

## Appendix

### DESIGN

The study compared California hospitals to hospitals in all other states in order to assess staffing and skill mix changes to national trends. We excluded Guam, Puerto Rico, and other territories and outlying areas. Hospitals with very high staffing ratios were excluded by capping the hours per patient day at 20.

We used propensity score matching of California hospitals to hospitals across the nation based on non-nursing covariates. To ensure robustness of our findings, we took two approaches. First, instead of propensity score matching, we compared all California hospitals to hospitals in all other states. Second, we employed single state comparisons in order to ensure that our national comparisons were not heavily influenced by averages. The comparison states were chosen for statistical comparison and regional diversity. Many states were too small to compare to California and larger states with a variety of hospital types and sizes were chosen in diverse regions to create comparisons.

*Policy Environment of Comparison States.* California is the only state with a mandated minimum patient-to-nurse ratio. Although many other states have some staffing legislation none of the states comprehensively regulate staffing shift-to-shift at the unit-level as California does. The types of alternative regulation include simple staffing data collection, establishing staffing committees, public reporting, and limits on overtime. Although none of our comparison states had staffing policy similar to California's during the period we investigated, it is worthy to note the nurse staffing related legislation in the states that we used as comparisons for California.

In 2009, Texas signed legislation into law requiring that hospital governing bodies adopt, implement and enforce a written nurse staffing policy created by a staffing committee. The purpose of the policy is to ensure a sufficient number and skill mix of nurses available to meet patients' needs by unit and shift but there are no minimum numbers as in California. Florida passed a law in 2006 requiring a registered nurse to be present in the operating room during the entire surgical procedure. Pennsylvania introduced but did not pass legislation during the 2009-2010 session to develop staffing plans by committee, whistleblower protections for nurses who report unsafe staffing, and public disclosure of staffing levels. New York enacted legislation in 2009 requiring health care facilities to publicly

report information on nurse staffing. Legislation in New York was also introduced but not passed to create minimum staffing levels for healthcare workers in various health care settings.

#### DATA SOURCES

It should be noted that the American Hospital Association Annual Survey data provides both estimated and reported data. With a response rate of approximately 85%-90%, the American Hospital Association uses a well-established multiple imputation methodology based on previous year's data and estimation techniques to create a current value for missing data.(1) Variable construction and data analysis were conducted on estimated, reported, and combined (estimated and reported) data for this study; no statistical difference was found between the two. As in most studies using the American Hospital Association data, the results we report here use the combined estimated and reported data.

#### VARIABLES

Additional information on the outcome measures and covariates is provided.

*Adjusted Hours Per Patient Day.* The American Hospital Association data on nurse staffing are limited in that they include both inpatient and outpatient nurses. To address this,

we applied a standard adjustment that utilizes the information on the ratio of outpatient revenue for adjustment.<sup>(2)</sup> Our measure of Adjusted patient days = inpatient days + (inpatient days X outpatient revenue/inpatient revenue). The data from the American Hospital Association provide one of the only consistent national data sources over the time period required to answer our research question.

*Covariates.* Hospital bedsize was defined as the number of hospital unit beds set up and staffed. Hospital teaching status was calculated as the ratio of resident physicians and fellows to hospital beds. Occupancy rate was calculated as the ratio of adjusted average daily hospital census to staffed hospital beds. Ownership status was defined as for-profit versus non-profit.

Three variables were included as controls for patient mix. Annual hospital-level case-mix index – the average Medicare diagnosis-related group (DRG) relative weight for each hospital – was obtained from the Centers for Medicare and Medicaid Services (CMS) in order to control for the patient severity of illness between hospitals, whereas a higher level of staffing might be indicative of a higher severity of illness. The patient payer mix, drawn from the American Hospital Association data, was controlled for using the percent of admissions with Medicare as the primary payer and the percent of patients with Medicaid as the primary payer.

Market characteristics that may have affected nurse staffing levels were included. The Herfindahl-Hirschman index (HHI) was included as a proxy for market competition. The HHI is the sum of squared market shares of all of the hospitals competing in the market where the markets were defined as the hospital service area outlined in the Dartmouth Atlas.(3) Market share data were drawn from the CMS Hospital Services Area Files for each year. Even though ratios were mandated in California, the degree of competition could potentially influence staffing because units and hospitals operate above the mandate and variation in staffing still existed.(4-6)

Finally, a measure of the availability of the local nursing workforce for each year was included. A registered nurse supply variable was calculated for each state in each year by dividing the number of active nurses, derived from the Bureau of Labor Statistics, Occupational Employment Statistics, by the state's population in each year, drawn from the U.S. Census Bureau, Population Division. This measure was standardized to represent the number of nurses per thousand population.

#### ANALYSIS DETAILS

We used fixed-effects modeling to ensure that the estimated effects of the policy were not due to unspecified time-invariant differences between hospitals in different states and markets

that may be associated with staffing and skill mix over time. We also included time fixed-effects (dummy variables for each time-period) to control for secular changes that may influence the availability and use of licensed nurses and trends between time periods that are common to all hospitals. To determine the effect of AB 394 on registered nurse staffing and skill mix we created models that included interactions between the California dummy variable and the three time periods (Pre-announcement, Announcement, and Implementation) and evaluated the sign, size, and significance of the coefficients for these interaction terms.

Hausman specification tests were used to confirm that fixed effects were preferred to random effects specifications. We also evaluated the effects using generalized estimating equations<sup>24</sup> and found no difference in the direction or level of significance of our findings. Models again included interactions between the California dummy variable and the three time periods (Pre-announcement, Announcement, and Implementation).

Propensity score analysis and traditional model-based analyses work best in combination.(7-8) The propensity score in this case was, in the baseline year of 2001 (the year prior to the announcement of the ratios faced by hospitals), the probability of an individual hospital being a California

hospital conditional on observed covariates. We conducted this analysis on a balanced panel of the hospitals that were present in all 12 years. By conditioning on the propensity score, we can approximate some aspects of a randomized controlled trial insofar as they hold for observed measures.

In the first step, we determined the best balance of covariates between treatment (California hospital) and comparison groups (non-California hospital). Covariates included those same variables used in our model-based analysis. We also included one-year lag variables for the time-varying covariates so the value of each variable from the year 2001 and 2000 was used in the propensity score model. We began with a general linear propensity score model defining the distance between two individual hospitals  $i$  and  $j$  as  $D_{ij} = |\text{logit}(e_i) - \text{logit}(e_j)|$ . We began with 1:1 nearest neighbor propensity score matching without replacement but found that 2:1 nearest neighbor propensity score matching without replacement provided better balance of covariates. We assessed balance using standard methods including the standardized difference in means which are non-sensitive to sample size and graphical displays such as Q-Q plots, jitter plots, and histograms.(7, 9-11) We have included such plots and the table of standardized biases to our **Supplementary Exhibits**. All matching and balance assessment was conducted using the MatchIt package(9) in the R statistical

program. We then conducted our analysis, modeled in a similar fashion, as the prior analysis to estimate the effect of the Announcement and Implementation of the staffing mandate. We included the same covariates in this analysis to add a double-robustness and account for any residual covariate imbalance.

As noted in the paper, we identified three key time intervals: 1) prior to 2002, the period before the final ratios were released, 2) 2002-2004, the post-announcement period but prior to when the California Department of Health Services (CDHS) regulations went into effect, and 3) 2004 and beyond, when the CDHS regulations implementing the ratios pursuant to AB 394 went into effect. The years prior to 2002 were combined as these were the years prior to the release of the ratios that hospitals would actually face. Although 1999 was the year that the legislation passed, the legislation itself only required the CDHS to promulgate regulations establishing minimum nurse-to-patient ratios. The specific ratios that hospitals would face were unknown until after a lengthy regulatory process establishing the final ratios in 2002. Additionally, when examining the literature [e.g., (12)] that had viewed trends in staffing in California prior to 2004, there was no evidence that staffing significantly increased in 1999 in response to the legislation prior to 2002.



It is not uncommon for organizations to be forward looking and to respond in anticipation to changes in the policy environment even before the changes occur. Likewise, evaluations of policy often determine whether there are such anticipatory (or announcement) effects particularly when a policy (such as AB 394) has a long period between the passage of legislation and the implementation of regulations. After the announcement of the ratios, there was a response from some hospitals to meet the mandate. On one hand, hospitals already meeting the mandate were able to boast early adoption, translating to good publicity for some organizations. For example, prior to the release of the final ratios, the hospitals of Kaiser Permanente system implemented ratios richer than the final minimum ratios ultimately established under AB 394. On the other hand, some hospitals needed to make changes to budget, and to work harder to attract and retain more nurses. Evaluating whether and to what degree the increase in staffing came following implementation beyond any anticipatory effect was an empirical question for us to investigate.

## References

1. American Hospital Association. Survey History & Methodology. Chicago: American Hospital Association; 2010 [cited 2010 October 31]; Available from: <http://www.ahadata.com/ahadata/html/historymethodology.html>.
2. Spetz J, Donaldson N, Aydin C, Brown DS. How many nurses per patient? measurements of nurse staffing in health services research. Health Serv Res. 2008 May 5;43(5):1674-92.
3. Wennberg J, Cooper M. The Dartmouth Atlas of Health Care. Dartmouth: The Center for the Evaluative Clinical Sciences, Dartmouth Medical School; 1998.
4. Anderson GF, Kohn LT. Hospital employment trends in California, 1982-1994. Health Aff (Millwood). 1996;15(1):152-8.
5. Mark B, Harless DW, Spetz J. California's minimum-nurse-staffing legislation and nurses' wages. Health Aff (Millwood). 2009 Mar-Apr;28(2):w326-34.
6. Robinson JC. Hospital competition and hospital nursing. Nurs Econ. 1988 May-Jun;6(3):116-9.
7. Stuart E. Matching methods for causal inference: A review and a look forward. Stat Sci. 2010 Feb;25(1):1-21.

8. Rubin DB. The use of matched sampling and regression adjustment to remove bias in observational studies. *Biometrics*. 1973;29(1):185-203.
9. Ho DE, Imai K, King G, Stuart EA. Matching as nonparametric preprocessing for reducing model dependence in parametric causal inference. *Political Analysis*. 2007;15(3):199-236.
10. Rosenbaum P. *Design of Observational Studies*. New York: Springer; 2009.
11. Dehejia R. Practical propensity score matching: a reply to Smith and Todd. *J Econometrics*. 2005;125(1-2):355-64.
12. Conway PH, Tamara Konetzka R, Zhu J, Volpp KG, Sochalski J. Nurse staffing ratios: trends and policy implications for hospitalists and the safety net. *J Hosp Med*. 2008 May;3(3):193-9.

**SUPPLEMENTARY EXHIBIT 1. Descriptive Statistics of Hospitals, 1997-2008**

	All U.S. hospitals		Individual state comparisons				Matched U.S. Hospitals	
	CA	Other states	NY	PA	TX	FL	CA	Other states
<b>Staffing<sup>a</sup></b>	6.16 (2.59)	5.40 (2.43)	4.47 (1.86)	5.23 (1.89)	5.51 (2.17)	5.84 (2.06)	6.25 (2.48)	5.84 (2.55)
<b>Skill mix<sup>b</sup></b>	0.866 (0.088)	0.834 (0.13)	0.867 (0.960)	0.868 (0.869)	0.731 (0.171)	0.872 (0.086)	0.87 (0.08)	0.86 (0.13)
<b>Hospital beds</b>	201.35 (150.61)	188.91 (185.80)	326.69 (281.32)	225.62 (177.57)	165.17 (183.16)	274.28 (258.67)	212.98 (147.47)	215.06 (161.10)
<b>Occupancy rate<sup>c</sup></b>	.88 (.18)	.89 (.21)	1.02 (.14)	.99 (.15)	.82 (.23)	.86 (.198)	1.05 (0.41)	1.06 (0.35)
<b>Teaching status<sup>d</sup></b>	0.054 (0.174)	0.042 (0.146)	0.126 (0.229)	0.081 (0.192)	0.020 (0.116)	0.023 (0.061)	0.07 (0.20)	0.07 (0.20)
<b>Case Mix Index<sup>e</sup></b>	1.38 (23.39)	1.28 (0.258)	1.32 (0.23)	1.33 (0.245)	1.268 (0.264)	1.40 (0.23)	1.39 (0.22)	1.37 (0.28)
<b>% Medicare admissions</b>	43.42 (15.19)	50.15 (17.46)	44.61 (13.77)	56.11 (14.55)	53.93 (16.48)	51.98 (13.69)	43.94 (15.83)	45.07 (15.79)
<b>% Medicaid admissions</b>	22.85 (17.47)	17.99 (15.18)	25.95 (17.29)	14.76 (11.94)	14.31 (11.08)	14.60 (8.65)	22.35 (16.62)	21.14 (16.05)
<b>Herfindahl-Hirschman Index<sup>f</sup></b>	1109.88 (922.53)	1119.08 (731.97)	1078.91 (745.80)	1190.61 (698.81)	1038.46 (725.82)	1155.52 (651.00)	1324.28 (1040.6)	1323.02 (706.02)
<b>Nurse supply<sup>g</sup></b>	6.10 (0.45)	8.14 (1.32)	8.51 (0.14)	9.45 (0.56)	6.46 (0.25)	8.06 (0.48)	6.12 (0.44)	8.08 (1.39)
<b>% Not-for-profit</b>	77.31	85.44	97.91	95.19	70.24	54.46	84.31	83.33

SOURCE: Authors' analysis. NOTE: All statistics are mean with standard errors in parentheses except for ownership which is a percentage. <sup>a</sup>Staffing is registered nurse hours per adjusted patient day. <sup>b</sup>Skill mix is the proportion of registered nurses among all licensed nurses (registered nurses plus licensed practical nurses). <sup>c</sup>Occupancy Rate is calculated as the adjusted daily census per total beds set up and staffed for the hospital for the year. <sup>d</sup>Teaching Status is a continuous resident/fellow-to-bed ratio. <sup>e</sup>Case Mix Index was drawn from annual files available from the Centers for Medicare and Medicaid Services (CMS). <sup>f</sup>Herfindahl-Hirshman index is a proxy measure for market competition measured as the sum of squared market shares of all of the hospitals competing in the market where the markets were defined as the hospital service area defined in the Dartmouth

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Atlas and market share data were drawn from the CMS Hospital Services Area Files for each year.<sup>9</sup>Nurse supply was measured as the ratio of nurses to total population in each state based on data from the Bureau of Labor Statistics, Occupational Employment Statistics and the US Census Bureau.

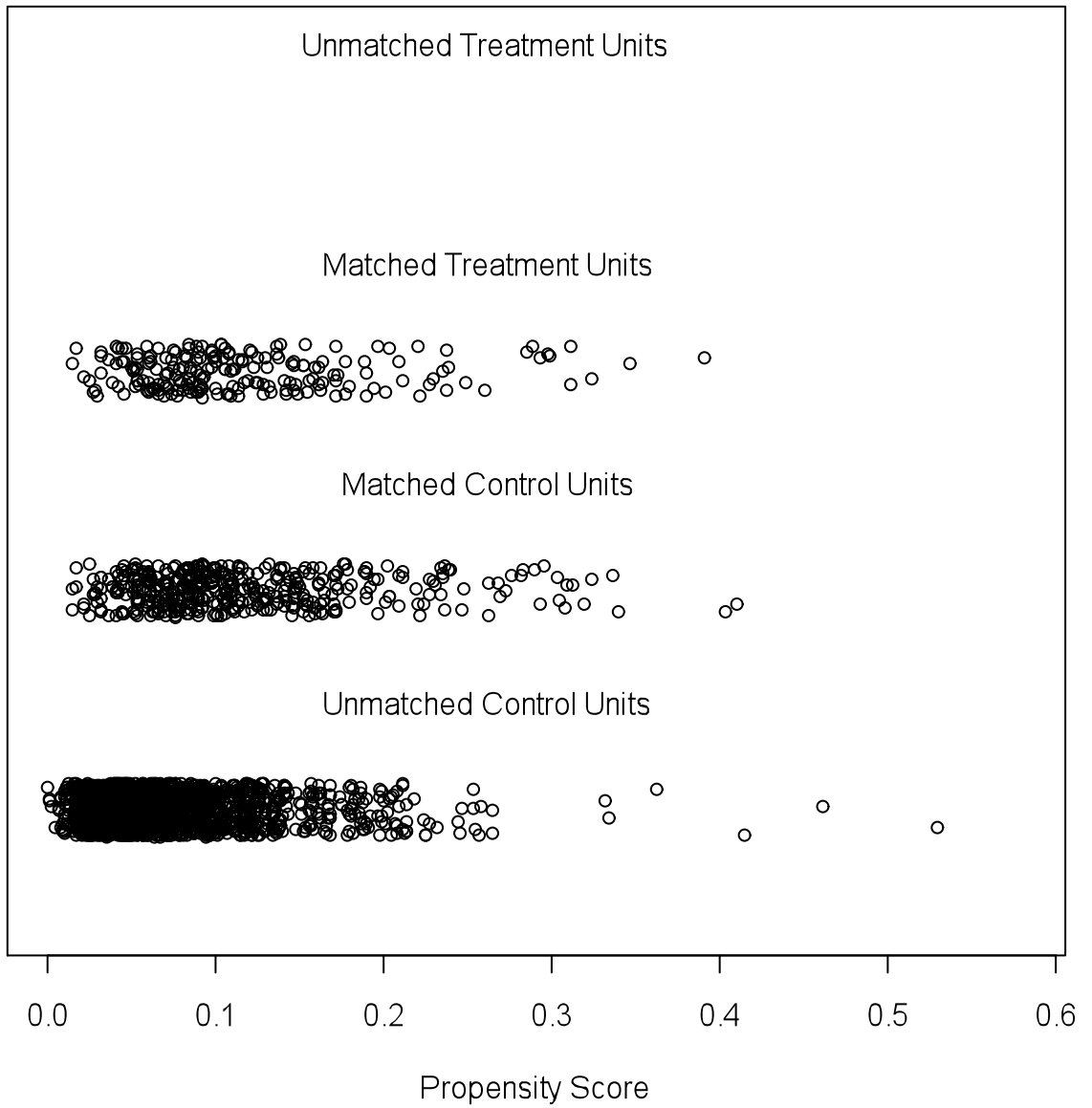
**SUPPLEMENTARY EXHIBIT 2. Sample sizes, 1997-2008**

	California	California, matched <sup>a</sup>	National	National, matched <sup>b</sup>	Florida	New York	Pennsylvania	Texas
<b>1997</b>	337	205	4035	410	168	197	175	333
<b>1998</b>	362	205	4193	410	180	204	182	345
<b>1999</b>	351	205	4091	410	179	197	179	336
<b>2000</b>	344	205	4041	410	172	191	175	335
<b>2001</b>	337	205	3980	410	172	186	169	332
<b>2002</b>	336	205	3930	410	172	182	162	328
<b>2003</b>	320	205	3263	410	167	182	165	284
<b>2004</b>	309	205	3056	410	164	181	158	270
<b>2005</b>	296	205	2909	410	164	175	153	256
<b>2006</b>	282	205	2855	410	165	173	147	252
<b>2007</b>	278	205	2860	410	166	170	144	253
<b>2008</b>	288	205	2825	410	163	165	145	247
<b>Mean</b>	320	205	3503	410	169	184	163	296

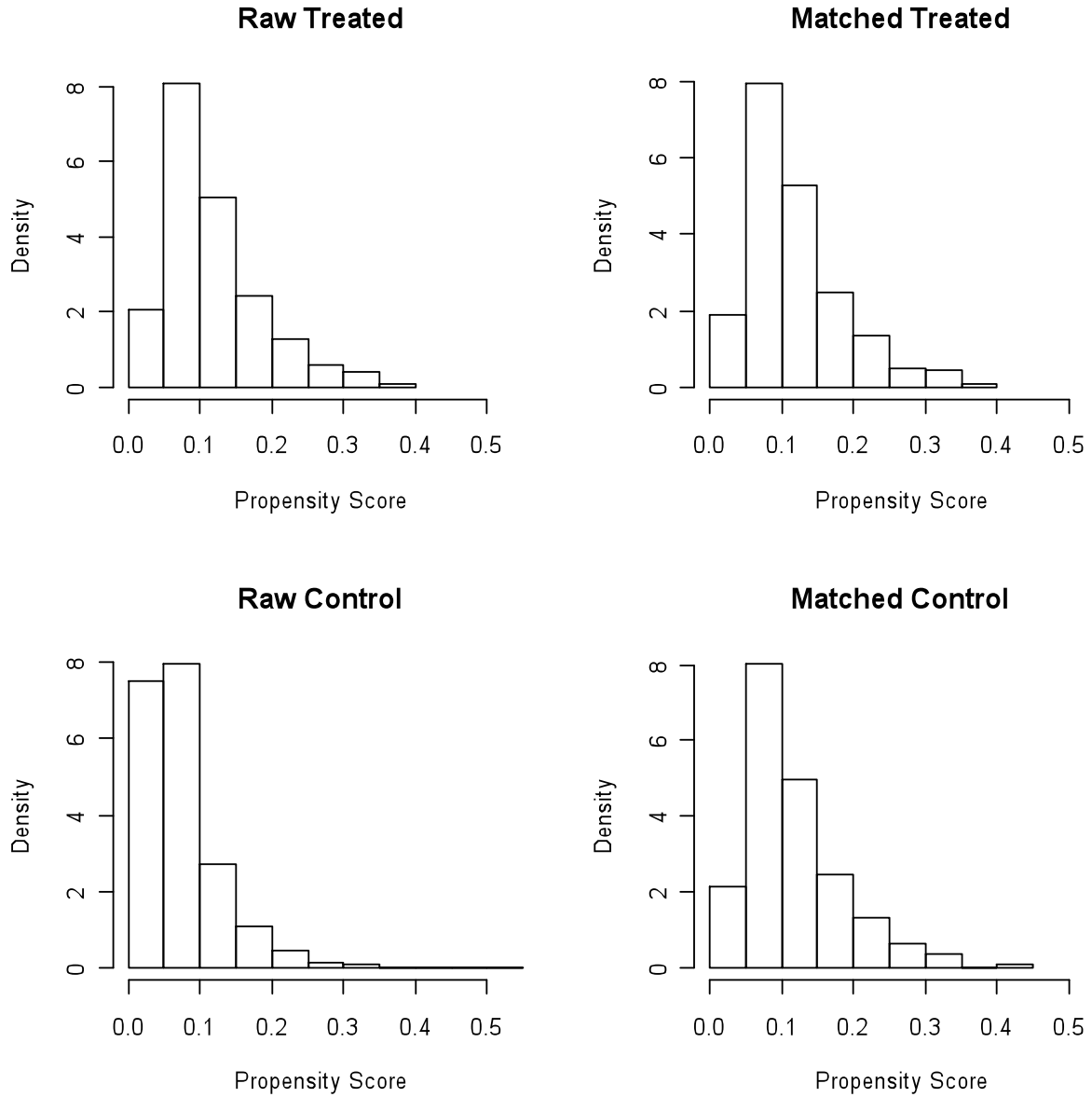
SOURCE: Authors' analysis. NOTE: Samples represent adult, non-federal acute care hospitals with data for variables of interest in the American Hospital Association data. <sup>a</sup>Sample of California hospitals for propensity score matched analysis is based on those hospitals present in all 12-years of data that could be matched based on propensity score to non-California hospitals. <sup>b</sup>Sample for propensity score matched analysis is based on those hospitals present in all 12-years of data and matched 2:1 with the 205 California hospitals.

**SUPPLEMENTARY EXHIBIT 3. Jitter Plot of Propensity Scores for Matched and Unmatched Treatment (California) Hospitals and Control (All Other) Hospitals**

### Distribution of Propensity Scores

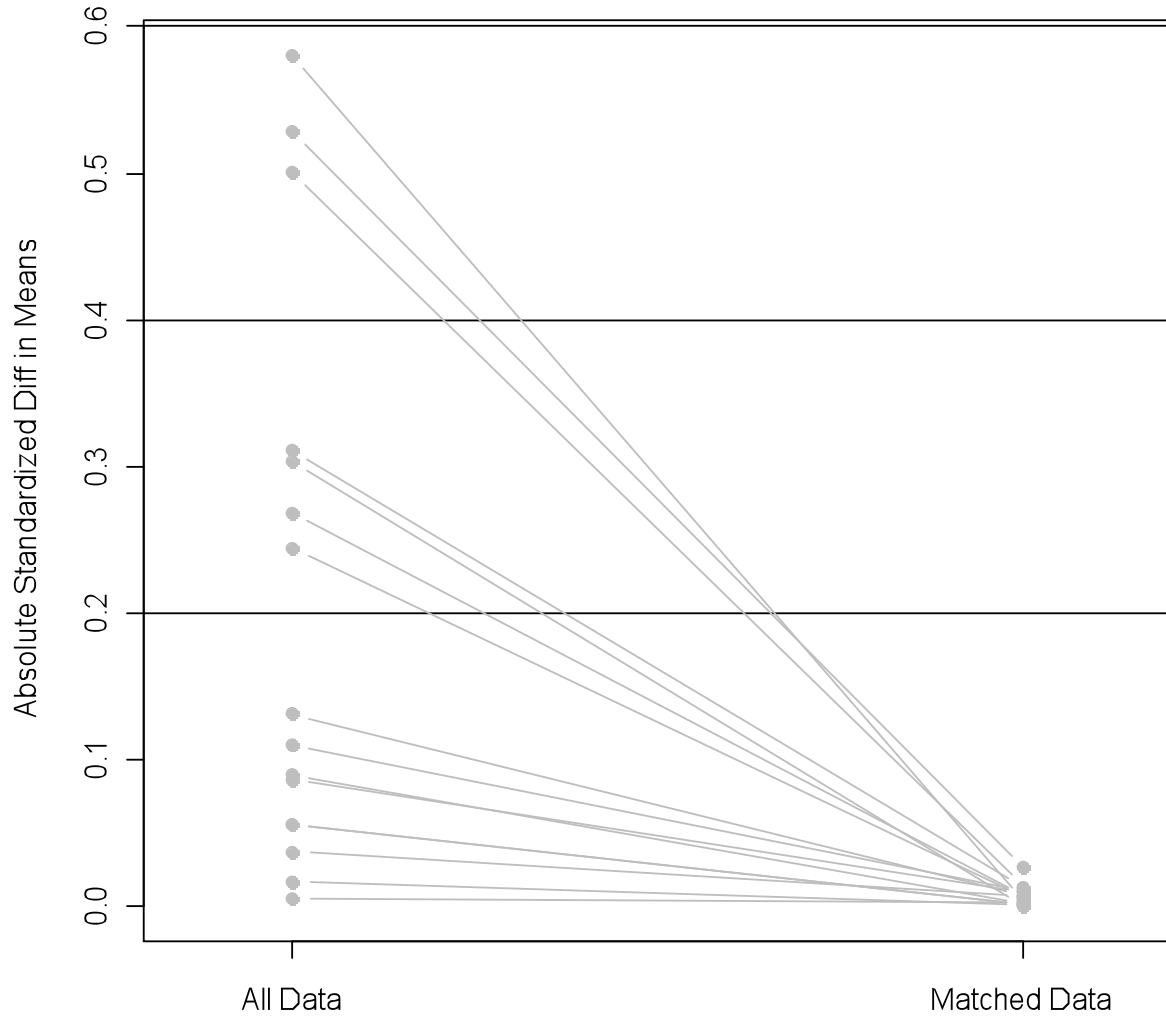


**SUPPLEMENTARY EXHIBIT 4. Histograms of Propensity Scores for Treatment (California) Hospitals and Control (All Other) Hospitals Before (Raw) and After (Matched) Matching**





**SUPPLEMENTARY EXHIBIT 5. Plot of Standardized Difference of Means of Covariates Before and After Matching**



**SUPPLEMENTARY EXHIBIT 6. Comparison of Standardized Biases Before and After Matching for California Hospitals Compared to All Other US Hospitals in 2001**

	Full Sample			Matched Sample			% Diff.
	Means Treated	Means Control	Mean Std. Diff.	Means Treated	Means Control	Mean Std. Diff.	
<b>Propensity score</b>	0.12	0.08	0.581	0.12	0.12	0.004	99.33
<b>Hospital beds</b>	215.03	212.59	0.017	215.03	214.88	0.001	94
<b>Case Mix Index</b>	1.38	1.33	0.244	1.38	1.38	0.006	97.62
<b>Herfindahl-Hirschman Index</b>	1324.22	1382.17	-0.056	1324.22	1322.92	0.001	97.76
<b>% Not-for-profit</b>	0.84	0.86	-0.037	0.84	0.84	0.007	81.99
<b>Occupancy rate</b>	1.00	1.05	-0.131	1.00	1.01	-0.007	94.38
<b>Teaching status</b>	0.07	0.05	0.11	0.07	0.07	0.01	90.77
<b>% Medicare admissions</b>	0.44	0.51	-0.5	0.44	0.44	0.013	97.31
<b>% Medicaid admissions</b>	0.22	0.17	0.311	0.22	0.22	0.013	95.91
<b>Hospital beds, 2000</b>	211.05	210.21	0.006	211.05	211.42	-0.003	55.67
<b>Case Mix Index, 2000</b>	1.39	1.34	0.268	1.39	1.39	0.007	97.52
<b>Herfindahl-Hirschman Index, 2000</b>	1324.22	1382.17	-0.056	1324.22	1322.92	0.001	97.76
<b>Occupancy rate, 2000</b>	1.01	1.04	-0.086	1.01	1.01	-0.01	88.11
<b>Teaching status, 2000</b>	0.07	0.05	0.09	0.07	0.07	-0.002	98.07
<b>% Medicare admissions, 2000</b>	0.44	0.51	-0.528	0.44	0.44	0.026	95.03
<b>% Medicaid admissions, 2000</b>	0.21	0.16	0.304	0.21	0.21	0	99.92

SOURCE: Authors' analysis. NOTE: Standardized bias (or standardized difference in means) is defined as the weighted difference in means divided by the standard deviation in the full group of non-California hospitals. Variables followed with the note '2000' indicate the value for the year 2000.

**SUPPLEMENTARY EXHIBIT 7. Effects of California Staffing Mandate (AB 394) on Nurse Staffing and Skill Mix: All Comparison Groups without Similar Staffing Policy, 1997-2008**

	Florida	New York	Pennsylvania	Texas	All U.S. hospitals	Matched U.S. hospitals <sup>a</sup>
<b>Staffing<sup>b</sup></b>						
<b>Announcement</b>	-0.318* (0.127)	-0.135 (0.105)	0.011 (0.116)	0.213 (0.095)	0.038 (0.062)	0.159 (0.093)
<b>Implementation (compared to Pre-Announcement)</b>	0.107 (0.1097)	0.395*** (0.087)	0.572*** (0.0992)	0.709*** (0.080)	0.628*** (0.0501)	0.726*** (0.071)
<b>Implementation (effect beyond Announcement)</b>	0.425** (0.128)	0.53*** (0.109)	0.561*** (0.117)	0.495*** (0.099)	0.5897*** (0.064)	0.567*** (0.094)
<b>Skill mix<sup>c</sup></b>						
<b>Announcement</b>	-0.005 (0.004)	.00006 (0.004)	0.003 (0.004)	0.006 (0.004)	0.001 (0.003)	0.004 (0.004)
<b>Implementation (compared to Pre-Announcement)</b>	-0.019*** (0.004)	-0.001 (0.003)	0.007 (0.003)	-0.012*** (0.003)	-0.001 (0.003)	0.002 (0.003)
<b>Implementation (effect beyond Announcement)</b>	-0.014** (0.004)	-0.001 (0.004)	0.003 (0.004)	-0.012** (0.004)	-0.002 (0.003)	-0.002 (0.004)

SOURCE: Authors' analysis. NOTE: Beta coefficients are from separate ordinary least squares fixed-effects regression models estimating the effects of AB 394 on staffing and skill mix using alternative comparison groups; standard errors are in parentheses. The Announcement effect is based on the interaction term of Announcement time period dummy variable and California dummy variable; the Implementation effect is based on the interaction term of Implementation time period dummy variable and California dummy variable. To estimate the coefficient for Implementation compared to Pre-Announcement and Implementation beyond Announcement, we used alternate coding of the time period dummy variables to establish the appropriate contrasts. Covariates include bed total, occupancy rate, teaching status, case mix index, percent admissions Medicare, percent admissions Medicaid, Herfindahl-Hirshman index, nurse supply. The "All U.S. hospitals" category pools all hospitals in the other 49 states (excluding California) as a 'National' contrast to California. <sup>a</sup>The 'Matched' column shows coefficients from model using the propensity score matched sample. <sup>b</sup>Staffing is registered nurse hours per adjusted patient day. <sup>c</sup>Skill mix is the proportion of registered nurses among all licensed nurses (registered nurses plus licensed practical nurses). \*p<.05; \*\*p<.01; \*\*\*p<.001