**Alternative Approaches to Ensuring Adequate Nurse Staffing: The Effect of State Legislation on Hospital Nurse Staffing**

**Appendix**

The purpose of this appendix is to provide additional documentation of the analytical approach and detailed statistics for descriptive and regression analyses.

**Difference-in-Difference Model Specification**

In this study, we run two multivariate linear regression models to measure the difference-in-difference estimates. Model (1) compares changes in hospital staffing in the state that mandated staffing ratios (i.e., California), in states that legislated staffing committees, and in states that legislated public reporting before and after the implementation of the legislation, to staffing changes in states that did not implement any staffing legislation during the same period. Model (2) omitted the state of California from the study sample.

The specification for model (1) is as following:

*Y*ist= *b*0 + *b*1mandatei + *b*2committeei + *b*3reportingi + *b*4mandate\_postit + *b*5committee\_postit + *b*6reporting\_postit + *b*7*X*ist + *u*i + *v*t+ *e*ist (1)

Where *Yit*represents the staffing outcomes of interest, as mentioned in the main text, for hospital *i* in state *s* at year *t*, mandatei is a dummy variable indicating hospital *i* = 1 in the state that legislated staffing mandate (i.e., California), committeei is a dummy variable indicating hospital *i* = 1 in states that legislated staffing committee, reportingi is a dummy variable indicating hospital *i* = 1 *i* in states that legislated public reporting, mandate\_postit is a dummy variable indicating hospital *i* = 1 in the state that legislated staffing mandate and at year *t* when the law was in effect, committee\_postit is a dummy variable indicating hospital *i* = 1 in states that legislated a staffing committee and at year *t* when the law was in effect, reporting\_postist is a dummy variable indicating hospital *i* = 1 *i* in states that legislated public reporting and at year *t* when the law was in effect, *X*istis a vector of hospital-level and state-level controls, *u*i is a vector of hospital fixed effects, and *v*t is a vector of year fixed effects. The coefficient *b*4 represents the difference-in-difference estimate in the state that legislated staffing mandates compared to states with no laws before and after the law was implemented, *b*5 reprsents the outcome estimate in states that legislated staffing committees compared to states with no laws before and after the law was implemented, and *b*6 represents the estimate in states that legislated public reporting compared to states with no laws before and after the law was implemented.

The specification for model (2) is as following:

*Y*ist= *b*0 + *b*1committeei + *b*2reportingi + *b*3committee\_postit + *b*4reporting\_postit + *b*5*X*ist + *u*i + *v*t+ *e*ist (2)

where all variables are explained the same as in model (1), except that the state that legislated staffing mandate (i.e., California) was excluded.

**Sensitivity Analysis for Oregon’s Enhancement Law in 2015**

As suggested by reviewers, we conducted a sensitivity analysis by including in the model (1) a dummy variable indicating the state of Oregon and a dummy variable indicating the state of Oregon interacting with the dummy indicating when Oregon implemented the enhancement law (2015). The model specification is shown as following:

*Y*ist= *b*0 + *b*1mandatei + *b*2committeei + *b*3reportingi + ***b*4oregoni** + *b*5mandate\_postit + *b*6committee\_postit + *b*7reporting\_postit + ***b*8oregon\_postit** + *b*9*X*ist + *u*i + *v*t+ *e*ist (3)

Where oregoni is a dummy variable indicating hospital *i* = 1 in the state of Oregon, oregon\_postit is a dummy variable indicating hospital *i* = 1 in the state of Oregon and at year *t* when the law was in effect (year>=2015). The coefficient *b*8 represents the difference-in-difference estimate in the state of Oregon compared to states with no laws before and after the law was implemented. Others are exaplained the same as in model (1), as described above.

**Control Variables**

The control variables included hospital characteristics, Saidin Index, Herfindahl-Hirschman Index, state-level supply, and state right-to-work status. These covariates were chosen or created based on prior studies of California’s staffing mandate1-5 and the potential correlation with staffing levels. Hospital size was measured by the number of licensed beds. Ownership status was measured using dummy variables for government-owned and for-profit hospitals; nonprofit was the reference group. Teaching status was measured using the ratio of resident and trainee full-time equivalents to licensed beds, where hospitals had a ratio between 0 and 0.25 were flagged as minor teaching hospitals and hospitals had a ratio of 0.25 or greater were flagged as major teaching hospitals; hospitals with no residents and trainees was the reference group. Location in metropolitan areas was measured using a dummy variable equal to one if a hospital reported it was located within a metropolitan area during the study period. Percent Medicare days was measured using the number of inpatient days covered by Medicare patients and percent Medicaid days was measured using the number of impatient days Medicaid patients. Herfindahl-Hirschman Index was computed using the number of licensed beds per year by hospital referral region, using Stata software with the *hhi* command. Past research indicates that using licensed beds to calculate HHI can capture the degree of potential competition for those hospitals producing below their capacity. 6 Saidin index is a measure of hospital technological sophistication that was derived from the AHA data, calculated based on a list of services available each year.7 State right-to-work status was a dummy variable for hospitals in states that currently have a right-to-work legislation. State-level supply was measured using the number of employed nurses and nursing assistants to population ratios each year for each state and was lagged one year to account for endogeneity.

**References**

McHugh MD, Kelly LA, Sloane DM, Aiken LH. Contradicting fears, California’s nurse-to-patient mandate did not reduce the skill level of the nursing workforce in hospitals. Health Affairs. 2011;30(7):1299-306.

Reiter KL, Harless DW, Pink GH, Mark BA. Minimum nurse staffing legislation and the financial performance of California hospitals. Health services research. 2012;47(3pt1):1030-50.

Reiter KL, Harless DW, Pink GH, Spetz J, Mark B. The effect of minimum nurse staffing legislation on uncompensated care provided by California hospitals. Medical Care Research and Review. 2011;68(3):332-51.

Spetz J, Harless DW, Herrera CN, Mark BA. Using minimum nurse staffing regulations to measure the relationship between nursing and hospital quality of care. Medical Care Research and Review. 2013;70(4):380-99.

Mark BA, Harless DW, Spetz J, Reiter KL, Pink GH. California's minimum nurse staffing legislation: results from a natural experiment. Health services research. 2013;48(2pt1):435-54.

Seo S, Spetz J. Demand for temporary agency nurses and nursing shortages. INQUIRY: The Journal of Health Care Organization, Provision, and Financing. 2013 Aug;50(3):216-28.

Spetz J, Maiuro LS. Measuring levels of technology in hospitals. The quarterly review of economics and finance. 2004 Jul 1;44(3):430-47.

**Appendix Table 1. Hospital Characteristics in Treatment and Comparison Groups, 2003-2017**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Hospital characteristics | No Law | | Staffing Mandate | | Staffing Committee | | Public Reporting | |
| **Hospitals, No.** | 3,417 |  | 427 |  | 1,020 |  | 324 |  |
| **Observations, No.** | 32,370 |  | 3,810 |  | 10,230 |  | 3,045 |  |
| **Location** |  |  |  |  |  |  |  |  |
| Metro, No. (%) | 20,379 | (63) | 3,583 | (94) | 7,724 | (76) | 2,674 | (88) |
| Non-metro, No. (%) | 11,991 | (37) | 227 | (6) | 2,506 | (24) | 371 | (12) |
| **Teaching Status** |  |  |  |  |  |  |  |  |
| Non-teaching, No. (%) | 24,470 | (76) | 2,064 | (54) | 8,117 | (79) | 1,360 | (45) |
| Minor teaching, No. (%) | 1,584 | (5) | 301 | (8) | 561 | (5) | 781 | (26) |
| Major teaching, No. (%) | 6,316 | (20) | 1,445 | (38) | 1,552 | (15) | 904 | (30) |
| **Ownership** |  |  |  |  |  |  |  |  |
| For-profit, No. (%) | 7,400 | (23) | 918 | (24) | 3,483 | (34) | 148 | (5) |
| Government-owned, No. (%) | 6,988 | (22) | 607 | (16) | 1,935 | (19) | 437 | (14) |
| Nonprofit, No. (%) | 17,982 | (56) | 2,285 | (60) | 4,812 | (47) | 2,460 | (81) |
| **Other Hospital Characteristics** |  |  |  |  |  |  |  |  |
| No. of licensed beds, mean (SD) | 155.1 | (179.5) | 221.86 | (201.3) | 155.14 | (182.6) | 287.07 | (260.4) |
| Occupancy rate, mean (SD) | 1.28 | (0.84) | 1.09 | (0.63) | 1.16 | (0.75) | 1.33 | (0.7) |
| Percent of Medicare days, mean (SD) | 0.52 | (0.22) | 0.42 | (0.18) | 0.53 | (0.22) | 0.48 | (0.19) |
| Percent of Medicaid days, mean (SD) | 0.15 | (0.14) | 0.23 | (0.17) | 0.14 | (0.14) | 0.20 | (0.17) |

Note: Estimates represent 15-year averages across hospitals by law type. The mean/percentage difference in hospital characteristics between treatment and comparison groups are all statistically significant at 0.01 level.

**Appendix Figure 1. Trends in Unadjusted Mean Registered Nurse Hours Per Patient Day in States that Implemented and Did Not Implement Nurse Staffing Legislation, 2003-2018**

Note: The figure represents the raw trend in each group. The number of states in each group is constant over time, despite that states with legislation implemented the law in different year.

**Appendix Figure 2. Trends in Unadjusted Mean** **Licensed Practical/Vocational Nurse Hours Per Patient Day in States that Implemented and Did Not Implement Nurse Staffing Legislation, 2003-2018**

Note: The figure represents the raw trend in each group. The number of states in each group is constant over time, despite that states with legislation implemented the law in different year.

**Appendix Figure 3. Trends in Unadjusted Mean Nurse Assistive Personnel Hours Per Patient Day in States that Implemented and Did Not Implement Nurse Staffing Legislation, 2003-2018**

Note: The figure represents the raw trend in each group. The number of states in each group is constant over time, despite that states with legislation implemented the law in different year.

**Appendix Table 2. Full Regression Results of Difference-in-Differences Estimates of the Effect of Nurse Staffing Legislation on Hospital Staffing**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Hours per patient day** | | | | | | | |
| **Model (1) Including California** | | | | **Model (2) Excluding California** | | | |
| **Total licensed nurse** | **Registered nurse** | **Licensed practical nurse** | **Nurse assistive personnel** | **Total licensed nurses** | **Registered nurse** | **Licensed practical nurse** | **Nurse assistive personnel** |
| **b(se)** | **b(se)** | **b(se)** | **b(se)** | **b(se)** | **b(se)** | **b(se)** | **b(se)** |
|  |  |  |  |  |  |  |  |  |
| **Difference-in-Difference Estimates** |  |  |  |  |  |  |  |  |
| Staffing mandate (CA) \* post | 1.022\*\*\* | 0.996\*\*\* | 0.024 | 0.224\*\* | - | - | - | - |
|  | (0.123) | (0.114) | (0.030) | (0.070) |  |  |  |  |
| Staffing committee (CT, NV, OH, TX, WA) \* post | -0.060 | 0.003 | -0.076\*\*\* | -0.070 | 0.027 | 0.086 | -0.073\*\*\* | -0.037 |
|  | (0.065) | (0.059) | (0.022) | (0.037) | (0.065) | (0.059) | (0.022) | (0.038) |
| Public reporting (NJ, NY, RI, VT) \* post | 0.277\*\* | 0.150 | 0.115\*\*\* | 0.095 | 0.366\*\*\* | 0.260\*\* | 0.117\*\*\* | 0.119 |
|  | (0.102) | (0.094) | (0.025) | (0.061) | (0.103) | (0.094) | (0.025) | (0.061) |
| **Control Variables** |  |  |  |  |  |  |  |  |
| Located in non-metropolitan areas | 0.126 | 0.172 | -0.026 | 0.007 | 0.086 | 0.133 | -0.028 | -0.003 |
|  | (0.129) | (0.120) | (0.036) | (0.071) | (0.129) | (0.120) | (0.036) | (0.071) |
| Government owned hospitals | -0.335\* | -0.407\*\* | 0.072 | 0.142 | -0.289\* | -0.360\*\* | 0.072 | 0.098 |
|  | (0.146) | (0.132) | (0.041) | (0.080) | (0.147) | (0.132) | (0.043) | (0.080) |
| Nonprofit hospitals | -0.471\*\*\* | -0.389\*\*\* | -0.077\*\* | -0.042 | -0.464\*\*\* | -0.387\*\*\* | -0.071\* | -0.038 |
|  | (0.116) | (0.106) | (0.029) | (0.052) | (0.115) | (0.105) | (0.030) | (0.054) |
| Minor teaching hospitals | 0.384\*\* | 0.255\* | 0.092\* | 0.140\* | 0.388\*\* | 0.242\* | 0.112\*\* | 0.149\* |
|  | (0.137) | (0.117) | (0.039) | (0.061) | (0.142) | (0.118) | (0.042) | (0.067) |
| Major teaching hospitals | -0.005 | -0.029 | 0.027\* | 0.003 | 0.111\*\* | 0.084\* | 0.029\* | 0.002 |
|  | (0.042) | (0.040) | (0.011) | (0.023) | (0.043) | (0.040) | (0.012) | (0.025) |
| Number of hospital unit set up and staffed beds | -0.002\*\*\* | -0.002\*\*\* | -0.000\* | -0.000 | -0.002\*\*\* | -0.002\*\*\* | -0.000\* | -0.000 |
|  | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Occupancy rates - ratio of daily census to staffed beds | -0.778\*\*\* | -0.686\*\*\* | -0.086\*\*\* | -0.210\*\*\* | -0.754\*\*\* | -0.661\*\*\* | -0.087\*\*\* | -0.213\*\*\* |
|  | (0.099) | (0.088) | (0.013) | (0.029) | (0.100) | (0.089) | (0.013) | (0.031) |
| Percent inpatient days covered by Medicare patients | 0.501\*\*\* | 0.237 | 0.207\*\*\* | 0.487\*\*\* | 0.396\*\* | 0.111 | 0.228\*\*\* | 0.472\*\*\* |
|  | (0.141) | (0.127) | (0.038) | (0.069) | (0.138) | (0.122) | (0.040) | (0.071) |
| Percent inpatient days covered by Medicaid patients | 0.570\*\*\* | 0.435\*\* | 0.089 | 0.152 | 0.468\*\* | 0.332\* | 0.091 | 0.075 |
|  | (0.172) | (0.155) | (0.046) | (0.110) | (0.175) | (0.155) | (0.048) | (0.120) |
| State employment to population ratio | 0.036 | -0.000 | 0.044\* | 0.056\*\*\* | 0.028 | 0.041 | 0.038 | 0.062\*\*\* |
|  | (0.030) | (0.032) | (0.023) | (0.016) | (0.031) | (0.032) | (0.023) | (0.016) |
| Right-to-work laws | -0.115 | -0.119\* | 0.004 | 0.043 | -0.036 | -0.059 | 0.006 | 0.061 |
|  | (0.065) | (0.060) | (0.020) | (0.036) | (0.065) | (0.060) | (0.020) | (0.036) |
| Herfindahl-Hirschman Index | 0.254 | 0.376 | -0.112 | -0.042 | 0.187 | 0.316 | -0.124 | -0.045 |
|  | (0.240) | (0.218) | (0.062) | (0.110) | (0.249) | (0.225) | (0.067) | (0.114) |
| Saidin index | 0.063\*\*\* | 0.060\*\*\* | -0.000 | 0.002 | 0.040\*\*\* | 0.039\*\*\* | 0.000 | 0.004 |
|  | (0.010) | (0.009) | (0.002) | (0.006) | (0.010) | (0.009) | (0.003) | (0.006) |
|  |  |  |  |  |  |  |  |  |
| Observations | 48,980 | 48,980 | 48,980 | 48,980 | 45,208 | 45,208 | 45,208 | 45,208 |
| R-squared | 0.107 | 0.145 | 0.140 | 0.053 | 0.096 | 0.131 | 0.143 | 0.046 |
| Note: Coefficients for dummies indicating treatment groups are omitted due to collinearity. The difference-in-difference estimates, that is, treatment group \* post, are presented. Total licensed nurse is the sum of registered nurse and licensed practical/vocational nurse, excluding nurse assistive personnel. All models included hospital and year fixed effects, and constants. Standard errors were clustered by hospital. *\*\*\* p<0.001, \*\* p<0.01, \* p<0.05* | | | | | | | | |

**Appendix Table 3. Full Regression Results from the Sensitivity Analysis for Oregon’s Enhancement Law**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Hours Per Patient Day** | | | |
|  | **Total licensed nurses** | **Registered nurse** | **Licensed practical nurse** | **Nurse assistive personnel** |
| VARIABLES | **b(se)** | **b(se)** | **b(se)** | **b(se)** |
|  |  |  |  |  |
| **Difference-in-Difference Estimates** |  |  |  |  |
| Staffing mandate (CA) \* post | 1.017\*\*\* | 0.987\*\*\* | 0.026 | 0.214\*\* |
|  | (0.123) | (0.114) | (0.030) | (0.070) |
| Staffing committee (CT, NV, OH, TX, WA) \* post | -0.064 | -0.000 | -0.077\*\*\* | -0.073\* |
|  | (0.064) | (0.059) | (0.022) | (0.037) |
| Public reporting (NJ, NY, RI, VT) \* post | 0.271\*\* | 0.146 | 0.115\*\*\* | 0.092 |
|  | (0.102) | (0.094) | (0.025) | (0.061) |
| Oregon \* post | -0.209 | -0.245 | 0.078\* | 0.292\* |
|  | (0.194) | (0.184) | (0.032) | (0.123) |
| **Control Variables** |  |  |  |  |
| Located in non-metropolitan areas | 0.107 | 0.159 | 0.169 | 0.120 |
|  | (0.127) | (0.118) | (0.118) | (0.118) |
| Government owned hospitals | -0.332\* | -0.402\*\* | -0.391\*\* | -0.356\*\* |
|  | (0.145) | (0.131) | (0.132) | (0.131) |
| Nonprofit hospitals | -0.471\*\*\* | -0.390\*\*\* | -0.381\*\*\* | -0.387\*\*\* |
|  | (0.116) | (0.106) | (0.106) | (0.105) |
| Minor teaching hospitals | 0.380\*\* | 0.250\* | 0.245\* | 0.238\* |
|  | (0.135) | (0.116) | (0.116) | (0.116) |
| Major teaching hospitals | -0.002 | -0.027 | -0.033 | 0.084\* |
|  | (0.042) | (0.039) | (0.039) | (0.040) |
| Number of hospital unit set up and staffed beds | -0.002\*\*\* | -0.001\*\*\* | -0.001\*\*\* | -0.002\*\*\* |
|  | (0.000) | (0.000) | (0.000) | (0.000) |
| Occupancy rates - ratio of daily census to staffed beds | -0.779\*\*\* | -0.688\*\*\* | -0.689\*\*\* | -0.664\*\*\* |
|  | (0.098) | (0.087) | (0.087) | (0.088) |
| Percent inpatient days covered by Medicare patients | 0.516\*\*\* | 0.245 | 0.259\* | 0.122 |
|  | (0.141) | (0.126) | (0.126) | (0.121) |
| Percent inpatient days covered by Medicaid patients | 0.570\*\*\* | 0.423\*\* | 0.427\*\* | 0.323\* |
|  | (0.172) | (0.154) | (0.155) | (0.155) |
| State employment to population ratio | 0.035 | -0.002 | -0.004 | 0.037 |
|  | (0.030) | (0.032) | (0.032) | (0.032) |
| Right-to-work laws | -0.116 | -0.115 | -0.124\* | -0.056 |
|  | (0.065) | (0.059) | (0.060) | (0.060) |
| Herfindahl-Hirschman Index | 0.231 | 0.355 | 0.378 | 0.291 |
|  | (0.240) | (0.219) | (0.220) | (0.226) |
| Saidin index | 0.064\*\*\* | 0.061\*\*\* | 0.065\*\*\* | 0.041\*\*\* |
|  | (0.010) | (0.009) | (0.009) | (0.009) |
|  |  |  |  |  |
| Observations | 49,772 | 49,772 | 49,772 | 49,772 |
| R-squared | 0.107 | 0.145 | 0.140 | 0.054 |
| Note: Coefficients for dummies indicating treatment groups are omitted due to collinearity. The difference-in-difference estimates, that is, treatment group \* post, are presented. Total licensed nurse is the sum of registered nurse and licensed practical/vocational nurse, excluding nurse assistive personnel. All models included hospital and year fixed effects, and constants. Standard errors were clustered by hospital. *\*\*\* p<0.001, \*\* p<0.01, \* p<0.05* | | | | |