

The Type of Nurse Matters: The Effects of Nurse Staffing Levels, Non-RNs, and Contract Nurses on Length of Stay

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## **Abstract**

**Background:** The impact of various types of nursing personnel on patient outcomes remains uncertain.

**Methods:** Four years of panel data (2002-2006) from all general acute care units and intensive care units (ICUs) in Department of Veterans Affairs (VA) hospitals were used. Using average patient length of stay (LOS) as the outcome, fixed effects, multivariate regressions controlling for known confounding variables were estimated with robust standard errors clustered by unit. A cost-benefit calculation was computed.

**Results:** 161 ICUs (7,148 monthly observations) and 266 acute care units (11,637 monthly observations). The mean nursing hours per patient day (HPPD) and LOS varied by unit (HPPD: ICU 18.2 vs acute care 7.9; LOS: ICU 3.0 days vs acute care 4.9 days). A one hour increase in HPPD was associated with LOS reductions of 1.6% (95% CI 1.3-1.9,  $p < 0.001$ ) in ICUs and 3.1% (95% CI 2.6-3.5,  $p < 0.001$ ) in acute care units. Both were approximately linear across the entire range of staffing levels. Increasing the HPPD by 1 hour per day would save \$350 per ICU and \$160 per acute care. An increase in contract nurses from 0% to 10% of nurse staffing was associated with 3.3% (95% CI 0.8-5.8,  $p < 0.001$ ) and 3.1% (95% CI 2.1-4.1,  $p < 0.001$ ) longer LOS for ICUs and acute care units, respectively. We also found that failure to control for unobserved heterogeneity results in a doubling of the estimated HPPD effect.

**Conclusions:** Hospitals should minimize the use of contract nurses while maintaining nurse staffing levels.

The idea of moving toward a value-based healthcare system that emphasizes quality and includes payment reform has received increased attention.<sup>1</sup> Indeed, to motivate hospitals to improve quality, the Centers for Medicare and Medicaid Services (CMS) has stopped paying for select “preventable complications”.<sup>2</sup> This new rule places hospitals under pressure to decrease cost of services while improving quality patient outcomes.<sup>3</sup> One way to reduce costs is to cut nursing personnel, which accounts for approximately 63% of hospital labor costs.<sup>4</sup>

Managers may be hesitant to reduce the nursing workforce because higher levels of nurse staffing, especially registered nurse (RN) staffing, in hospitals seems to improve patient outcomes. However, the underlying research base is limited and many of the seminal studies employed cross-sectional designs in which researchers aggregated data at the hospital level for an entire year.<sup>5-7</sup> Some researchers have used longitudinal data sets with annual, hospital-level analyses,<sup>8-10</sup> but the findings provide only limited support that more RN staffing in hospitals improves the quality of patient care. Other researchers have used unit-specific data to examine the relationships between nurse staffing and adverse events,<sup>11-13</sup> but these studies have used relatively small samples limited to specific geographic regions. Recently, Sales et al. concluded that hospital level analyses resulted in biased estimates due to mixing heterogeneous groups.<sup>14</sup>

Another major limitation of many prior studies is the measurement of nurse staffing from administrative datasets that do not account for nurses “floating” to other units or the use of temporary personnel (i.e., contract nurses).<sup>15</sup> In a recent review, researchers found limited evidence that use of non-permanent staff increases patients’ risk of healthcare associated infections.<sup>16</sup>

In this study we address previous limitations by using four years of monthly, unit-level data from all Department of Veterans Affairs (VA) hospitals to examine the impact of nurse staffing levels and contract nurses on quality as measured by patients' length of stay (LOS). Furthermore, we provide a cost-benefit calculation estimating the tradeoffs between nurse staffing and overall costs of care.

## METHODS

A retrospective observational study was conducted using panel data for all intensive care units (ICUs) and general acute care inpatient units in the VA health care system from October 1, 2002 through September 30, 2006. These data were initially obtained from 215 ICUs and 438 general acute care units at 143 VA facilities. The study was approved by the human subjects committees at Stanford and Columbia Universities.

### Data Sources

The VA Decision Support System (DSS) integrates detailed clinical and financial data on each patient. The Intermediate Product Department (IPD) data tracks patient movement, including admissions, discharges and transfers between units and "bedsections". The VA also creates a separate discharge abstract with *International Classification of Diseases, 9<sup>th</sup> Revision, Clinical Modification* diagnoses and procedure codes for each bedsection in which a patient is treated.

The discharge abstracts were linked to the IPD data to characterize the patients on each unit each month. DSS also tracks the cost of patient care for each unit.

Summaries of the labor hours and associated costs allocated to each unit by month, by type of nursing personnel (i.e., RN, licensed practical nurse [LPN], and

unlicensed assistive personnel [UAP]) were available from DSS. These data allow the exclusion of paid time off (e.g., vacation or sick hours), but include all paid time at work (e.g., time in required training) and are not specific to direct patient care. However, the data included adjustments for floating and allowed the exclusion of administrative and specialty nurses (e.g., nurse managers and clinical nurse specialists).<sup>15</sup>

DSS also tracks the monthly total hours and costs for contract nursing (travelers and agency nurses) allocated to each unit. However, there is no identification of the type of nursing labor (RN, LPN, or UAP). An examination of hourly costs indicated that most, but not all, of the contract nurses during the study period were RNs. For ICUs, over 90% had hourly costs consistent with RNs, while for acute care units about 85% were RN-level wages.

### Variables

By combining the DSS and IPD data we calculated total nursing (i.e., RNs, LPNs, UAPs, and contract nurses) hours per patient day (HPPD) and the percentage of these hours provided by LPNs, UAPs, and contract nurses. To control for variations in patient populations we calculated the average patient age and a case-mix index using Medicare Diagnostic Related Group (DRG) information. We also calculated the Elixhauser Index and Nursing Intensity Weights but they did not contribute to the analysis and were excluded from final results.<sup>17, 18</sup>

The National Quality Forum (NQF) has identified nursing sensitive adverse safety outcomes, including failure to rescue, specific nosocomial infections, decubitus ulcers and falls.<sup>19</sup> Given that previous studies with hospital-level data have found only limited statistical significance for these indicators,<sup>7</sup> our use of monthly, unit-level data meant that

these outcomes were very rare events, a combined endpoint was needed. It has been well demonstrated that these adverse outcomes increase LOS and LOS is a NQF-endorsed quality measure.<sup>20</sup> Therefore, we used LOS as a combined indicator of adverse patient outcomes.

#### Nursing Unit-Month Eligibility

When we examined the monthly data for each unit, we observed that HPPD became very unstable when patient days dropped below certain levels. Therefore, we excluded monthly observations with less than 60 patient days. Monthly observations with incomplete data were also excluded, and a unit was entirely excluded if more than half of the months for that unit were excluded. These exclusions dropped 53 ICUs and 171 acute care units entirely and 447 monthly observations from an additional 95 units.

#### Data Analysis

Descriptive statistics were examined for both unit types. The standard deviations were estimated both between and within-units to understand sources of variation. Additionally, LOS was logarithmically transformed because it was not normally distributed, it.

We estimated multivariate ordinary least squares regressions with robust standard errors clustered by unit. The explanatory variables were HPPD, percentage of nursing hours provided by LPNs, UAPs, and contract nurses, DRG case mix, patient age, and a vector of dummy variables for each of the 48 months. To prevent undue influence of small units, which have inherently higher variances, we weighted our regressions by the mean number of monthly “discharges” per unit. We estimated separate models for ICUs and acute care units.

The panel nature of the data enabled us to include nursing unit fixed effects that vary by year. These fixed effects control for characteristics of the nursing unit, hospital, or patient population that might influence patient outcomes but do not vary within a year, such as teaching status, geographic regions, and structural characteristics of the hospital or unit (e.g. size, technology). To examine how the effect of nurse staffing varied across the range of staffing levels, we also estimated our models using deciles of HPPD. To place our findings in context with previous results that used more aggregated data and different statistical methods, we re-estimated our models with annual, hospital-level data, both with and without fixed effects.

Because it is expensive to increase nurse staffing levels or to increase the share of nursing care provided by RNs, we examined net costs to the system. To estimate net cost effects, we used our regression results, the average daily cost of care in each unit type, and median VA nursing wages.<sup>21</sup> The benefit of increasing HPPD by one hour is calculated by multiplying the mean length of stay times the regression coefficient, times the cost of a day (\$1763 and \$4965 in acute care units and ICUs, respectively). The associated cost is calculated by multiplying the median RN wage by the mean length of stay. The benefit from reducing the UAP share of nursing hours by 10% and increasing the RN share by 10% follows the same approach while the cost calculation includes the difference between RN and UAP wages.

## RESULTS

The final sample included 427 units (161 ICUs and 266 acute care units, 7,148 and 11,637 monthly observations, respectively) at 126 VA facilities. Over the four years,

there were 1,596,740 discharges from acute care units (7,033,109 patient days) and 380,893 ICU discharges (1,050,089 patient days). The levels of nurse staffing and patient demographics for the acute care units and ICUs are shown in Tables 1 and 2, respectively. The between and within unit standard deviations demonstrate considerable variation in our data; validating our use of panel fixed-effects regression, which is powered off of within-unit variance.

As expected, average total nursing HPPD were higher in ICUs (18.2) than in acute care units (7.9). Further, ICUs used less non-RN nursing staff, 1 to 2%, compared to a mean of 24% for LPNs and 16% for UAP in acute care units. While the mean use of contract nurses was low in both unit types (2%), there was considerable variation; up to 50% in some units in some months. The mean LOS was 3.0 days for ICUs and 4.9 days for acute care units. The average number of patient days corresponds to an average patient census of 4.5 patients in ICUs and 16.5 patients in acute care units.

Our primary regression results are presented in Table 3. The first row shows the marginal effect of a one hour increase in HPPD. Since the dependent variable was the natural logarithm of LOS, these estimates imply a one hour increase in HPPD was associated with a 3.1% (95% confidence interval (CI) 2.6-3.5,  $p < 0.001$ ) reduction in LOS for acute care units and a 1.6% (95% CI 1.3-1.9,  $p < 0.001$ ) reduction for ICUs. The coefficients for the percent of LPNs, UAPs, and contract nurses represent the effect of shifting from 0 to 100 percent use of this labor. Dividing the coefficients by 10 represents the effect of changing nursing staff composition of that type of nurse by 10 percentage points. For example, increasing the share of total nursing hours provided by contract nurses from 0 to 10 percent was associated with 3.1% (95% CI 2.1-4.1,  $p < 0.001$ )

and 3.3% (95%CI 0.8-5.8,  $P < 0.001$ ) increases in LOS in acute care units and ICUs, respectively. The effect for increased use of LPNs was not statistically significant for either acute care or ICUs. A 10 percentage point increase in the use of UAPs was associated with 0.9% (95%CI 0.1-1.7,  $p < .01$ ) increase in LOS for acute care units; the ICU effect was larger (2.2%) but not significant.

Figure 1 reports the effect of nurse staffing by decile of HPPD, for acute care and ICUs. They show that additional staffing had statistically significant and approximately linear effects across the entire range of staffing levels for both types of units. For acute care units, LOS was over 20% shorter for units in the 10<sup>th</sup> decile of nurse staffing levels, compared to those in the 1<sup>st</sup> decile, while this difference was about 30% for ICUs.

Table 4 shows results estimated by aggregating data at the hospital-year level with (column 1) and without (column 2) fixed effects. Aggregating to hospital-year markedly increases the estimated effects of using LPNs and UAPs on LOS. The parameter estimate for HPPD shrinks markedly with the addition of fixed effects, and that for LPNs loses its statistical significance. Contract labor becomes positive and significant when fixed-effects are used.

In our cost-benefit calculation, increasing the HPPD by 1 hour per day yielded a net savings of about \$160 for acute care units and \$350 for ICUs. The estimated savings from shifting 10% of total nursing hours from UAPs to RNs were smaller, about \$25 and \$120 for acute care and ICUs, respectively.

## DISCUSSION

We used detailed VA data to extend analysis of the effects of nurse staffing on patient outcomes in two important ways. First, our data enabled us to show that, controlling for overall nurse staffing levels, use of higher shares of contract nurses was associated with longer LOS. Second, the data allowed us to address data aggregation and unobserved heterogeneity that have biased most previous studies. We show that increased nurse staffing is significantly associated with shorter LOS and that most previous studies have probably over-estimated the magnitude of this effect.

Using a cross-sectional hospital level design, Aiken found that nurses employed in hospitals with more supplemental nurses self-reported higher quality.<sup>22</sup> Using our rigorous analytic design, however, we found that increased use of contract nurses was associated with increased LOS. Our sensitivity analysis shows that this difference in results was probably due to control for unobserved heterogeneity, which includes the unit work environment. Our findings suggest that the use of contract nurses should be minimized, perhaps because contract nurses find it difficult to function effectively in unfamiliar settings. This finding has policy implications since previous researchers have found high use of contract staff to fill individual shifts and accommodate short-term staffing needs arising from vacations and medical leaves.<sup>23</sup> While additional research is needed, our results imply that to maintain patient safety, nursing managers need to adjust patient assignments to compensate for contract nurses' reduced productivity associated with working in an unfamiliar setting.

Our use of unit-level, panel data provides more reliable evidence than previous studies to support the notion that better nurse staffing results in better patient outcomes. Because our models were powered off the within-unit variance in staffing levels, they

eliminate much of the unobserved heterogeneity that biased previous studies.

Additionally, the extent of bias in most previous studies due to data aggregation and unobserved heterogeneity is evident; failure to control for unobserved heterogeneity resulted in a doubling of the estimated HPPD effect. It also resulted in a reversal of the effect of using contract nurses. While some previous studies have found that the effect of better nurse staffing is concentrated at lower staffing levels,<sup>10</sup> we found that the beneficial effects of increased nurse staffing levels were approximately linear across the entire range of staffing levels. We also found much smaller adverse effects of non-RN staff than some previous studies,<sup>7</sup> which was probably due to the aggregation of data across units.

The savings associated with reduced LOS were larger than the costs of more robust nurse staffing. Other researchers have also predicted net savings with better nurse staffing.<sup>24</sup> Since most hospital payments are prospective, there are clear financial benefits to reducing LOS. The potential benefits to hospitals may be magnified by the recent change in Medicare payment rules to disallow additional payment for hospital-acquired complications.<sup>25</sup> As these complications probably drive increases in LOS, it is likely that the savings due to better nurse staffing will more than offset the costs. Since nursing labor is the largest operating budget of any hospital, it is one of the first places that managers try to cut when operating costs need to be reduced. Our results indicate that hospitals need to be careful about cutting nursing budgets, as reduced nursing personnel could well yield a net financial loss due to added patient care costs. However, our cost-benefit calculations were based on average costs, and actual savings could be

smaller. This issue needs to be studied more carefully before reaching a firm conclusion about the net cost effects of better nurse staffing.

There are some limitations to our data. We observed hours worked by each nurse, not hours of direct patient care. Also, our results may not apply exactly to non-VA hospitals. The VA staffs nursing units based on an 85% occupancy rate and, unlike other hospital systems, the VA does not reduce staffing when the patient census falls, so a drop in the patient census produces an increase in HPPD. This could change the magnitude of the relationship between HPPD and LOS, which may not be linear or persist across the entire range of staffing levels in non-VA hospitals.

In summary, we have shown that data aggregation bias and failure to control for unobserved heterogeneity have probably over-estimated the favorable effects of higher nurse staffing. Nonetheless, we still found statistically significant and clinically meaningful benefits of better nurse staffing. We also showed that use of larger shares of contract nurses was associated with longer lengths of stay. Finally, we provided preliminary evidence that the savings associated with shorter stays more than pays for the added costs of better nurse staffing in VA hospitals.

Figure 1: The Effect of Increased Nurse Staffing on Length of Stay, by Decile of Staffing Level in All VA Acute Care and Intensive Care Units, 2003-2006

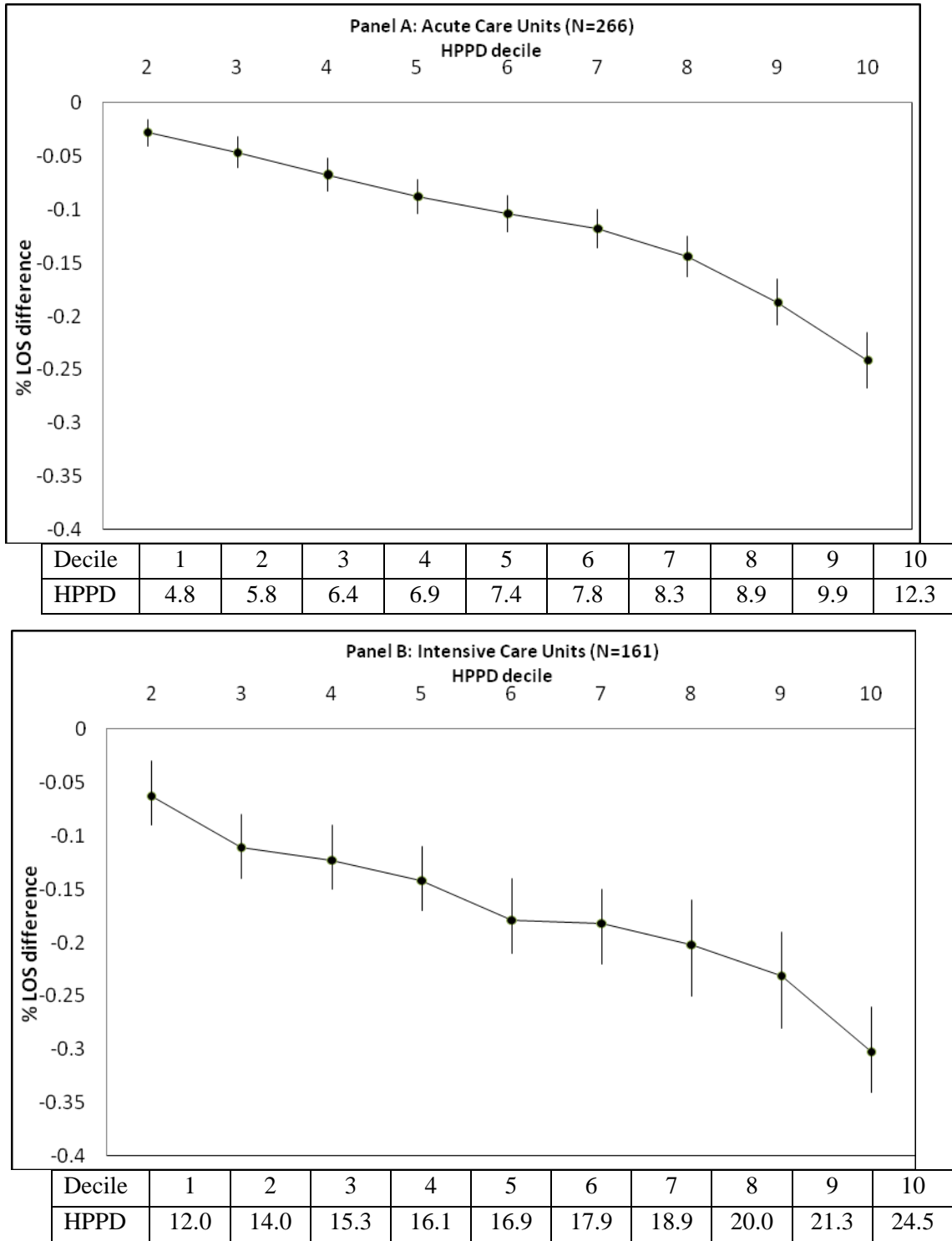


Figure footnote: Reference group is the lowest decile of staffing, by hours per patient day (HPPD) of care. Data are monthly, unit-level data for all VA Intensive Care Units. The regression models control for the share of nurses that are LPNs, UAPs, and contract nurses, DRG case-mix, patient age, time trends, and unit-level fixed effects.

Table 1: Summary Statistics of Monthly Data For All Acute Care Units in VA Hospitals, 2003-2006.

	Observations	Mean	Standard Deviation		
			Overall	Between	Within
Length of Stay	11637	4.867	3.67	4.05	1.69
Total Nursing hrs per Patient Day	11637	7.948	2.50	2.01	1.65
Percent Nursing hrs by LPN	11637	0.235	0.13	0.13	0.05
Percent Nursing hrs by UAP	11637	0.162	0.11	0.11	0.05
Percent Nursing hrs by Contract Nurses	11637	0.025	0.06	0.05	0.04
Patient Age	11637	65.254	3.00	2.60	1.71
DRG Weight	11637	1.074	0.24	0.22	0.13
Elixhauser Index	11637	1.316	0.25	0.21	0.14
Number of Admissions	11637	115.415	48.14	46.07	21.31
Number of Patient Days	11637	495.432	194.32	181.59	92.91

Data are from 266 non-ICU acute care units across 126 VA Medical Centers.

Table 2: Summary Statistics, of Monthly Data For All Intensive Care Units in VA Hospitals, 2003-2006

	Observations	Mean	Standard Deviation		
			Overall	Between	Within
Length of Stay	7148	2.978	1.52	0.94	1.18
Total Nursing hrs per Patient Day	7148	18.194	4.96	3.37	3.66
Percent Nursing hrs by LPN	7148	0.012	0.04	0.03	0.02
Percent Nursing hrs by UAP	7148	0.023	0.04	0.03	0.03
Percent Nursing hrs by Contract Nurses	7148	0.016	0.05	0.03	0.03
Patient Age	7148	65.128	2.72	1.83	2.01
DRG Weight	7148	1.830	0.70	0.58	0.39
Elixhauser Index	7148	1.253	0.27	0.20	0.18
Number of Admissions	7148	48.398	23.11	20.77	10.18
Number of Patient Days	7148	135.813	68.62	59.19	35.57

Data are from 161 ICUs across 102 VA Medical Centers.

Table 3. Monthly, Unit-Level Regression Estimates From Veterans Affairs Medical Centers of The Effect Of Nursing Hours, Use Of Non-RN Nursing Staff, And Use Of Contract Nurses On Length Of Stay

	<b>Acute</b>	<b>ICUs</b>
Nursing Hours Per Patient Day	-0.031*** [-0.035, -0.026]	-0.016*** [-0.019, -0.013]
Percent of Nursing Hours Provided by LPNs	-0.041 [-0.128, 0.046]	0.215 [-0.482, 0.913]
Percent of Nursing Hours Provided by UAP	0.088** [0.001, 0.169]	0.217 [0.119, 0.553]
Percent of Nursing Hours Provided by Contract Nurses	0.310*** [0.214, 0.405]	0.333*** [0.086, 0.581]
R-squared	0.258	0.188

The regression models control for DRG case-mix, patient age, time trends, and unit-level fixed effects that vary by year. Robust standard errors were used to control for the clustering of patients within units. Data from all VA inpatient acute medical care units with complete data; 161 ICUs and 266 other acute medical care units at 126 VA medical centers.

\*p<.10; \*\* p<.05; \*\*\*p<.01

Table 4. Sensitivity Analyses of the Effects of Nurse Staffing Using Annual Hospital-Level Data to Examine the Effects of Aggregation Bias and Unobserved Heterogeneity

	<b>Hospital Year Fixed Effects</b>	<b>Hospital Year No Fixed Effects</b>
Nursing Hours Per Patient Day	-0.027** [-0.040, -0.014]	-0.052** [-0.070, -0.035]
Percent of Nursing Hours Provided by LPNs	0.506 [-0.017, 1.028]	0.524** [0.230, 0.819]
Percent of Nursing Hours Provided by UAP	1.127** [0.682, 1.571]	0.824* [0.501, 1.147]
Percent of Nursing Hours Provided by Contract Nurses	0.538* [0.093, 0.983]	-0.094 [-0.702, 0.513]
R-squared	0.408	0.388

The regression models control for DRG case-mix, patient age, time trends. Hospital-level fixed effects were included for column 1, but not column 2. Robust standard errors were used to control for the clustering of patients within hospitals. Data from all VA inpatient acute medical care units at the 126 VA medical centers included in Table 3.

\*p<.05; \*\*p<.01

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