws. It is clear that individual SOP laws are associated with increased wage, for example, full prescriptive authority was associated with a $5,238 higher wage in 1997, but with a negative wage growth of $319 for each subsequent year of the study. This is also seen with SOP at practice level, which is associated with a $3,094 higher wage in 1997, but a $251 lower wage growth for each subsequent year of the study. Together, this indicates that in the early period of this study, some SOP elements were associated with increased average wage, however, the impact of this increase diminished over time in all such instances. This suggests that the importance of these SOP elements on increasing wage decreased over time.

Throughout the decades there has been an expansion of state PA practice laws through the national moment of the AAPA Six Key Elements. This study supports previous literature showing that as of 2017 the majority of states have permissive practice laws and with this realisation, it is not surprising that the constituents of AAPA have pressed forward to expand practice autonomy further through Optimal Team Practice (OTP).[17, 25] The tenets of OTP include eliminating a legal requirement for a specific relationship with a physician, creating a separate majority-PA board to regulate PAs, and authorize PAs to directly bill for services.[26] With this continued work to expand the role of physician assistants on the healthcare team, future research needs to determine if these proposed health policies have an impact on earnings.

With the average age of physician assistants at 40-year-old, we did find that age was strongly correlated with increased wage. As our profession becomes younger it has also has transitioned to a majority female occupation. Our study only found a negative linear correlation between annual wage and percent female PAs in 2012, but this was non-significant in our multivariable growth models. This may indicate that the increase in the percentage of female workforce is not negatively impacting annual wage growth, yet we know from AAPA annual salary report that females report earning an average of $11,000 less than their male counterparts.[18] Future research is needed to explore the influence of the feminization of the profession on salary growth.

As the PA profession has been anointed the “Best Job in America” by the US News and World Report for 2021, the Bureau of Labor and Statistics projects a 31% growth in employment

over the next 10 years.[27, 28] This growth projection is due to the expected increase in demand for health care services and the ability to train PAs faster than physicians. With a projected shortage of 21,400 to 55,200 primary care physicians by 2033, PAs are often cited as one solution to meet this demand.[29] Research indicates that the supply of PAs is impacted by SOP laws with an increase the number of PAs per state population in states with permissive regulations.[17] At the same time, the supply of PAs willing to work in primary care is likely restricted by the decreased earnings.[9] Our study did not delineate by specialty which directly impacts PA wage. So, as our country continues to grapple with solutions to increase access to primary care, future research needs to better understand the levers that influence physician assistants' earnings, including specialty care.

This study has a number of important limitations. First, we analysed aggregate data at the state level; such ecological analyses are inherently limited and preclude drawing causal conclusions. Second, our analysis does not include other possible confounding variables that may impact PA wage, including specialty area of clinical employment, physician or nurse practitioner employment numbers, or state and federal healthcare legislative policies. Third, we were unable to account for lag time in terms of when the SOP laws were passed and the impact on wage. Fourth, the AAPA data on PA demographics is from a survey and the response rate ranged from 10-35% annually which may lead to a sampling bias towards or away from the null. These limitations are counterbalanced by a number of important strengths, including the robust SOP data provided by AAPA that was cross referenced and verified for each state and each year combined with annual wage data from the Bureau of Labor and Statistics.

CONCLUSIONS

Physician Assistant median wage has risen 220% in the past two decades. At the same time, there has been a significant expansion of state scope of practice laws where the majority of PAs today work in states with permissive regulations. This rise in physician assistant wage is mainly explained by time and the age of providers with minimal explanation earlier in the study period by state scope of practice laws. With the projected growth of the PA profession juxtaposed with the projected dearth of primary care physicians, health policy leaders need to look at implementing policy that will impact PA salary in areas of healthcare need.

Contributorship Statement

VLV, SN, and TJH were involved in the data analysis, interpretation, drafting the manuscript, and reviewed/edited the manuscript.

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Competing interests

None declared.

Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication

Not required.

Ethics approval

As we used publicly available BLS data, and the requested AAPA data does not contain identifying variables, this study was determined exempt from review by the University of Utah Institutional Review Board (IRB 00115478).

Data availability statement

BLS and the United States Census Bureau have public use linkage to access Labor Statistics and population data, respectively. The data from AAPA on PA census and legislative history was requested through AAPA research department.

Figure 1 caption: Physician Assistant Annual Wage and Number of States with Each Practice Law from 1997 to 2017

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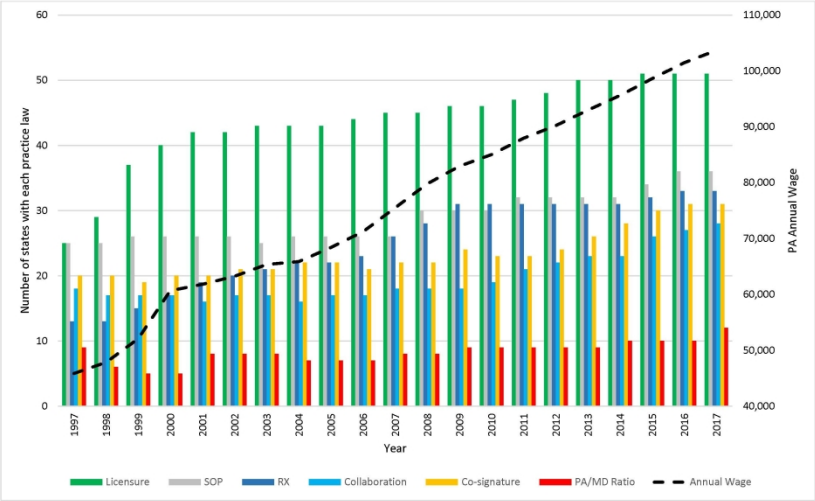

Figure 1 caption: Physician Assistant Annual Wage and Number of States with Each Practice Law from 1997 to 2017

Figure 1: Physician Assistant Annual Wage and Number of States with Each Practice Law from 1997 to 2017

279x215mm (300 x 300 DPI)

Supplementary Table 1 Correlation between PA Annual Wage and Mean PA Age and Percent Female PA in 1997, 2002, 2007, 2012, and 2017

	Year				
	1997	**2002**	**2007**	**2012**	**2017**
Age					
Pearson's correlation coefficient[a]	-0.08	0.31	0.22	0.52	0.29
P	0.600	0.028	0.129	<0.001	0.042
Percent female PA					
Pearson's correlation coefficient[a]	0.41	-0.21	-0.03	-0.41	-0.15
P	0.003	0.134	0.822	0.003	0.296

[a] Weighted by states' PA population

Supplementary Table 2 Cross-sectional Associations between Presence of Individual Scope of Practice Laws and Physician Assistants Annual Wage (US$) in 1997, 2002, 2007, 2012, and 2017[a]

Scope of practice laws	1997	2002	2007	2012	2017
	Physician Assistants Annual Wage				
Licensure					
β (# of states)	$172 (25)	-$4878 (42)	-$7007 (45)	-$4600 (48)	N/A (51)
95% CI	(-4,229 , 4,573)	(-11,271 , 1,515)	(-11,978 , -2,036)**	(-10,054 , 853)	
Adjusted R^2	0.1471	0.0879	0.1412	0.2755	
PA to physician collaboration ratio					
β (# of states)	-$243 (9)	$2572 (8)	-$5212 (8)	-$5828 (9)	-$2413 (12)
95% CI	(-7,367 , 6,881)	(-7,866 ,13,010)	(-12,790 , 2,365)	(-12,351 , 695)	(-8,196 , 3,370)
Adjusted R^2	0.1471	0.0472	0.0336	0.2805	0.0382
Full prescriptive authority					
β (# of states)	$5940 (13)	$3310 (20)	-$2991 (26)	-$1833 (31)	$2699 (33)
95% CI	(-139 , 12,019)	(-2,486 , 9,107)	(-7,104 , 1,122)	(-5,730 , 2,065)	(-1,737 , 7,135)
Adjusted R^2	0.2118	0.0683	0.0380	0.2455	0.0539
Adaptable collaboration					
β (# of states)	$3865 (18)	$7290 (17)	$1581 (18)	$3081 (22)	$4497 (28)
95% CI	(-626 , 8,356)	(2,125 , 12,455)**	(-2,842 , 6,004)	(-600 , 6,763)	(36 , 8,957)*
Adjusted R^2	0.1982	0.1824	0.0052	0.2748	0.1023
Co-signature					
β (# of states)	-$3520 (20)	-$8187 (21)	-$133 (22)	-$211 (24)	$1438 (31)
95% CI	(-8,510 , 1,471)	(-13,582 , -2,792)**	(-4,441 , 4,175)	(-4,008 , 3,585)	(-3,175 , 6,051)
Adjusted R^2	0.1821	0.2007	-0.0057	0.2313	0.0319
SOP at practice level					
β (# of states)	$4141 (25)	-$1152 (26)	$1444 (26)	$2850 (32)	$3714 (36)
95% CI	(-155 , 8,436)	(-6,541 , 4,238)	(-2,681 , 5,568)	(-1,019 , 6,720)	(-1,534 , 8,963)
Adjusted R^2	0.2102	0.0459	0.0047	0.2654	0.0641

CI: Confidence Interval
N/A: Not applicable, as all states and DC in year 2017 observed licensure.
[a] Models were adjusted for PA mean-age and percent female PA. Weighted by PA number.
* 0.01 < p <0.05
** p <0.01

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4-5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4-5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-5
Bias	9	Describe any efforts to address potential sources of bias	5-6, 14
Study size	10	Explain how the study size was arrived at	4-5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	5-6
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	4-5
		(*e*) Describe any sensitivity analyses	None

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	4-5
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6-7
		(b) Indicate number of participants with missing data for each variable of interest	5-6
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	9-12
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	*9-12*
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	6-9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	6-12
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Associations between State Scope of Practice Laws and US Physician Assistant Wages from 1997–2017: A Longitudinal Analysis

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Title Page

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Associations between State Scope of Practice Laws and US Physician Assistant Wages from 1997–2017: A Longitudinal Analysis

ABSTRACT

Objective

The purpose of this study is to determine whether, and to what degree, variation in Physician Assistant (PA) state scope of practice (SOP) laws across states are associated with 1) PA median wage over time, and 2) if a specific SOP key element has a greater impact on PA median wage than others. We hypothesize that expanded SOP laws would be associated with higher PA wage.

Design

Longitudinal analysis from 1997 to 2017.

Setting

Fifty states and the District of Columbia (US Capital region).

Participants

Employed PAs from 1997 to 2017.

Methods

Four national data sets were combined to allow for longitudinal analysis of state level annual PA wage with state SOP laws. We used linear regression models to explore the predicting effect of SOP elements on PA wage in 5-year intervals and individual growth models to assess the change in PA annual wage over the study period.

Results

There was a 220% increase in weighted PA annual wage over two-decades. There was a positive linear correlation between annual wage and age in 2012 and 2017 ($r=0.52$, $P<0.01$; $r=0.29$, $P=0.04$, respectively). The adjusted R^2 for individual SOP elements in the selected years were all small (Range: 0.0-0.29), with no appreciable pattern across time for any SOP element. In 1997, several SOP laws show association with median wage but this impact disappears over time.

Conclusions

PA median wage has risen over two-fold in the past two decades with the rise in PA wage mainly explained by time and the age of providers. In 1997 some SOP elements were associated with increased average wage, however, the impact of this increase diminished over time in all such instances. As the PA profession moves towards Optimal Team Practice, future research should examine if this move towards greater autonomy impacts wage.

Key Words

Physician assistant, annual wage, scope of practice laws, health policy, organization of health services

Strengths and Limitations

- Data from the Bureau of Labor and Statistics (BLS) provided employed Physician Assistants (PAs) census data for all employed PAs from 1997 to 2017 for all 50 states and the District of Columbia.
- Comprehensive state legislative SOP data from the American Academy of Physician Assistants (AAPA) was cross referenced and verified for each state and each year and then combined with the annual wage data from the BLS.
- This is the first study analysing two decades of national PA wage data for all 50 states and the District of Columbia longitudinally to describe the effect of state SOP laws on wage.
- The analysis did not include other possible confounding variables that may impact PA wage including PA specialty, physician or nurse practitioner employment numbers, or state and federal healthcare legislative policies.

Associations between State Scope of Practice Laws and US Physician Assistant Wages from 1997–2017: A Longitudinal Analysis

INTRODUCTION

Despite the increase in supply of Physician Assistants (PAs) over the last twenty years, PA salaries have continued to rise.[1, 2] The number of employed PAs has risen from 13,500 in 1992 to 140,000 in 2019.[3, 4] Meanwhile, the median salary has continued to rise to a reported $105,000 in 2019.[5] Nonetheless, demand remains strong with an estimated five job postings per PA graduate.[1] Due to this demand, a survey of 26 academic medical centers reported a range of 3.5 to 63 weeks to fill an open PA position.[6]

This high employer demand continues to draw large numbers of students to the PA profession, with a reported 2.95 applicants per 1 PA program seat.[7] An analysis of American Academy of Physician Assistants (AAPA) student surveys indicated that upon entering PA school, a majority of students expect to amass student loan debt of $75,000–$124,999 and earn salaries between $80,000 and $89,999.[8] Prior research on PA wages indicates that wage is impacted by gender, specialty, geographic region, years of practice, cost of living, local economy, and population density.[2] An analysis by Morgan et al. demonstrated that a higher ratio of PAs to MDs was correlated with higher salaries, suggesting that restrictions around practice ratios may have an impact on salaries.[9] Higher PA salaries have also been correlated with larger number of PAs employed in high-paid specialties.[1, 2] Together, these prior studies suggest that scope of practice (SOP) may be associated with PA wages, however this relationship remains largely unexplored.[1, 10-12]

In the United States (US) physician assistant scope of practice is determined at the state level and includes six key elements. The AAPA's Modern PA Practice Act includes: licensure as a regulatory term, full prescriptive authority, scope of practice determined at the practice level, adaptable collaboration requirements, co-signature requirements determined at the practice level, and number of PAs a physician may collaborate with determined at the practice level.[13] Prior research has shown that as of 2017 the majority of PAs work in states with permissive SOP regulations, defined as 5-6 of the six key elements.[14]

Prior research has demonstrated that there is an inverse relationship between the supply of PAs and NPs and the level of restrictiveness of scope of practice laws. An analysis of 2018 AAPA Salary Report data found a statistically significant difference in PA salary in states that passed the following three scope of practice (SOP) key elements: scope determined at practice site; adaptable supervision requirements; and no chart co-signature requirement.[14-20] Whereas, past analysis of the impact of SOP laws from 1994-2005 showed no impact on PA wage.[12] Over the past two decades there has been significant legislative work at the state level, but there remains wide variation in PA SOP laws in the US, ranging from restrictive to permissive.[21] The purpose of this study is to determine whether, and to what degree, variation in PA state SOP laws across states are associated with 1) PA median wage over time,

and 2) if a specific SOP key element has a greater impact on PA median wage than others. We hypothesize that expanded PA scope of practice would be associated with higher PA wage.

METHODS

Data

Data were obtained from the Bureau of Labor and Statistics (BLS), AAPA census, and the AAPA database on PA legislative history. Census data were obtained from the U.S. Census Bureau to estimate PA/population ratio by state.[22-25] These four datasets were linked to allow for evaluation of annual PA demographics, SOP laws by state, and wage data from all 50 U.S. states and the District of Columbia (DC) during the 21-year period from 1997 to 2017. The combined state/year dataset included number of employed PAs and median wage in each state annually from the BLS, PA demographics from the AAPA census, state SOP laws from AAPA legislative history, and PA/population ratio by state from the U.S. Census Bureau.

Independent Variables (IV), Dependent Variable (DV), and Covariates

Scope of Practice (IV): The AAPA established the ideal PA practice act which includes the 6 Key Elements of a Modern PA Practice Act: 1) licensure as a regulatory term, 2) full prescriptive authority, 3) scope of practice determined at the practice level, 4) adaptable collaboration requirements, 5) co-signature requirements determined at the practice level, and 6) number of PAs a physician may collaborate with determined at the practice level.[13] Data compiled by the AAPA legislative staff were obtained from AAPA and included which six key elements were approved in each state by year. From this, the total number of key elements in a given state in a given year was calculated. There were no missing data for the number of key elements.

Annual Wage Estimates (DV): In the BLS occupational employment statistics (OES) survey, annual wage estimates are defined as straight-time, gross pay, exclusive of premium pay. Included in the collection of OES wage data are base rate, cost-of-living allowances, guaranteed pay, hazardous-duty pay, incentive pay including commissions and production bonuses, on-call pay, and tips. Excluded from the wage data are back pay, jury duty pay, overtime pay, severance pay, shift differentials, nonproduction bonuses, and tuition reimbursements.[26]

Covariates: The AAPA census provided mean age and percent female gender for each state by year. There were no missing data for mean age or gender. To adjust for the inflation over years 1997–2017, US consumer price index (CPI) percent change was used.[27]

Statistical Analysis

We used descriptive statistics to summarize PA and states demographics. We conducted multiple linear regression models to explore the predicting effect of SOP elements in PA wage change in the selected

years of 1997, 2002, 2007, 2012, and 2017. Multiple linear regression models were adjusted for age and percent female PA, and weighted for the PA population size in each state. To assess the change in PA annual wage over years 1997 to 2017, individual growth analyses were applied at the level of the state to examine the impact of presence or absence of a key element on wage growth over time. All growth models were adjusted for year, and the time-varying covariates of mean PA age, and percent female PAs within the state. As in our linear regression models, our individual growth models were additionally weighted for the PA population size in each state.

Missing Data: State-level missing values on the time-varying variables of PA annual wage (n=9, 0.8%), number of employed PAs (n=28, 2.6%), and PA age and percent female PAs (n=204, 19% per variable) were imputed with the average of the state's last known and next known observations. In case of 2 missing values in a row (i.e. PA age and percent female PAs in years 2011 and 2012 for all states and DC), the last observation carried forward (LOCF) and the next observation carried backward (NOCB) techniques were used, respectively. In two cases of 3 missing values in a row for employed PAs (Hawaii and Arkansas), after replacing the LOCF and NOCB for the 1st and 3rd missing values, respectively, the average of these replaced values was used for the middle (2nd) missing value.

All analyses were conducted using SAS version 9.4.

RESULTS

We analyzed 1,071 PA annual wage records from 50 states and DC over 21 years. **Table 1** summarizes cross-sectional demographics of US employed PAs, and states demographics for selected years of 1997, 2002, 2007, 2012, and 2017 (5-year intervals). Overall, weighted PA annual wage increased steadily with the minimum wage earned seen in Mississippi for all years measured except 1997. The median age of sampled PAs was stable across time at between 40 and 41 years. The median percent of female PAs showed a constant increase over the study time frame, growing from 49% in 1997 to 69% in 2017. There was a positive linear correlation between annual wage and age in 2012 and 2017 ($r = 0.52$, $P < 0.01$; $r = 0.29$, $P = 0.04$, respectively). The negative linear correlation between annual wage and percent female PAs was only statistically significant in 2012 ($r = -0.41$, $P < 0.01$) (**Supplementary Table 1**). The weighted PA median ratio per 100,000 population increased almost monotonically from 23.4 PA in 1997 to 33.2 PA per 100,000 population in 2017. Likewise, the median number of PA SOP laws also increased monotonically over the study period, from 2 in 1997 to 4 in 2017. **Figure 1** demonstrates the 220% increase in weighted PA annual wage over the observation period, from a median of $47,060 in 1997 to $103,480 in 2017.

Table 1 Physician Assistant and State Demographics and Median Wage in 1997, 2002, 2007, 2012, and 2017

	Year				
	1997	**2002**	**2007**	**2012**	**2017**
Physician Assistants Demographics					
Age[a]					
Mean (SD)	40.9 (1.8)	41.2 (1.8)	39.7 (2.1)	40.8 (2.1)	39.7 (2.1)
Median (IQR)	41 (3)	41 (2)	41 (3)	41 (3)	40 (2)
Minimum (state)	36 (NJ)	37 (NJ)	37 (NJ)	34 (DC)	33 (AR)
Maximum (state)	46 (AR)	48 (NM)	47 (AK, NM)	47 (WY)	47 (WY)
Percent female[a]					
Mean (SD)	48.2 (8.6)	58.4 (7.0)	63.9 (6.0)	67.0 (6.0)	69.2 (5.8)
Median (IQR)	49 (11)	60 (11)	64 (7)	68 (6)	69 (6)
Minimum (state)	20 (MS)	18 (MS)	38 (UT)	40 (WY)	44 (HI)
Maximum (state)	75 (ND)	75 (ND)	79 (ND)	77 (ND)	78 (IL, PA, WI)
Annual wage (USD)[ab]					
Mean (SD)	44,921 (8,315)	63,546 (9,545)	77,843 (7,231)	92,451 (7,579)	104,760 (7,886)
Median (IQR)	47,060 (12,250)	67,520 (11,270)	79,240 (5,560)	92,150 (10,800)	103,480 (12,150)
Minimum (state, # scope of practice laws)	22,700 (AR, 1)	37,490 (MS, 1)	42,160 (MS, 2)	50,200 (MS, 2)	70,190 (MS, 2)
Maximum (state, # scope of practice laws)	77,210 (DE, 3)	78,900 (AR, 4)	91,010 (CT, 2)	112,250 (RI, 6)	120,200 (WA, 3)
State Demographics					
Population density/square mile[c]					
Mean (SD)	245.4 (470.9)	253.4 (469.5)	257.1 (462.2)	266.3 (513.3)	274.2 (565.7)
Median (IQR)	173.5 (195.8)	177.2 (195.8)	187.2 (189.8)	200.1 (185.3)	210.8 (177.3)
Minimum (state)	1.1 (AK)	1.1 (AK)	1.2 (AK)	1.3 (AK)	1.3 (AK)
Maximum (state)	9,307.2 (DC)	9,396.0 (DC)	9,416.5 (DC)	10,408.5 (DC)	11,391.9 (DC)
Number of scope of practice laws[d]					
Mean (SD)	2.2 (1.4)	2.6 (1.4)	2.8 (1.4)	3.3 (1.4)	3.7 (1.4)
Median (IQR)	2 (2)	2 (2)	3 (2)	3 (2)	4 (2)
Minimum (state)	0 (MS,NV,OH,PA,SC,VA,WI)	0 (OH,PA)	0 (OH)	0 (OH)	1 (AL,IA,SC)
Maximum (state)	5 (ME, NC)	6 (RI)	6 (NM, RI)	6 (ND, NM, RI)	6 (ND,NM,MA,MI,MN,RI)
PA ratio/100,000 population[e]					
Mean (SD)	24.7 (7.6)	26.2 (11.4)	26.2 (10.8)	31.9 (12.6)	38.5 (14.0)
Median (IQR)	23.4 (9.5)	25.5 (19.8)	23.5 (14.7)	32.9 (21.9)	33.2 (20.5)
Minimum (state)	8.8 (RI)	3.2 (MS)	4.6 (AR)	4.4 (MS)	8.4 (MS)
Maximum (state)	47.9 (DE)	52.6 (SC)	80.1 (DC)	75.3 (AK)	72.0 (DC)

SD: Standard Deviation; IQR: Interquartile Range; USD: United States Dollar
For the states name, we used two-letter states abbreviations.
[a] Weighted by states' PA population
[b] See supplementary Table 1 for -linear correlation of PA annual wage with age and percent female PA in the respective year
[c] Densities of 50 States + DC per square mile, weighted by the population of states and DC (state population in year/state area in square mile)[22-25]
[d] PA scope of practice laws are the 6 Key Elements of a Modern PA Practice Act [13]
[e] (employed PA in year/state population in that year) * 100,000, weighted by states' PA population

Table 2 shows the adoption of SOP laws in the US for selected years of 1997, 2002, 2007, 2012, and 2017. The number of states with adoption of each of the six AAPA key elements is indicated with licensure accepted quickly by all states and PA to physician collaboration ratio determined at the practice level least adopted much more slowly. SOP elements roughly follow a similar pattern of increased adoption over time, including: licensure (100% in 2017 versus 49% in 1997); SOP at practice level (71% in 2017 versus 49% in 1997); full prescriptive authority (65% in 2017 versus 25% in 1997); co-signature requirements (61% in 2017 versus 39% in 1997); adaptable collaboration requirements (55% in 2017 versus 35% in 1997); and number of PAs a physician may collaborate with (24% in 2017 versus 18% in 1997).

There is also significant heterogeneity in each SOP element adoption by state. For example, Alabama, Iowa, and South Carolina had adopted only one, while six states (North Dakota, New Mexico, Massachusetts, Michigan, Minnesota, and Rhode Island) had adopted all six key elements as of 2017 (**Table 1**).

In general, SOP elements did not appear to be significantly associated with PA wage within the selected years. While some significant associations were found (i.e., adaptable collaboration and co-signature in 2002; licensure in 2007; adaptable collaboration in 2017) there is no overall pattern within any SOP element over time. The same pattern was observed in the cross-sectional adjusted full models, controlling for all 6 policies. Except, in the year 2017, in the full model, the adaptable collaboration was not any more significant, and instead full prescriptive authority became significant in that year. Likewise, the adjusted R^2 in regression models for individual SOP elements in the selected years were all small (Range: 0.0-0.29), with no appreciable pattern across time for any SOP element (**Table 2**).

Table 2 Cross-sectional Associations between Presence of Individual Scope of Practice Laws and Physician Assistants Annual Wage (US$) in 1997, 2002, 2007, 2012, and 2017[a]

Scope of practice laws	1997	2002	2007	2012	2017
	Physician Assistants Annual Wage				
Licensure					
β (# of states)	$172 (25)	-$4878 (42)	-$7007 (45)	-$4600 (48)	N/A (51)
95% CI	(-4,229 , 4,573)	(-11,271 , 1,515)	(-11,978 , -2,036)**	(-10,054 , 854)	
Adjusted R^2	0.1471	0.0879	0.1412	0.2755	
PA to physician collaboration ratio					
β (# of states)	-$243 (9)	$2572 (8)	-$5212 (8)	-$5828 (9)	-$2413 (12)
95% CI	(-7,367 , 6,881)	(-7,866 ,13,010)	(-12,790 , 2,365)	(-12,351 , 696)	(-8,196 , 3,370)
Adjusted R^2	0.1471	0.0472	0.0336	0.2805	0.0382
Full prescriptive authority					
β (# of states)	$5940 (13)	$3310 (20)	-$2991 (26)	-$1833 (31)	$2699 (33)
95% CI	(-139 , 12,019)	(-2,486 , 9,107)	(-7,104 , 1,122)	(-5,730 , 2,065)	(-1,737 , 7,135)
Adjusted R^2	0.2118	0.0683	0.0380	0.2455	0.0539
Adaptable collaboration					
β (# of states)	$3865 (18)	$7290 (17)	$1581 (18)	$3081 (22)	$4497 (28)
95% CI	(-626 , 8,356)	(2,125 , 12,455)**	(-2,842 , 6,004)	(-600 , 6,763)	(36 , 8,957)*
Adjusted R^2	0.1982	0.1824	0.0052	0.2748	0.1023
Co-signature					
β (# of states)	-$3520 (20)	-$8187 (21)	-$133 (22)	-$211 (24)	$1438 (31)
95% CI	(-8,510 , 1,471)	(-13,582 , -2,792)**	(-4,441 , 4,175)	(-4,008 , 3,586)	(-3,175 , 6,051)
Adjusted R^2	0.1821	0.2007	-0.0057	0.2313	0.0319
SOP at practice level					
β (# of states)	$4141 (25)	-$1152 (26)	$1444 (26)	$2850 (32)	$3714 (36)
95% CI	(-155 , 8,436)	(-6,541 , 4,238)	(-2,681 , 5,568)	(-1,019 , 6,720)	(-1,534 , 8,963)
Adjusted R^2	0.2102	0.0459	0.0047	0.2654	0.0641
Full model (all 6 policies)					
β Licensure	-$705	-$583	-$8,320	-$4,060	N/A
95% CI	(-4,967, 3,556)	(-6,796, 5,630)	(-14,567, -2,073)*	(-9,853, 1,733)	N/A
β PA to physician collaboration ratio	-$908	-$558	-$4,047	-$5,688	-$5,653
95% CI	(-8,028, 6,211)	(-10,503, 9,387)	(-12,771, 4,677)	(-12,897, 1,521)	(-11,757, 451)
β Full prescriptive authority	$4,465	$3,447	-$1,984	-$1,867	$5,802
	(-1,928, 10,858)	(-1,921, 8,815)	(-6,124, 2,156)	(-5,950, 2,215)	(913, 10,692)*
	$3,228	$6,846	-$1,902	$657	$4,748

95% CI	(-1,356, 7,813)	(1,409, 12,284)*	(-6,837, 3,033)	(-3,693, 5,001)	(-57, 9,553)
β Adaptable collaboration	-$3,362	-$8,812	-$1,779	-$85	-$919
95% CI	(-8,329, 1,605)	(-13,937, -3,687)**	(-6,747, 3,189)	(-4,151, 3,981)	(-5,732, 3,893)
β Co-signature	$2,514	-$1,521	$1,374	$2,942	$3,718
95% CI	(-2,017, 7,046)	(-6,367, 3,324)	(-3,125, 5,872)	(-1,383, 7,268)	(-1,845, 9,282)
β SOP at practice level	0.228	0.3074	0.1341	0.304	0.1699
95% CI					
Adjusted R^2					

CI: Confidence Interval

N/A: Not applicable, as all states and DC in year 2017 observed licensure.

[a] Models were adjusted for PA mean-age and percent female PA. Weighted by PA number.

* $0.01 < p < 0.05$

** $p < 0.01$

Table 3 presents the results of our individual growth models showing the associations between the presence of individual SOP elements and PA wage over time. Model 3 shows that states with full prescriptive authority in 1997 had predicted annual wage of $5,227 (95% CI $2,784, $7,670) higher than in states without this law. In the individual model of full prescriptive authority (model 3), each year since 1997 was associated with a mean wage growth of $3,047, however, the wage growth over time among states with full prescriptive authority grew $309 less (95% CI $-513, $-105) per year than in states without this SOP element. A similar pattern is observed in Model 6 where SOP at the practice level in 1997 had wages $3,134 (95% CI $431, $5,837) higher compared to states without this SOP element. In the adjusted full model 7, $3,134 decreased to $3,023 (95% CI $278, $5,769). In the individual model of SOP at practice level (model 6), each year since 1997 was associated with a mean wage growth of $3,096, but wage growth was $251 less (95% CI $-449, $-56) among these states compared to those without SOP at the practice level. Interestingly, states with the adaptable collaboration law had no significant difference in wage in 1997 (P = 0.6483), but again saw a decrease of $285 (95% CI $-484, $-86) in wage growth per year compared to states without this law. In the adjusted full model 7, prescriptive authority and SOP at practice level in 1997 predicted annual wage of $4,506 (95% CI $1,946, $7,066), and $3,023 (95% CI $278, $5,769) higher than in states without this law, respectively. States with the co-signature law had no significant difference in wage in 1997 (P = 0.6645), but saw a decrease of $268 (95% CI $-477, $-60) in wage growth per year compared to states without this law. These changes in model 7, which contained all six elements, relative to models 1-6, which each contained a single element, may reflect either confounding of the associations between individual SOP elements and wage by other SOP elements, or variance inflation due to multicollinearity.

Table 3 Adjusted associations between Mean US PA Annual Wage (US$) Growth and Presence of Scope of Practice Laws Over Time (1997–2017) [a, b, c]

Models	Parameter Estimate	Standard Error	Lower 95% CI	Upper 95% CI	p
Model 1					
Intercept (year 1997)	45,356	1,502	42,338	48,374	<0.0001
Licensure	669	1,085	-1,461	2,798	0.538
Year	3,079	103	2,871	3,287	<0.0001
CPI	138	162	-180	457	0.3935
Mean age	524	150	229	819	0.0005
Percent female	14	15	-16	43	0.3609
Licensure*year	-134	93	-318	49	0.1507
Model 2					
Intercept (year 1997)	45,734	1,360	43,003	48,465	<0.0001
PA to physician collaboration ratio	378	1,963	-3,474	4,230	0.8472
Year	2,951	76	2,799	3,103	<0.0001
CPI	159	161	-158	476	0.3263
Mean age	580	147	292	868	<0.0001
Percent female	9	15	-20	38	0.5343
Ratio*year	71	130	-185	327	0.5867
Model 3					
Intercept (year 1997)	44,165	1,316	41,522	46,807	<0.0001
Full prescriptive authority	5,227	1,245	2,784	7,670	<0.0001
Year	3,047	87	2,873	3,222	<0.0001
CPI	157	162	-161	476	0.3318
Mean age	477	147	188	765	0.0012
Percent female	17	15	-13	46	0.2616
Prescription*year	-309	104	-513	-105	0.003
Model 4					
Intercept (year 1997)	45,452	1,437	42,565	48,339	<0.0001
Adaptable collaboration	719	1,575	-2,373	3,810	0.6483
Year	3,090	87	2,916	3,264	<0.0001
CPI	151	159	-161	463	0.3435
Mean age	466	148	176	755	0.0017
Percent female	13	15	-16	42	0.3725
Collaboration*year	-285	101	-484	-86	0.005
Model 5					
Intercept (year 1997)	45,222	1,431	42,348	48,095	<0.0001
Co-signature	1,563	1,429	-1,240	4,367	0.2741
Year	3,138	87	2,963	3,313	<0.0001
CPI	99	159	-214	412	0.5363

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Mean age	445	150	150	139	0.0031
Percent female	11	15	-17	50	0.4333
Co-signature*year	-356	99	-551	162	0.0003
Model 6					
Intercept (year 1997)	44,233	1,473	41,275	47,191	<0.0001
SOP at practice level	3,134	1,377	431	5,837	0.0231
Year	3,096	90	2,914	3,277	<0.0001
CPI	167	161	-149	484	0.2991
Mean age	533	148	244	823	0.0003
Percent female	12	15	-17	41	0.4287
SOP*year	-253	100	-449	-56	0.0119
Model 7					
Intercept (year 1997)	42,509	1,759	38,976	46,042	<0.0001
Licensure	163	1,089	-1,975	2,301	0.8812
PA to physician collaboration ratio	836	1,924	-2,939	4,611	0.6639
Full prescriptive authority	4,506	1,304	1,946	7,066	0.0006
Adaptable collaboration	17	1,575	-3,075	3,109	0.9915
Co-signature	637	1,467	-2,243	3,516	0.6645
SOP at practice level	3,023	1,399	278	5,769	0.031
Year	3,315	129	3,056	3,574	<0.0001
CPI	120	160	-193	433	0.4529
Mean age	276	153	-24	577	0.0714
Percent female	26	15	-4	55	0.0856
Licensure*year	-86	98	-278	106	0.3807
Ratio*year	123	131	-134	379	0.3491
Prescription*year	-180	119	-414	53	0.1306
Collaboration*year	-180	108	-392	33	0.0969
C0-signature*year	-268	106	-477	-60	0.0118
SOP*year	-154	107	-363	55	0.1487

CI: Confidence Interval; CPI: Consumer price index percent change

[a] Models were adjusted for PA mean-age, percent female PA, and CPI. Weighted by PA number.

[b] Linear mixed models were used to generate least square means.

[c] See Supplementary Tables 3–9 for per state coefficients per SOP laws. All these models are weighted and adjusted by age and percent female.

DISCUSSION

Over the 20-year study period PA wages increased 2.2-fold with the change in wage primarily explained by time and not specific state scope of practice laws. It is clear that individual SOP laws are associated with increased wage, particularly early in our study period, but the impact of these SOP elements changed over time. For example, full prescriptive authority was associated with a $5,227 higher wage in 1997, but with a negative wage growth of $309 for each subsequent year of the study. This is also seen with SOP at practice level, which was associated with a $3,134 higher wage in 1997, but a $253 lower wage growth for each subsequent year of the study. Together, this indicates that in the early period of this study, some SOP elements were associated with increased average wage, however, the impact of this increase diminished over time in all such instances. This suggests that the importance of these SOP elements on increasing wage decreased over time.

The findings of this study support previous work by Perry (2009) showing an increase in PA scope of practice did not increase wage.[12] As PAs are able to provide a wider breadth of care there is arguably a benefit to society through an increase in access to care. Yet, previous research indicates that expanded SOP for nurse practitioners (NPs) does also increase wage but specifically related to independence.[12, 28] As the majority of states have permissive SOP laws and with this realisation, it is not surprising that the constituents of AAPA have pressed forward to expand practice autonomy further through Optimal Team Practice (OTP).[21, 29] The principles of OTP include eliminating a legal requirement for a specific relationship with a physician, creating a separate majority-PA board to regulate PAs, and authorize PAs to directly bill for services.[30] The tenets of OTP will move the PA profession closer to independent practice, similar to nurse practitioners. Future research should then investigate if this expansion of scope of practice impacts PA wage mirroring our nurse practitioner colleagues.

Our study only found a negative linear correlation between annual wage and percent female PAs in 2012, but this was non-significant in our multivariable growth models. This may indicate that the increase in the percentage of female workforce is not negatively impacting annual wage growth. These findings juxtapose the other research that notes an $11,000 reported difference in wage by female PAs and an $12,859 difference by female NPs.[13, 31] Future research is needed to further explore the influence of the feminization of the PA profession on salary growth.

As the PA profession has been anointed the "Best Job in America" by the US News and World Report for 2021, the Bureau of Labor and Statistics projects a 31% growth in employment over the next 10 years.[32, 33] This growth projection is due to the expected increase in demand for health care services and the ability to train PAs faster than physicians. With a projected shortage of 21,400 to 55,200 primary care physicians by 2033, PAs are often cited as one solution to meet this demand.[34] Research indicates that the supply of PAs is impacted by SOP laws with an increase the number of PAs per state population in states with permissive regulations.[21] At the same time, the supply of PAs willing to work in primary care is likely restricted by the decreased earnings.[9] Our study did not delineate specialty which directly impacts PA wage. So, as our country continues to grapple with solutions to increase access to primary care, future research needs to better understand the levers that influence physician assistants' earnings, including specialty care.

This study has a number of important limitations. First, we analysed aggregate data at the state level; such ecological analyses are inherently limited and preclude drawing causal conclusions. Second, our analysis does not include other possible confounding variables that may impact PA wage, including specialty area of clinical employment, physician or nurse practitioner employment numbers, or state and federal healthcare legislative policies. Third, we were unable to account for lag time in terms of when the SOP laws were passed and the impact on wage. Fourth, the AAPA data on PA demographics is from a survey and the response rate ranged from 10-35% annually which may lead to a sampling bias towards or away from the null. These limitations are counterbalanced by a number of important strengths, including the robust SOP data provided by AAPA that was cross referenced and verified for each state and each year combined with annual wage data from the Bureau of Labor and Statistics.

CONCLUSIONS

Physician Assistant median wage has risen 220% in the past two decades. At the same time, there has been a significant expansion of state scope of practice laws such that the majority of PAs today work in states with permissive regulations. This rise in physician assistant wage is mainly explained by time and the age of providers with minimal explanation by state scope of practice laws. As the PA profession moves towards Optimal Team Practice, future research

should examine if this move towards greater autonomy impacts wage, as occurred in nurse practitioners.

Contributorship Statement

VLV, SN, and TJH were involved in the data analysis, interpretation, drafting the manuscript, and reviewed/edited the manuscript.

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Competing interests

None declared.

Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication

Not required.

Ethics approval

As we used publicly available BLS data, and the requested AAPA data does not contain identifying variables, this study was determined exempt from review by the University of Utah Institutional Review Board (IRB 00115478).

Data availability statement

BLS and the United States Census Bureau have public use linkage to access Labor Statistics and population data, respectively. The data from AAPA on PA census and legislative history was requested through AAPA research department.

Figure 1 caption: Physician Assistant Annual Wage and Number of States with Each Practice Law from 1997 to 2017

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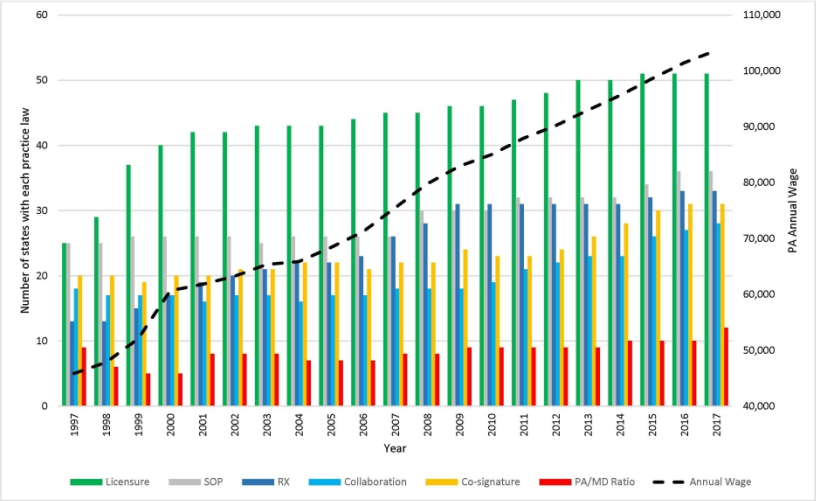

Figure 1 caption: Physician Assistant Annual Wage and Number of States with Each Practice Law from 1997 to 2017

Figure 1: Physician Assistant Annual Wage and Number of States with Each Practice Law from 1997 to 2017

279x215mm (300 x 300 DPI)

Supplementary Table 1 Correlation between PA Annual Wage and Mean PA Age and Percent Female PA in 1997, 2002, 2007, 2012, and 2017

	Year				
	1997	**2002**	**2007**	**2012**	**2017**
Age					
Pearson's correlation coefficient[a]	-0.08	0.31	0.22	0.52	0.29
P	0.600	0.028	0.129	<0.001	0.042
Percent female PA					
Pearson's correlation coefficient[a]	0.41	-0.21	-0.03	-0.41	-0.15
P	0.003	0.134	0.822	0.003	0.296

[a] Weighted by states' PA population

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4-5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4-5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-5
Bias	9	Describe any efforts to address potential sources of bias	5-6, 14
Study size	10	Explain how the study size was arrived at	4-5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	5-6
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	4-5
		(*e*) Describe any sensitivity analyses	None

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	4-5
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6-7
		(b) Indicate number of participants with missing data for each variable of interest	5-6
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	9-12
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	*9-12*
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	6-9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	6-12
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Associations between State Scope of Practice Laws and US Physician Assistant Wages from 1997–2017: A Longitudinal Analysis

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Title Page

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Associations between State Scope of Practice Laws and US Physician Assistant Wages from 1997–2017: A Longitudinal Analysis

ABSTRACT

Objective

The purpose of this study is to determine whether, and to what degree, variation in Physician Assistant (PA) state scope of practice (SOP) laws across states are associated with 1) PA median wage over time, and 2) if a specific SOP key element has a greater impact on PA median wage than others. We hypothesize that expanded SOP laws will be associated with higher PA wage.

Design

Longitudinal analysis from 1997 to 2017.

Setting

Fifty states and the District of Columbia (US Capital region).

Participants

Employed PAs from 1997 to 2017.

Methods

Four national data sets were combined to allow for longitudinal analysis of state level annual PA wage with state SOP laws. We used linear regression models to explore the associations of SOP elements on PA wage in 5-year intervals and individual growth models to assess the change in PA annual wage over the study period.

Results

There was a 220% increase in weighted PA annual wage over two-decades. There was a positive linear correlation between annual wage and age in 2012 and 2017 ($r=0.52$, $P<0.01$; $r=0.29$, $P=0.04$, respectively). The adjusted R^2 for individual SOP elements in the selected years were all small (Range: 0.0-0.29), with no appreciable pattern across time for any SOP element. In 1997, several SOP laws show association with median wage but this impact disappears over time.

Conclusions

PA median wage has risen over two-fold in the past two decades, with the rise in PA wage mainly explained by time and provider age. In 1997 some SOP elements were associated with increased average wage, however, the impact of this increase diminished over time in all such instances. As the PA profession moves towards Optimal Team Practice, future research should examine if this move towards greater autonomy impacts wage.

Key Words

Physician assistant, annual wage, scope of practice laws, health policy, organization of health services

Strengths and Limitations

- Data from the Bureau of Labor and Statistics (BLS) provided employed Physician Assistants (PAs) census data for all employed PAs from 1997 to 2017 for all 50 states and the District of Columbia.
- Comprehensive state legislative SOP data from the American Academy of Physician Assistants (AAPA) was cross referenced and verified for each state and each year and then combined with the annual wage data from the BLS.
- This is the first study analysing two decades of national PA wage data for all 50 states and the District of Columbia longitudinally to describe the effect of state SOP laws on wage.
- The analysis did not include other possible confounding variables that may impact PA wage including PA specialty, physician or nurse practitioner employment numbers, or state and federal healthcare legislative policies.

Associations between State Scope of Practice Laws and US Physician Assistant Wages from 1997–2017: A Longitudinal Analysis

INTRODUCTION

Despite the increase in supply of Physician Assistants (PAs) over the last twenty years, PA salaries have continued to rise.[1, 2] The number of employed PAs has risen from 13,500 in 1992 to 140,000 in 2019.[3, 4] Meanwhile, the median salary has continued to rise to a reported $105,000 in 2019.[5] Nonetheless, demand remains strong with an estimated five job postings per PA graduate.[1] Due to this demand, a survey of 26 academic medical centers reported a range of 3.5 to 63 weeks to fill an open PA position.[6]

This high employer demand continues to draw large numbers of students to the PA profession, with a reported 2.95 applicants per 1 PA program seat.[7] An analysis of American Academy of Physician Assistants (AAPA) student surveys indicated that upon entering PA school, a majority of students expect to amass student loan debt of between $75,000 and $124,999 and earn salaries between $80,000 and $89,999.[8] Prior research on PA wages indicates that wage is impacted by gender, specialty, geographic region of practice, years of practice, cost of living, the local economy, and population density.[2] An analysis by Morgan et al. demonstrated that a higher ratio of PAs to MDs was also correlated with higher PA salaries, suggesting that restrictions around practice ratios may impact wages.[9] Higher PA salaries have also been correlated with larger number of PAs employed in high-paid specialties.[1, 2] Together, these prior studies suggest that scope of practice (SOP) may be associated with PA wages, however this relationship remains largely unexplored.[1, 10-12]

In the United States (US), physician assistant scope of practice is determined at the state level and includes six key elements. The AAPA Modern PA Practice Act includes the following SOP elements: Licensure as a regulatory term; full prescriptive authority; scope of practice determined at the practice level; adaptable collaboration requirements; co-signature requirements determined at the practice level; and number of PAs a physician may collaborate with determined at the practice level.[13] Prior research has shown that as of 2017, the majority of PAs work in states with permissive SOP regulations, defined as 5-6 of these six key elements.[14] With this success, the AAPA is now working to expand practice autonomy further through Optimal Team Practice (OTP).The principles of OTP include eliminating a legal requirement for a specific relationship with a physician, creating a separate majority-PA board to regulate PAs, and authorize PAs to directly bill for services.[15]

Prior research has demonstrated that there is an inverse relationship between the supply of PAs and NPs and the restrictiveness of scope of practice laws. An analysis of 2018 AAPA Salary Report data found a statistically significant difference in PA salary in states that passed the following three scope of practice (SOP) key elements: Scope determined at practice site; adaptable supervision requirements; and

no chart co-signature requirement.[14, 16-21] Whereas, past analysis of the impact of SOP laws from 1994-2005 showed no impact on PA wage.[12] Over the past two decades there has been significant legislative work at the state level, but there remains wide variation in PA SOP laws in the US, ranging from restrictive to permissive.[22] The purpose of this study is to determine whether, and to what degree, variation in PA state SOP laws across states are associated with 1) PA median wage over time, and 2) if a specific SOP key element has a greater impact on PA median wage than others. We hypothesize that expanded PA scope of practice will be associated with higher PA wage.

METHODS

Data

Data were obtained from the Bureau of Labor and Statistics (BLS), AAPA census, and the AAPA database on PA legislative history. Census data were obtained from the U.S. Census Bureau to estimate PA/population ratio by state.[23-26] These four datasets were linked to allow for evaluation of annual PA demographics, SOP laws by state, and wage data from all 50 U.S. states and the District of Columbia (DC) during the 21-year period from 1997 to 2017. The combined state/year dataset included number of employed PAs and median wage in each state annually from the BLS, PA demographics from the AAPA census, state SOP laws from AAPA legislative history, and PA/population ratio by state from the U.S. Census Bureau.

Independent Variables (IV), Dependent Variable (DV), and Covariates

Scope of Practice (IV): The AAPA established the ideal PA practice act which includes the 6 Key Elements of a Modern PA Practice: 1) licensure as a regulatory term, 2) full prescriptive authority, 3) scope of practice determined at the practice level, 4) adaptable collaboration requirements, 5) co-signature requirements determined at the practice level, and 6) number of PAs a physician may collaborate with determined at the practice level.[13] Data compiled by the AAPA legislative staff were obtained from AAPA and included which of these six key elements were approved in each state by year. From this, the total number of key elements in a given state in a given year was calculated. There were no missing data for the number of key elements.

Annual Wage Estimates (DV): In the BLS occupational employment statistics (OES) survey, annual wage estimates are defined as straight-time, gross pay, exclusive of premium pay. Included in the collection of OES wage data are base rate, cost-of-living allowances, guaranteed pay, hazardous-duty pay, incentive pay including commissions and production bonuses, on-call pay, and tips. Excluded from the wage data are back pay, jury duty pay, overtime pay, severance pay, shift differentials, nonproduction bonuses, and tuition reimbursements.[27]

Covariates: The AAPA census provided mean age and percent female gender for each state by year. To adjust for the inflation over years 1997–2017, US consumer price index (CPI) percent change was used.[28] There was no missing data for these covariates.

Statistical Analysis

We used descriptive statistics to summarize PA and state demographics. We conducted multiple linear regression models to explore the associations of SOP elements in PA wage change in the selected years of 1997, 2002, 2007, 2012, and 2017. Multiple linear regression models were adjusted for age and percent female PA, and weighted for the PA population size in each state. To assess the change in PA annual wage over years 1997 to 2017, individual growth analyses were applied at the level of the state to examine the impact of presence or absence of a key element on wage growth over time. All growth models were adjusted for year, and the time-varying covariates of mean PA age, percent female PAs within the state, and the US CPI. As in our linear regression models, our individual growth models were additionally weighted for the PA population size in each state.

Missing Data: State-level missing values on the time-varying variables of PA annual wage (n=9, 0.8%), number of employed PAs (n=28, 2.6%), and PA age and percent female PAs (n=204, 19% per variable) were imputed with the average of the state's last known and next known observations. In case of 2 missing values in a row (i.e. PA age and percent female PAs in years 2011 and 2012 for all states and DC), the last observation carried forward (LOCF) and the next observation carried backward (NOCB) techniques were used, respectively. In two cases of 3 missing values in a row for employed PAs (Hawaii and Arkansas), after replacing the LOCF and NOCB for the 1st and 3rd missing values, respectively, the average of these replaced values was used for the middle (2nd) missing value.

All analyses were conducted using SAS version 9.4.

RESULTS

We analyzed 1,071 PA annual wage records from 50 states and the District of Columbia over 21 years. **Table 1** summarizes cross-sectional demographics of US employed PAs, and state demographics for the selected years of 1997, 2002, 2007, 2012, and 2017 (5-year intervals). Overall, weighted PA annual wage increased steadily, with the minimum wage earned seen in Mississippi for all years measured except 1997. The median age of sampled PAs was stable across time at between 40 and 41 years. The median percent of female PAs showed a constant increase over the study time frame, growing from 49% in 1997 to 69% in 2017. There was a positive linear correlation between annual wage and age in 2012 and 2017 ($r = 0.52$, $P < 0.01$; $r = 0.29$, $P = 0.04$, respectively). The negative linear correlation between annual wage and percent female PAs was only statistically significant in 2012 ($r = -0.41$, $P < 0.01$) (**Supplementary**

Table 1). The weighted PA median ratio per 100,000 population increased almost monotonically from 23.4 PA in 1997 to 33.2 PA per 100,000 population in 2017. Likewise, the median number of PA SOP laws also increased monotonically over the study period, from 2 in 1997 to 4 in 2017. **Figure 1** demonstrates the 220% increase in weighted PA annual wage over the observation period, from a median of $47,060 in 1997 to $103,480 in 2017.

Table 1 Physician Assistant and State Demographics and Median Wage in 1997, 2002, 2007, 2012, and 2017

	Year				
	1997	**2002**	**2007**	**2012**	**2017**
Physician Assistants Demographics					
Age[a]					
Mean (SD)	40.9 (1.8)	41.2 (1.8)	39.7 (2.1)	40.8 (2.1)	39.7 (2.1)
Median (IQR)	41 (3)	41 (2)	41 (3)	41 (3)	40 (2)
Minimum (state)	36 (NJ)	37 (NJ)	37 (NJ)	34 (DC)	33 (AR)
Maximum (state)	46 (AR)	48 (NM)	47 (AK, NM)	47 (WY)	47 (WY)
Percent female[a]					
Mean (SD)	48.2 (8.6)	58.4 (7.0)	63.9 (6.0)	67.0 (6.0)	69.2 (5.8)
Median (IQR)	49 (11)	60 (11)	64 (7)	68 (6)	69 (6)
Minimum (state)	20 (MS)	18 (MS)	38 (UT)	40 (WY)	44 (HI)
Maximum (state)	75 (ND)	75 (ND)	79 (ND)	77 (ND)	78 (IL, PA, WI)
Annual wage (USD)[ab]					
Mean (SD)	44,921 (8,315)	63,546 (9,545)	77,843 (7,231)	92,451 (7,579)	104,760 (7,886)
Median (IQR)	47,060 (12,250)	67,520 (11,270)	79,240 (5,560)	92,150 (10,800)	103,480 (12,150)
Minimum (state, # scope of practice laws)	22,700 (AR, 1)	37,490 (MS, 1)	42,160 (MS, 2)	50,200 (MS, 2)	70,190 (MS, 2)
Maximum (state, # scope of practice laws)	77,210 (DE, 3)	78,900 (AR, 4)	91,010 (CT, 2)	112,250 (RI, 6)	120,200 (WA, 3)
State Demographics					
Population density/square mile[c]					
Mean (SD)	245.4 (470.9)	253.4 (469.5)	257.1 (462.2)	266.3 (513.3)	274.2 (565.7)
Median (IQR)	173.5 (195.8)	177.2 (195.8)	187.2 (189.8)	200.1 (185.3)	210.8 (177.3)
Minimum (state)	1.1 (AK)	1.1 (AK)	1.2 (AK)	1.3 (AK)	1.3 (AK)
Maximum (state)	9,307.2 (DC)	9,396.0 (DC)	9,416.5 (DC)	10,408.6 (DC)	11,391.9 (DC)
Number of scope of practice laws[d]					
Mean (SD)	2.2 (1.4)	2.6 (1.4)	2.8 (1.4)	3.3 (1.4)	3.7 (1.4)
Median (IQR)	2 (2)	2 (2)	3 (2)	3 (2)	4 (2)
Minimum (state)	0 (MS,NV,OH,PA,SC,VA,WI)	0 (OH,PA)	0 (OH)	0 (OH)	1 (AL,IA,SC)
Maximum (state)	5 (ME, NC)	6 (RI)	6 (NM, RI)	6 (ND, NM, RI)	6 (ND,NM,MA,MI,MN,RI)
PA ratio/100,000 population[e]					
Mean (SD)	24.7 (7.6)	26.2 (11.4)	26.2 (10.8)	31.9 (12.6)	38.5 (14.0)
Median (IQR)	23.4 (9.5)	25.5 (19.8)	23.5 (14.7)	32.9 (21.9)	33.2 (20.5)
Minimum (state)	8.8 (RI)	3.2 (MS)	4.6 (AR)	4.4 (MS)	8.4 (MS)
Maximum (state)	47.9 (DE)	52.6 (SC)	80.1 (DC)	75.3 (AK)	72.0 (DC)

SD: Standard Deviation; IQR: Interquartile Range; USD: United States Dollar
For the states name, we used two-letter states abbreviations.
[a] Weighted by states' PA population
[b] See supplementary Table 1 for -linear correlation of PA annual wage with age and percent female PA in the respective year
[c] Densities of 50 States + DC per square mile, weighted by the population of states and DC (state population in year/state area in square mile)[23-26]
[d] PA scope of practice laws are the 6 Key Elements of a Modern PA Practice Act [13]
[e] (employed PA in year/state population in that year) * 100,000, weighted by states' PA population

Table 2 shows the adoption of SOP laws in the US for selected years of 1997, 2002, 2007, 2012, and 2017. SOP elements are progressively adopted by states over time, although some are consistently adopted more than others [i.e. licensure (100% in 2017 versus 49% in 1997); SOP at practice level (71% in 2017 versus 49% in 1997); full prescriptive authority (65% in 2017 versus 25% in 1997); co-signature requirements (61% in 2017 versus 39% in 1997); adaptable collaboration requirements (55% in 2017 versus 35% in 1997); and number of PAs a physician may collaborate with (24% in 2017 versus 18% in 1997)].

There is also significant heterogeneity in each SOP element adoption by state. For example, as of 2017 Alabama, Iowa, and South Carolina had adopted only one SOP element, while six states (North Dakota, New Mexico, Massachusetts, Michigan, Minnesota, and Rhode Island) had adopted all six key elements as of this date (**Table 1**).

In general, SOP elements did not appear to be significantly associated with PA wage within the selected years. While some significant associations were found (i.e., adaptable collaboration and co-signature in 2002; licensure in 2007; adaptable collaboration in 2017) there is no overall pattern within any SOP element over time. The same general pattern was observed in our cross-sectional models controlling for all 6 policies. Likewise, the adjusted R^2 in regression models for individual SOP elements in the selected years were all small (Range: 0.0-0.29), with no appreciable pattern across time for any SOP element (**Table 2**).

Table 2 Cross-sectional Associations between Presence of Individual Scope of Practice Laws and Physician Assistants Annual Wage (US$) in 1997, 2002, 2007, 2012, and 2017[a]

Scope of practice laws	1997	2002	2007	2012	2017
	Physician Assistants Annual Wage				
Licensure					
β (# of states)	$172 (25)	-$4878 (42)	-$7007 (45)	-$4600 (48)	N/A (51)
95% CI	(-4,229 , 4,573)	(-11,271 , 1,515)	(-11,978 , -2,036)**	(-10,054 , 854)	
Adjusted R^2	0.1471	0.0879	0.1412	0.2755	
PA to physician collaboration ratio					
β (# of states)	-$243 (9)	$2572 (8)	-$5212 (8)	-$5828 (9)	-$2413 (12)
95% CI	(-7,367 , 6,881)	(-7,866 ,13,010)	(-12,790 , 2,365)	(-12,351 , 695)	(-8,196 , 3,370)
Adjusted R^2	0.1471	0.0472	0.0336	0.2805	0.0382
Full prescriptive authority					
β (# of states)	$5940 (13)	$3310 (20)	-$2991 (26)	-$1833 (31)	$2699 (33)
95% CI	(-139 , 12,019)	(-2,486 , 9,107)	(-7,104 , 1,122)	(-5,730 , 2,065)	(-1,737 , 7,135)
Adjusted R^2	0.2118	0.0683	0.0380	0.2455	0.0539
Adaptable collaboration					
β (# of states)	$3865 (18)	$7290 (17)	$1581 (18)	$3081 (22)	$4497 (28)
95% CI	(-626 , 8,356)	(2,125 , 12,455)**	(-2,842 , 6,004)	(-600 , 6,763)	(36 , 8,957)*
Adjusted R^2	0.1982	0.1824	0.0052	0.2748	0.1023
Co-signature					
β (# of states)	-$3520 (20)	-$8187 (21)	-$133 (22)	-$211 (24)	$1438 (31)
95% CI	(-8,510 , 1,471)	(-13,582 , -2,792)**	(-4,441 , 4,175)	(-4,008 , 3,586)	(-3,175 , 6,051)
Adjusted R^2	0.1821	0.2007	-0.0057	0.2313	0.0319
SOP at practice level					
β (# of states)	$4141 (25)	-$1152 (26)	$1444 (26)	$2850 (32)	$3714 (36)
95% CI	(-155 , 8,436)	(-6,541 , 4,238)	(-2,681 , 5,568)	(-1,019 , 6,720)	(-1,534 , 8,963)
Adjusted R^2	0.2102	0.0459	0.0047	0.2654	0.0641
Full model (all 6 policies)					
β Licensure	-$705	-$583	-$8,320	-$4,060	N/A
95% CI	(-4,967, 3,556)	(-6,796, 5,630)	(-14,567, -2,073)*	(-9,853, 1,733)	N/A
β PA to physician collaboration ratio	-$908	-$558	-$4,047	-$5,688	-$5,653
95% CI	(-8,028, 6,211)	(-10,503, 9,387)	(-12,771, 4,677)	(-12,897, 1,521)	(-11,757, 451)
β Full prescriptive authority	$4,465	$3,447	-$1,984	-$1,867	$5,802
	(-1,928, 10,858)	(-1,921, 8,815)	(-6,124, 2,156)	(-5,950, 2,215)	(913, 10,692)*
	$3,228	$6,846	-$1,902	$657	$4,748

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95% CI	(-1,356, 7,813)	(1,409, 12,284)*	(-6,837, 3,033)	(-3,693, 5,001)	(-57, 9,553)
β Adaptable collaboration	-$3,362	-$8,812	-$1,779	-$85	-$919
95% CI	(-8,329, 1,605)	(-13,937, -3,687)**	(-6,747, 3,189)	(-4,151, 3,981)	(-5,732, 3,893)
β Co-signature	$2,514	-$1,521	$1,374	$2,942	$3,718
95% CI	(-2,017, 7,046)	(-6,367, 3,324)	(-3,125, 5,872)	(-1,383, 7,268)	(-1,845, 9,282)
β SOP at practice level	0.228	0.3074	0.1341	0.304	0.1699
95% CI					
Adjusted R^2					

CI: Confidence Interval

N/A: Not applicable, as all states and DC in year 2017 observed licensure.

[a] Models were adjusted for PA mean-age and percent female PA. Weighted by PA number.

* 0.01 < p <0.05

** p <0.01

Table 3 presents the results of our individual growth models showing the associations between the presence of individual SOP elements and PA wage over time. Model 3 shows that states with full prescriptive authority in 1997 had predicted annual wage of $5,227 (95% CI $2,784, $7,670) higher than in states without this law. In the individual model of full prescriptive authority (model 3), each year since 1997 was associated with a mean wage growth of $3,047, however, the wage growth over time among states with full prescriptive authority grew $309 less (95% CI $-513, $-105) per year than in states without this SOP element. A similar pattern is observed in Model 6 where SOP at the practice level in 1997 had wages $3,134 (95% CI $431, $5,837) higher compared to states without this SOP element. In the adjusted full model 7, $3,134 decreased to $3,023 (95% CI $278, $5,769). In the individual model of SOP at practice level (model 6), each year since 1997 was associated with a mean wage growth of $3,096, but wage growth was $251 less (95% CI $-449, $-56) among these states compared to those without SOP at the practice level. Interestingly, states with the adaptable collaboration law had no significant difference in wage in 1997 (P = 0.6483), but again saw a decrease of $285 (95% CI $-484, $-86) in wage growth per year compared to states without this law. When modelling all SOP elements simultaneously (model 7), prescriptive authority and SOP at practice level in 1997 predicted annual wage of $4,506 (95% CI $1,946, $7,066), and $3,023 (95% CI $278, $5,769) higher than in states without this law, respectively. States with the co-signature law had no significant difference in wage in 1997 (P = 0.6645), but saw a decrease of $268 (95% CI $-477, $-60) in wage growth per year compared to states without this law. These changes in model 7, which contained all six elements, relative to models 1-6, which each contained a single element, may reflect either confounding of the associations between individual SOP elements and wage by other SOP elements, or variance inflation due to multicollinearity.

Table 3 Adjusted associations between Mean US PA Annual Wage (US$) Growth and Presence of Scope of Practice Laws Over Time (1997–2017) [a, b]

Models	Parameter Estimate	Standard Error	Lower 95% CI	Upper 95% CI	p
Model 1					
Intercept (year 1997)	45,356	1,502	42,338	48,374	<0.0001
Licensure	669	1,085	-1,461	2,798	0.538
Year	3,079	103	2,871	3,287	<0.0001
CPI	138	162	-180	457	0.3935
Mean age	524	150	229	819	0.0005
Percent female	14	15	-16	43	0.3609
Licensure*year	-134	93	-318	49	0.1507
Model 2					
Intercept (year 1997)	45,734	1,360	43,003	48,465	<0.0001
PA to physician collaboration ratio	378	1,963	-3,474	4,230	0.8472
Year	2,951	76	2,799	3,103	<0.0001
CPI	159	161	-158	476	0.3263
Mean age	580	147	292	868	<0.0001
Percent female	9	15	-20	38	0.5343
Ratio*year	71	130	-185	327	0.5867
Model 3					
Intercept (year 1997)	44,165	1,316	41,522	46,807	<0.0001
Full prescriptive authority	5,227	1,245	2,784	7,670	<0.0001
Year	3,047	87	2,873	3,222	<0.0001
CPI	157	162	-161	476	0.3318
Mean age	477	147	188	765	0.0012
Percent female	17	15	-13	46	0.2616
Prescription*year	-309	104	-513	-105	0.003
Model 4					
Intercept (year 1997)	45,452	1,437	42,565	48,339	<0.0001
Adaptable collaboration	719	1,575	-2,373	3,810	0.6483
Year	3,090	87	2,916	3,264	<0.0001
CPI	151	159	-161	463	0.3435
Mean age	466	148	176	755	0.0017
Percent female	13	15	-16	42	0.3725
Collaboration*year	-285	101	-484	-86	0.005
Model 5					
Intercept (year 1997)	45,222	1,431	42,348	48,095	<0.0001
Co-signature	1,563	1,429	-1,240	4,367	0.2741
Year	3,138	87	2,963	3,313	<0.0001
CPI	99	159	-214	412	0.5363

Mean age	445	150	150	139	0.0031
Percent female	11	15	-17	50	0.4333
Co-signature*year	-356	99	-551	162	0.0003
Model 6					
Intercept (year 1997)	44,233	1,473	41,275	47191	<0.0001
SOP at practice level	3,134	1,377	431	5837	0.0231
Year	3,096	90	2,914	3277	<0.0001
CPI	167	161	-149	484	0.2991
Mean age	533	148	244	823	0.0003
Percent female	12	15	-17	41	0.4287
SOP*year	-253	100	-449	-56	0.0119
Model 7					
Intercept (year 1997)	42,509	1,759	38,976	46042	<0.0001
Licensure	163	1,089	-1,975	2301	0.8812
PA to physician collaboration ratio	836	1,924	-2,939	4611	0.6639
Full prescriptive authority	4,506	1,304	1,946	7066	0.0006
Adaptable collaboration	17	1,575	-3,075	3109	0.9915
Co-signature	637	1,467	-2,243	3516	0.6645
SOP at practice level	3,023	1,399	278	5769	0.031
Year	3,315	129	3,056	3574	<0.0001
CPI	120	160	-193	433	0.4529
Mean age	276	153	-24	577	0.0714
Percent female	26	15	-4	55	0.0856
Licensure*year	-86	98	-278	106	0.3807
Ratio*year	123	131	-134	379	0.3491
Prescription*year	-180	119	-414	53	0.1306
Collaboration*year	-180	108	-392	33	0.0969
C0-signature*year	-268	106	-477	-60	0.0118
SOP*year	-154	107	-363	55	0.1487

CI: Confidence Interval; CPI: Consumer price index percent change

[a] Models were adjusted for PA mean-age, percent female PA, and CPI. Weighted by PA number.

[b] Linear mixed models were used to generate least square means.

DISCUSSION

Over the 20-year study period, PA wages increased 2.2-fold with the change in wage primarily explained by time and not specific state scope of practice laws. It is clear that individual SOP laws are associated with increased wage, particularly early in our study period, but the impact of these SOP elements changed over time. For example, full prescriptive authority was associated with a $5,227 higher wage in 1997, but with a negative wage growth of $309 for each subsequent year of the study. This is also seen with SOP at practice level, which was associated with a $3,134 higher wage in 1997, but a $253 lower wage growth for each subsequent year of the study. Together, this indicates that in the early period of this study, some SOP elements were associated with increased average wage, however, the impact of this increase diminished over time in all such instances. This suggests that the impact of these SOP elements on wage decreased over time.

The findings of this study support previous work by Perry (2009) showing an increase in PA scope of practice did not increase wage.[12] Yet, previous research indicates that expanded SOP for nurse practitioners (NPs) does indeed increase wage, but only when specifically related to independence.[12, 29] As PAs are able to provide a wider breadth of care as their SOP increases, there is arguably a benefit to society through an increase in access to care, however this does not appear to translate into individual wage growth *per se*. As the majority of states have permissive SOP laws and with this realisation, it is not surprising that the constituents of AAPA have pressed forward to expand practice autonomy further through Optimal Team Practice.[22, 30] The tenets of OTP will move the PA profession closer to independent practice, similar to nurse practitioners. Future research should then investigate if this expansion of scope of practice impacts PA wage as has been observed for nurse practitioners.

Our study only found a negative linear correlation between annual wage and percent female PAs in 2012, but this was non-significant in our multivariable growth models. This may indicate that the increase in the percentage of female workforce is not impacting annual wage growth. These findings juxtapose the other research that notes an $11,000 reported difference in wage by female PAs and an $12,859 difference by female NPs.[13, 31] Future research is needed to explore the influence of the feminization of the PA profession on salary growth.

As the PA profession has been anointed the "Best Job in America" by the US News and World Report for 2021, the Bureau of Labor and Statistics projects a 31% growth in employment over the next 10 years.[32, 33] This growth projection is due to the expected increase in demand for health care services and the ability to train PAs faster than physicians. With a projected shortage of 21,400 to 55,200 primary care physicians by 2033, PAs are often cited as one solution to meet this demand.[34] Research indicates that the supply of PAs is impacted by SOP laws, resulting in an increase in PAs per capita in states with permissive regulations.[22] At the same time, the supply of PAs willing to work in primary care is likely restricted by the decreased earnings.[9] Our study did not delineate specialty which directly impacts PA wage. So, as our country continues to grapple with solutions to increase access to primary care, future research needs to better understand the levers that influence physician assistants' earnings, including specialty care.

This study has a number of important limitations. First, we analysed aggregate data at the state level; such ecological analyses are inherently limited and preclude drawing causal conclusions. Second, our analysis does not include other possible confounding variables that may impact PA wage, including specialty area of clinical employment, physician or nurse practitioner employment numbers, or state and federal healthcare legislative policies. Third, we were unable to account for lag time in terms of when the SOP laws were passed and the impact on wage. Fourth, the AAPA data on PA demographics is from a survey and the response rate ranged from 10-35% annually which may lead to a sampling bias towards or away from the null. These limitations are counterbalanced by a number of important strengths, including the robust SOP data provided by AAPA that was cross referenced and verified for each state and each year combined with annual wage data from the Bureau of Labor and Statistics.

CONCLUSIONS

Physician Assistant median wage has risen 220% in the past two decades. At the same time, there has been a significant expansion of state scope of practice laws such that the majority of PAs today work in states with permissive regulations. This rise in physician assistant wage is mainly explained by time and the age of providers with minimal explanation by state scope of practice laws. As the PA profession moves towards Optimal Team Practice, future research should examine if this move towards greater autonomy impacts wage, as occurred in nurse practitioners.

Contributorship Statement

VLV, SN, and TJH were involved in the data analysis, interpretation, drafting the manuscript, and reviewed/edited the manuscript.

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Grant number: N/A

Competing interests

None declared.

Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication

Not required.

Ethics approval

As we used publicly available BLS data, and the requested AAPA data does not contain identifying variables, this study was determined exempt from review by the University of Utah Institutional Review Board (IRB 00115478).

Data availability statement

BLS and the United States Census Bureau have public use linkage to access Labor Statistics and population data, respectively. The data from AAPA on PA census and legislative history was requested through AAPA research department.

Figure 1 caption: Physician Assistant Annual Wage and Number of States with Each Practice Law from 1997 to 2017

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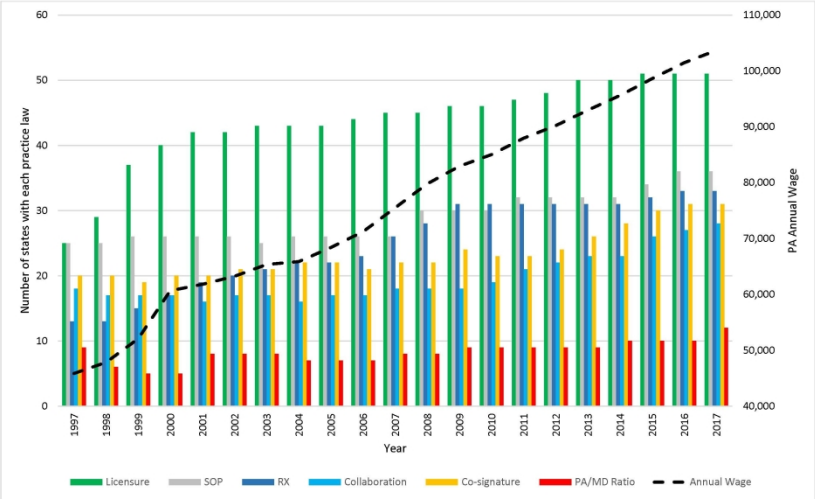

Figure 1 caption: Physician Assistant Annual Wage and Number of States with Each Practice Law from 1997 to 2017

Figure 1: Physician Assistant Annual Wage and Number of States with Each Practice Law from 1997 to 2017

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Supplementary Table 1 Correlation between PA Annual Wage and Mean PA Age and Percent Female PA in 1997, 2002, 2007, 2012, and 2017

	Year				
	1997	**2002**	**2007**	**2012**	**2017**
Age					
Pearson's correlation coefficient[a]	-0.08	0.31	0.22	0.52	0.29
P	0.600	0.028	0.129	<0.001	0.042
Percent female PA					
Pearson's correlation coefficient[a]	0.41	-0.21	-0.03	-0.41	-0.15
P	0.003	0.134	0.822	0.003	0.296

[a] Weighted by states' PA population

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4-5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4-5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-5
Bias	9	Describe any efforts to address potential sources of bias	5-6, 14
Study size	10	Explain how the study size was arrived at	4-5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	5-6
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	4-5
		(*e*) Describe any sensitivity analyses	None

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	4-5
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6-7
		(b) Indicate number of participants with missing data for each variable of interest	5-6
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	9-12
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	*9-12*
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	6-9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	6-12
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.