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Original Study

The Relationship between Nursing Home Staffing and Health Outcomes Revisited

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A B S T R A C T

Objective: Nursing homes make staffing decisions in conjunction with choosing quality goals, potentially leading to endogeneity bias between staffing and quality. We use instrumental variables (IVs) to explore it.
Design: Retrospective statistical analysis of 2017–2019 Payroll-Based Journal, Minimum Data Set, Nursing Home Care Compare, and Long-Term Care Focus.
Settings and Participants: A total of 11,261 nursing homes nationally.
Methods: We estimated separate models for each of 6 quality measures as dependent variables, and registered nurses (RNs), certified nurse assistants (CNAs), and licensed practical nurses (LPNs) as independent variables, including other control variables associated with quality. The models were estimated using both ordinary least squares (OLS) and 2-stage least squares (2SLS) methods, the latter accounting for endogeneity. The IVs were defined as the average staffing of competing nursing homes in the same market as the index facility.
Results: Estimated coefficients for the quality measures in the 2SLS models were up to 5 times larger than in the OLS models. The 2SLS estimates for antipsychotic medications use increased with higher RN staffing [0.279 (0.004 to 0.553)] and decreased with higher CNAs [−0.125 (−0.198 to −0.052)]. Hospitalizations decreased with more RNs [−1.328 (−1.673 to −0.983)] and LPN staffing [−0.483 (−0.755 to −0.211])] and increased with CNA [0.201 (0.109 to 0.293)] staffing. Emergency room visits decreased with higher RNs [−1.098 (−1.500 to −0.696)] and increased with CNAs [0.191 (0.084 to 0.298)]. Long-stay activities of daily living [−0.313 (−0.416 to −0.209)] and short-stay functioning [−0.481 (−0.598 to −0.364)] improved only with higher CNA staffing and pressure sores improved only with increased RN staffing [−0.436 (−0.836 to −0.035)].
Conclusions and Implications: Our findings demonstrate the importance of accounting for endogeneity in studies of staffing and quality. Endogeneity changes conclusions about significance, direction, and magnitude of the relationship between staffing and specific quality measures. These findings highlight the need to further study and understand the nuanced relationship between different staffing types and different health outcomes such as the difference between the relationship of RN and CNA hours per resident day to antipsychotic quality measures.

The relationship between nursing home staffing and quality of care has been the subject of numerous studies for decades. The consensus among researchers and policy makers is that when it comes to staffing, more is better. The actual level of needed staffing is subject to debate, as demonstrated by the discussion surrounding the Biden-Harris administration's proposed minimum RN and CNA staffing levels.[1,2] High minimum standards have cost implications for nursing homes, their patients, and payers. However, if minimum standards are

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set too low, they will fail to achieve the objective of "*President Biden … to building a long-term care system where all seniors can age with dignity, where people with disabilities can receive high-quality services and supports in the setting of their choice…*"[1]

Data available to measure quality have evolved over time, to include both facility-level structure and process measures, such as number of deficiency citations issued by state surveyors and risk-adjusted outcome rates based on individual residents' health assessments collected in the Minimum Data Set (MDS).[3] Recently, the release of Payroll-Based Journal (PBJ) data reflecting detailed daily staffing levels has enabled substantially more reliable measurement of staffing in nursing homes as well. In combination, the ability of the field to assess the relationship between staffing levels and quality has improved dramatically.

A review of the literature to date paints a mixed picture, suggesting that higher staffing levels and staffing mix are associated with better quality in some but not all cases, and may depend on the particulars of the study data sources, definitions, and methods.[4] A review of 70 peer-reviewed studies conducted from 1991 to 2006,[5] before PBJ data were available, examined the relationship of registered nurses (RNs), licensed practical nurses (LPNs), and certified nurse assistants (CNAs) with more than 302 quality indicators (process and outcome). It found that only 40% of the quality indicators were positively associated with staffing, 5% were negatively associated, and 55% were not significantly associated with staffing at all. The review also found that RN and CNA staffing were associated with better quality much more often than LPNs. Another review of studies conducted during 2007–2013, also predating PBJ data, included only longitudinal studies, a methodological improvement over previous studies, also found both positive and negative associations between higher staffing and better quality, which was attributed to major methodological and theoretical limitations.[6]

One of the methodological limitations that only 2 studies to our knowledge has addressed is the potential endogeneity between quality and staffing, which may bias the estimated relationships.[7,8] Although there might be several sources for endogeneity,[9] in this context we are particularly concerned with 2. One, a mechanistic factor, results from the fact that both staffing levels and quality measures depend on similar unobserved variables, mostly patient severity, thus leading to omitted variable bias. The second, grounded in theory, arises from the fact that nursing home managers who make staffing decisions, make those decisions in conjunction with the decision about the level of quality they wish to provide their clients.[7,8,10] These 2 decisions are inexorably linked as both influence costs, revenues, and profits. Therefore, staffing levels and quality should be treated as endogenous a priori, and estimating the relationship between them should account for this interrelationship (ie, the potential endogeneity bias). If not, the estimates are unlikely to be accurate.

In this article we examine the relationship between staffing and several important quality measures with and without correction for endogeneity, comparing the regression coefficients of both models. Another innovation that we offer is the use of the PBJ data, which are much more reliable than the staffing data that were available to most studies in the past.[11]

Methods

Data and Sample

The study was reviewed as expedited by the first author's institutional review board.

The initial sample included all 15,790 nursing homes nationally that submitted data to the PBJ during 2017–2019. (We avoided the COVID-19 period because both staffing and quality were not reflective of normal operations.) Other data included quality measures (QMs) calculated by the Centers for Medicare & Medicaid Services (CMS) and published in Nursing Homes Care Compare (NHCC), and nursing home and market characteristics obtained from the Long-Term Care Focus and the U.S. Census.[12,13] We excluded nursing homes if they were missing MDS data (88) or staffing information (510) in any year; nursing homes in the top or bottom 1% of the national staffing distributions of hours per resident day (HPRD) for RNs, LPNs, or CNAs (559)[14]; those that were the only facility in their county (718); missing one of the QMs (1909); and any observations missing nursing home or market characteristics (745). Our analysis sample included 11,261 nursing homes, 71% of the initial sample.

Variables

We defined RN, LPN, and CNA HPRD (excluding administrators and directors of nursing) as daily hours divided by the daily resident census. These were averaged over the year to create annual variables.

We chose QMs that were included by CMS in its 5-Star measure during the study period and are expected to be sensitive to staffing levels. Four were claims-based measures: percentage of short-stay residents who were hospitalized, who had an emergency room (ER) visit not followed by a hospitalization, the number of hospitalizations and number of ER visits per 1000 long-stay resident-days. All were measured annually. Six were MDS-based measures: Percentage of long-stay residents whose need for help with daily activities increased, those with high-risk pressure ulcers, those who received antipsychotic medications, those whose ability to move independently declined, percentage of short-stay residents whose functioning did not improve, and those who received a new antipsychotic medication. All were reported quarterly but averaged for each year to create annual variables.

To reduce the number of QMs, we performed exploratory factor analysis on the standardized QMs (ZQMs) and used it to guide reduction of the initial 10 ZQMs to obtain the final 6 ZQMs. Those were used in the analysis and are listed in Table 1. All are defined such that higher values mean worse quality.

All other variables likely to influence both staffing and quality are listed in Table 1. Variables describing resident characteristics [eg, age, case mix based on the Resource Utilizations Groups (RUGs) IV] were obtained from the MDS for each resident and averaged to the facility level daily, based on admission and discharge information. Daily averages were then averaged to create an annual resident profile for the facility.

Regression Models

We estimated 6 separate regression models, each having 1 of the 6 ZQMs as a dependent variable. All had the same independent variables, with the 3 staffing variables (ie, RN, CNA, and LPN HPRDs) as the variables of interest, and variables describing the facility residents' profile (case mix, age, gender, race, payer mix, short-stay percent), its characteristics (ownership, occupancy, chain and hospital affiliation), and its market defined at the county level (competition, hospital wage index, percent males, population older than 65, county racial mix, median income, females in the labor force, and unemployment) included as control variables.

We estimated these models as both ordinary least squares (OLS) models, the typical approach used in past studies, and as 2-stage least square (2SLS) models, where the latter replaced the 3 staffing variables with predicted variables based on instrumental variables (IVs).[15] The 2SLS models correct for the potential endogeneity between staffing and QMs, and a comparison of the coefficients of each one of the coefficients of the staffing variables between the OLS and the 2SLS estimates indicates whether endogeneity exists and the magnitude of the bias introduced when it is ignored. All models included up to 3

Table 1
Descriptive Statistics*

	Analysis Sample			Excluded From Analysis			*P* Value† [95% CI for Difference]
	n	Mean	SD	n	Mean	SD	
Staffing in average HPRDs							
RNs	11,261	0.42	0.25	4505	0.64	0.82	<.001 [0.20 to 0.24]
LPNs	11,261	0.80	0.26	4505	0.84	0.54	<.001 [0.02 to 0.05]
CNAs	11,261	2.16	0.43	4505	2.30	0.76	<.001 [0.12 to 0.16]
Standardized QMs (ZQMs) – higher values indicate worse quality							
Long-stay ADLs and movement	11,261	−0.01	0.77	3954	0.01	0.85	.172 [−0.01 to 0.05]
Antipsychotic medication (long- and short-stay)	11,261	−0.09	0.59	4466	0.33	1.29	<.001 [0.39 to 0.45]
Hospitalizations (long- and short-stay)	11,261	−0.02	0.70	4095	−0.02	0.83	.748 [−0.03 to 0.02]
Outpatient ER visit (long- and short-stay)	11,261	−0.02	0.76	4040	0.15	0.98	<.001 [0.14 to 0.20]
Short-stay decline or no change in functioning	11,261	−0.00	0.90	2681	0.04	1.06	.037 [0.00 to 0.08]
High-risk long-stay residents with pressure sores	11,261	0.02	0.83	3949	−0.01	1.08	.106 [−0.06 to 0.01]
Resident characteristics							
Case mix index (RUGs IV)	11,261	1.60	0.28	4918	1.57	0.56	<.001 [−0.05 to −0.02]
% male residents	11,261	34.9	10.4	4938	38.4	15.7	<.001 [3.1 to 3.9]
% residents younger than 65	11,261	14.8	12.2	4938	18.6	19.8	<.001 [3.3 to 4.3]
% residents age 65–74	11,261	18.5	7.7	4938	19.1	10.2	<.001 [0.3 to 0.9]
% residents age 75–84	11,261	27.2	5.9	4938	26.7	10.2	<.001 [−0.8 to −0.3]
% short-stay residents	11,261	17.1	12.0	4953	23.1	31.0	<.001 [5.3 to 6.7]
Nursing home characteristics							
Number of certified beds	11,261	117	61	3792	77	50	<.001 [−42 to −38]
Nursing home occupancy	11,261	81.2	13.0	3790	77.0	17.1	<.001 [−4.7 to −3.6]
% residents with payer: Medicare	11,261	13.5	9.6	3792	12.7	19.8	.003 [−1.2 to −0.2]
% residents with payer: Medicaid	11,261	59.4	20.4	3792	62.3	28.0	<.001 [2.0 to 3.6]
County characteristics							
HHI	11,261	0.14	0.14	4624	0.32	0.34	<.001 [0.18 to 0.19]
Hospital wage index	11,261	0.96	0.12	4613	0.93	0.11	<.001 [−0.03 to −0.02]
% county population male in county	11,261	49.2	1.2	4613	49.7	2.0	<.001 [0.5 to 0.6]
% county population age 65 or older	11,261	16.3	3.9	4613	16.8	4.3	<.001 [0.4 to 0.7]
% county population not White	11,261	23.2	16.1	4613	21.8	17.3	<.001 [−2.0 to −0.8]
County median income in $10,000s	11,261	6.0	1.6	4613	5.6	1.5	<.001 [−0.5 to −0.4]
% females in labor force in county	11,261	72.7	5.3	4613	71.4	6.9	<.001 [−1.6 to −1.2]
County unemployment rate	11,261	5.4	1.7	4613	5.4	2.3	0.873 [−0.1 to 0.1]

Nursing home characteristics	n	Frequency	Percent	n	Frequency	Percent	*P* Value‡
Nursing home is for-profit	11,261	8249	73.3	3792	2275	60.0	<.001
Nursing home is hospital-based	11,261	170	1.5	3792	487	12.8	<.001
Nursing home is part of a chain	11,261	6960	61.8	3792	1760	46.4	<.001

HHI, Herfindahl-Hirschman Index; RUG, resource utilization group.
*The values reported are averages over the time period.
†Based on *t* test where H_0: Mean for analysis sample − Mean for excluded sample = 0.
‡Based on χ^2 test where H_0: There is no relationship between the independent variable and whether the variable is in the analysis or the excluded sample.

annual observations for each nursing home and were estimated with nursing home level random-effects and cluster-robust standard errors at the facility level.

The IV for each staffing variable was defined as the average of the HPRDs for each staffing variable separately (eg, HPRD for RNs) for all competitors in the same market (ie, same county) as the index nursing home. For example, if there were n nursing homes in the county, the IV for $(\text{RN HPRD})_i$ for the index nursing home i was calculated as the average of the $(\text{RN HPRD})_{j=1\ldots(n-1)}$ of all $(n-1)$ other nursing homes in the county during the same year. The rationale for this IV is that staffing should be highly correlated among nursing homes in the same market through competitive forces with quality competition dominating price competition, because about 75% of residents are either Medicare or Medicaid residents who do not pay out-of-pocket for their stay.[16] Furthermore, because staffing levels are reported in the federal NHCC, these data are available to both the public and to competing nursing home operators, making competition with respect to staffing levels very likely.[17,18] This IV also plausibly fulfills the second requirement of IVs, the exclusion requirement, that the IV should affect the dependent variable only through its effect on the endogenous variable and not other pathways. In other words, if competitor nursing homes increase their staffing, this should not directly affect quality at the index facility, other than through increasing the index facility's incentive to also increase staffing. To support this assumption, we divided all counties into 2 groups, those with high values for the IVs and those with low values and compared the values for each covariate across these groups to examine whether the IVs create plausibly balanced samples as indicated by average covariates. Because the IV depends on the strength of competition, we performed sensitivity analysis, including only counties with 4 or more nursing homes in the county.

To demonstrate the predicted relationship by each model between staffing and the ZQMs, we calculated the percentage change in 1 SD of each ZQM that is predicted by an increase of 1 hour per resident day in each staff type, holding everything else, including the other staffing types, constant.

Results

Table 1 presents descriptive statistics for the sample of nursing homes included and excluded from the analysis. The study sample average staffing ranged from 0.42 HPRD for RNs to 2.16 for CNAs. As expected, the ZQMs averaged all around zero because they were standardized. Standard deviations ranged from 0.59 to 0.90. The case mix index was 1.60 and most residents were women, older than 65, and long-stay. Beds averaged 117 with 81.2% occupancy and 73% were for-profit.

Supplementary Tables 1 to 6 present the full first-stage equations that create the 3 IVs for each of the 6 ZQM models. The strength of the IV is measured by the partial F statistic and typically values above 10 are considered acceptable. All partial Fs for all first-stage models are above 10, ranging from the lowest at 598 to the highest at 785. Supplementary Table 7 addresses the exclusion restriction. Its inspection shows that the differences between the values in the high and low IV counties are small, suggesting that the covariates are not associated with the IVs and hence meet the exclusion criterion.

Table 2 presents key results of the regression models for all 6 ZQM models estimated using OLS and 2SLS and the 3 staffing variables. The full models are in Supplementary Tables 8 and 9. In most cases the coefficients for staffing are substantially larger (abstracting from statistical significance and direction), by factors of up to 5, in the 2SLS compared with the OLS models. For example, the coefficient for RN HPRD in the hospitalizations model was −0.261 in OLS and −1.328 in the 2SLS, a factor of 5.1.

Table 3 presents the significant ($P \leq 0.05$) findings in terms of the percentage change in the SD of the ZQM, as predicted by an increase of 1 HPRD of staffing, everything else held constant, including the levels of the other 2 staffing types. The findings varied depending on the staffing type and the ZQM, some changing significance levels, some magnitude of the effect, and some improvement in quality to deterioration or vice versa. Based on the 2SLS models, while higher CNA staffing improves the antipsychotic ZQM (−41%), higher RN staffing worsens antipsychotics (+47%). On the other hand, higher RN staffing substantially improves both hospitalization (−190%) and ER visit (−144%) ZQMs, and higher CNAs worsens these 2 ZQMs by +29% and +25%, respectively. Higher CNA improvement is primarily with respect to long-stay activities of daily living (ADLs) and movement (−41%) and short-stay decline in functioning (−53%), and only RNs improve pressure sores (−53%). Higher LPN HPRD improves both the hospitalization and the ER visit ZQMs but is twice as important ER visits QM at (−127%) than hospitalizations (−69%).

Sensitivity analysis, repeating the analysis only including counties with 4 or more nursing homes, is presented in Supplementary Table 10. Findings are mainly similar and discussed in the Supplementary Material.

Discussion

This article presents the relationship between staffing HPRDs and 6 QMs that were estimated using 2 different methods, OLS, the method most often used in prior studies, and 2SLS, a method that accounts for potential endogeneity between quality and staffing and corrects for it. We find that accounting for endogeneity makes a substantial difference in the estimates of the coefficients expressing the relationship between staffing and quality, sometimes by factors as high as 5. Furthermore, endogeneity affects not only the magnitude of the relationship, but may also change its direction and significance, thus highlighting important variations and nuances in the relationships between staffing types and health outcomes.

Several findings are of particular interest. The first is that increasing CNA staffing lowers use of antipsychotic medications while increasing RN staffing increases it. The relationship between more CNA HPRDs and lower antipsychotic use is not surprising given the role of CNAs in providing most of the daily care and ADL support that often triggers resident behavioral symptoms. This vantage point allows CNAs to develop insights into person-centered care routines and other behavioral and environmental modifications that might mitigate symptoms. In addition, increased HPRDs allow CNAs to provide care that is less rushed, to anticipate residents' needs, and prevent some of the agitation and poor behavioral responses. The relationship between more RN HPRDs and increased prescribing of antipsychotics is less expected. We speculate that the explanation

Table 2
Comparison of 6 OLS and 6 2SLS Models of ZQMs

ZQMs	OLS						2SLS					
	RNs HPRD		CNAs HPRD		LPNs HPRD		RNs HPRD		CNAs HPRD		LPNs HPRD	
	Coefficient	*P* Value [95%CI]	Coefficient	*P* Value [95%CI]	Coefficient	*P* Value [95%CI]	Coefficient	*P* Value [95%CI]	Coefficient	*P* Value [95%CI]	Coefficient	*P* Value [95%CI]
Long-Stay ADLs and movement	−0.016	0.631 [−0.084 to 0.051]	−0.178	<.000 [−0.212 to −0.143]	0.173	<.000 [0.114 to 0.232]	0.103	0.613 [−0.296 to 0.503]	−0.313	<.000 [−0.416 to−0.209]	0.290	0.066 [−0.019 to0.599]
Antipsychotic medication	0.023	0.324 [−0.023 to 0.069]	0.007	0.600 [−0.019 to 0.032]	−0.008	0.693 [−0.050 to 0.033]	0.279	0.047 [0.004 to 0.553]	−0.125	0.001 [−0.198 to −0.052]	0.096	0.363 [−0.110 to −0.302]
Hospitalizations	−0.261	<.001 [−0.323 to −0.200]	0.013	0.415 [−0.019 to 0.045]	0.093	0.001 [0.039 to 0.146]	−1.328	<.000 [−1.673 to −0.983]	0.201	<.000 [0.109 to 0.293]	−0.483	0.001 [−0.755 to −0.211]
Outpatient ER visits	−0.155	<.000 [−0.217 to −0.094]	−0.024	0.154 [−0.057 to 0.009]	0.009	0.737 [−0.045 to 0.063]	−1.098	<.000 [−1.500 to −0.696]	0.191	<.000 [0.084 to 0.298]	−0.969	<.000 [−1.275 to −0.663]
Short-stay decline or no change in functioning	−0.111	0.003 [−0.182 to −0.039]	−0.153	<.000 [−0.192 to −0.114]	0.064	0.051 [−0.000 to 0.128]	−0.080	0.728 [−0.530 to −0.370]	−0.481	<.000 [−0.598 to −0.364]	0.079	0.660 [−0.274 to 0.432]
Long-stay high-risk pressure sores	0.160	<.000 [0.087 to 0.233]	−0.108	<.000 [−0.145 to −0.072]	0.287	<.000 [0.221 to 0.353]	−0.436	0.033 [−0.836 to −0.035	−0.008	0.879 [−0.111 to 0.095]	−0.242	0.124 [−0.551 to 0.067]

The table presents estimates for staffing HPRD only. Full models controlling for patient and nursing home characteristics can be found in the supplementary tables.

Table 3
Percentage Change in the SD of the ZQM Due to a 1 HPRD Increase in Staffing

Quality Measures	SD of ZQMs	RNs		CNAs		LPNs	
		OLS	2SLS	OLS	2SLS	OLS	2SLS
		%	%	%	%	%	%
Long-stay ADLs and movement	0.77	NS	NS	−23	−41	22	NS
Antipsychotic medication (long- and short-stay)	0.59	NS	47	NS	−21	NS	NS
Hospitalizations (long- and short-stay)	0.70	−37	−190	NS	29	13	−69
Outpatient ER visits (long- and short-stay)	0.76	−20	−144	NS	25	NS	−127.5
Short-stay decline or no change in functioning	0.90	−12	NS	−17	−53	NS	NS
Long-stay high-risk pressure sores	0.83	19	−53	−13	NS	35	NS

NS cells indicate nonsignificant findings ($P > .05$). Negative numbers indicate improvement in quality, that is, a decrease in the value of the ZQM. Positive numbers indicate deterioration in quality.

might relate to RNs' role directly communicating behavioral concerns to the prescribing provider and that RNs may initiate the request for antipsychotic orders. RN involvement in developing overall care plans and other policies that support a facility culture focused on person-centered care may not be captured in non-leadership RN HPRDs. Studies that investigate the causes for the different approaches adopted by RNs, LPNs, and CNAs might offer information that would lead to new interventions that could lower the use of antipsychotic medications.

Another interesting finding relates to hospitalizations and ER visits. As expected, RNs are particularly important with respect to hospitalization and ER visits not followed by a hospitalization. On the other hand, increasing CNA HPRDs is associated with an increase in both hospitalization and ER visits. Although the magnitude of this relationship is much smaller than the magnitude of the effect of RNs and LPNs (approximately 30% compared with 150% to 190%), it is not negligible. Perhaps an increase of CNA HPRDs at the margin, while keeping the number of RNs and LPNs the same (as is the case with regression model estimates), may lead to CNAs having more time to observe residents and to detect and report changes from baseline. In the absence of more RN time to follow up and perform full assessments, more residents may be sent to the ER for fuller workup of these changes.

Finally, the 2SLS emphasizes the important effect that CNAs have on improving ADLs[19]; however, the improvement effect that CNAs seem to have on pressure injuries based on the OLS estimates becomes much smaller and insignificant when estimated by the 2SLS model. A possible explanation for this may be related to the fact that prevention and treatment of pressure injuries require assessment and identification of risks and development of appropriately matched care plans. For higher-risk residents, this can be complex and require more than 1 intervention. Thus, CNAs' effectiveness might depend on more complex performance than in other care areas and may require closer supervision by RNs to ensure that the necessary care is provided. Therefore, as CNA HPRDs are increased and the number of RNs remains the same, their ability to supervise the CNAs is diminished, leading to decreased effectiveness for the more complex care the CNAs provide, including pressure sore care.

These findings suggest that there are important nuances and interplays between staffing types. Although they suggest in some of the cases that increasing staff HPRDs improves outcomes, they also indicate that considering how the scope of practice among RNs, LPNs, and CNAs plays out in practice, and how they interact and support each other is an important consideration in optimizing the quality of care they provide.

One limitation to be noted is that as with all IV models, our estimates are a local average treatment effect. Our estimates are derived from nursing homes that respond to competitive pressures of other nursing homes in their market to increase or decrease staffing. Thus, our findings may not be generalizable to nursing homes in very concentrated markets with little or no competition, as is the case in rural areas. Our findings also cannot be generalized to nursing homes too small to be included in the CMS NHCC.

Conclusions and Implications

Our findings demonstrate the importance of correcting for endogeneity in studies of staffing and quality. Endogeneity affects conclusions about significance of the relationship of staffing on specific quality aspects, direction, and the magnitude of their impact. In an era when new staffing regulations are under consideration and specific levels are being debated, it is important to have accurate estimates of the relationship between staffing levels and quality. Mandated staffing ratios face many obstacles and challenges, but finding a way to achieve higher staffing ratios may be well worth it in terms of resident outcomes.

Our findings also highlight the need for further study to understand and recognize the interdependence between staffing types. Although we often look for where staff can improve outcomes, it might be just as important to understand where and why staff might hinder good outcomes and consider the implications for staffing regulations.

Disclosures

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Supplementary Table 1
First-Stage Equation Long-Stay ADLs and Movement

	RN HPRD				LPN HPRD				CNA HPRD			
	Coefficient	*P* Value	[95% CI]		Coefficient	*P* Value	[95% CI]		Coefficient	*P* value	[95% CI]	
Case mix index	0.064	.000	0.048	0.079	0.086	.000	0.070	0.103	−0.008	.544	−0.032	0.017
Percent of residents who are male	0.001	.000	0.001	0.001	−0.001	.004	−0.001	0.000	0.002	.000	0.001	0.002
Percent of residents younger than 65	−0.001	.000	−0.002	−0.001	0.001	.000	0.001	0.002	−0.005	.000	−0.006	−0.005
Percent of residents age 65−74	−0.004	.000	−0.005	−0.004	0.000	.150	−0.001	0.000	−0.009	.000	−0.009	−0.008
Percent of residents age 75−84	−0.003	.000	−0.003	−0.002	−0.001	.041	−0.001	−0.000	−0.005	.000	−0.006	−0.004
Percent of residents who are short stay	0.005	.000	0.005	0.006	0.002	.000	0.002	0.003	0.002	.000	0.001	0.003
Total number of beds	0.000	.000	0.000	0.000	0.000	.000	0.000	0.000	−0.000	.596	0.000	0.000
Percent occupancy	−0.001	.000	−0.001	0.000	−0.001	.000	−0.001	−0.001	0.001	.000	0.001	0.002
NH is for-profit	−0.042	.000	−0.049	−0.035	−0.020	.000	−0.028	−0.013	−0.149	.000	−0.161	−0.137
NH is hospital-based	0.155	.000	0.120	0.190	0.037	.023	0.005	0.070	0.081	.000	0.038	0.124
NH is part of a chain	0.003	.235	−0.002	0.008	−0.016	.000	−0.022	−0.010	−0.085	.000	−0.094	−0.076
Percent of residents whose payer is Medicare	−0.001	.001	−0.001	0.000	0.000	.199	−0.001	0.000	0.000	.181	0.000	0.001
Percent of residents whose payer is Medicaid	−0.001	.000	−0.001	0.000	−0.001	.000	−0.001	0.000	−0.002	.000	−0.002	−0.002
HHI	0.007	.571	−0.018	0.032	−0.020	.164	−0.049	0.008	−0.126	.000	−0.171	−0.080
Hospital wage index	0.032	.04	0.001	0.063	0.052	.005	0.016	0.088	0.273	.000	0.223	0.322
Percent of county population that is male	0.001	.335	−0.001	0.004	−0.010	.000	−0.012	−0.007	0.001	.578	−0.003	0.006
Percent of the county population younger than 65	0.001	.125	0.000	0.002	0.001	.136	0.000	0.002	0.004	.000	0.003	0.006
Percent of the county population not whole	0.000	.071	−0.001	0.000	0.000	.007	0.000	0.001	0.002	.000	0.001	0.002
County median income	0.013	.000	0.010	0.015	0.000	.972	−0.003	0.003	−0.010	.000	−0.015	−0.006
Percent of females in the labor force	0.004	.000	0.003	0.005	−0.003	.000	−0.004	−0.002	−0.006	.000	−0.007	−0.004
County unemployment rate	0.007	.000	0.004	0.009	0.002	.178	−0.001	0.004	0.006	.003	0.002	0.010
Year: 2018	0.022	.000	0.017	0.026	0.007	.007	0.002	0.012	0.023	.000	0.015	0.031
Year: 2019	0.027	.000	0.023	0.032	0.006	.022	0.001	0.012	0.024	.000	0.015	0.032
IV: RN HPRD	0.248	.000	0.228	0.268	−0.134	.000	−0.154	−0.114	−0.083	.000	−0.111	−0.055
IV: LPN HPRD	−0.264	.000	−0.281	−0.247	0.488	.000	0.464	0.513	−0.102	.000	−0.130	−0.074
IV: CNA HPRD	0.055	.000	0.045	0.065	−0.004	.521	−0.015	0.007	0.533	.000	0.514	0.551
Constant	−0.041	.588	−0.191	0.109	1.024	.000	0.854	1.194	1.567	.000	1.268	1.867
Partial F	618.51				755				780.55			
Number of observations	25,653				25,653				25,653			
Number of NHs	11,261				11,261				11,261			

HHI, Herfindahl-Hirschman Index; NH, nursing home.

Supplementary Table 2
First-Stage Equation Antipsychotic Medication (Long- and Short-Stay)

	RN HPRD				LPN HPRD				CNA HPRD			
	Coefficient	*P* Value	[95% CI]		Coefficient	*P* Value	[95% CI]		Coefficient	*P* Value	[95% CI]	
Case mix index	0.064	.000	0.048	0.079	0.087	.000	0.070	0.103	−0.008	.535	−0.032	0.017
Percent of residents who are male	0.001	.000	0.001	0.001	−0.001	.003	−0.001	0.000	0.002	.000	0.001	0.002
Percent of residents younger than 65	−0.001	.000	−0.002	−0.001	0.001	.000	0.001	0.002	−0.005	.000	−0.006	−0.005
Percent of residents age 65−74	−0.004	.000	−0.005	−0.004	0.000	.146	−0.001	0.000	−0.009	.000	−0.009	−0.008
Percent of residents age 75−84	−0.003	.000	−0.003	−0.002	−0.001	.039	−0.001	0.000	−0.005	.000	−0.006	−0.004
Percent of residents who are short stay	0.005	.000	0.005	0.006	0.002	.000	0.002	0.003	0.002	.000	0.001	0.003
Total number of beds	0.000	.000	0.000	0.000	0.000	.000	0.000	0.000	0.000	.612	0.000	0.000
Percent occupancy	−0.001	.000	−0.001	0.000	−0.001	.000	−0.001	−0.001	0.001	.000	0.001	0.002
NH is for-profit	−0.042	.000	−0.049	−0.036	−0.020	.000	−0.028	−0.013	−0.150	.000	−0.162	−0.138
NH is hospital-based	0.156	.000	0.122	0.191	0.037	.024	0.005	0.070	0.081	.000	0.038	0.124
NH is part of a chain	0.003	.244	−0.002	0.008	−0.016	.000	−0.022	−0.011	−0.086	.000	−0.095	−0.077
Percent of residents whose payer is Medicare	−0.001	.001	−0.001	0.000	0.000	.192	−0.001	0.000	0.000	.169	0.000	0.001
Percent of residents whose payer is Medicaid	−0.001	.000	−0.001	0.000	−0.001	.000	−0.001	0.000	−0.002	.000	−0.002	−0.002
HHI	0.007	.566	−0.017	0.032	−0.019	.180	−0.048	0.009	−0.125	.000	−0.170	−0.079
Hospital wage index	0.032	.042	0.001	0.063	0.052	.004	0.016	0.088	0.271	.000	0.222	0.320
Percent of county population that is male	0.0012	.346	−0.001	0.004	−0.009	.000	−0.012	−0.007	0.001	.578	−0.003	0.006
Percent of the county population younger than 65	0.0007	.131	0.000	0.002	0.001	.134	0.000	0.002	0.004	.000	0.003	0.006
Percent of the county population not White	−0.0002	.068	−0.001	0.000	0.000	.007	0.000	0.001	0.002	.000	0.001	0.002
County median income	0.0126	.000	0.010	0.015	0.000	.938	−0.003	0.003	−0.010	.000	−0.015	−0.006
Percent of females in the labor force	0.0039	.000	0.003	0.005	−0.003	.000	−0.004	−0.002	−0.006	.000	−0.007	−0.004
County unemployment rate	0.0067	.000	0.005	0.009	0.002	.178	−0.001	0.004	0.006	.002	0.002	0.010
Year: 2018	0.0218	.000	0.017	0.026	0.007	.008	0.002	0.012	0.023	.000	0.015	0.031
Year: 2019	0.027	.000	0.023	0.032	0.006	.022	0.001	0.012	0.024	.000	0.015	0.032
IV: RN HPRD	0.249	.000	0.229	0.270	−0.134	.000	−0.154	−0.114	−0.083	.000	−0.111	−0.055
IV: LPN HPRD	−0.265	.000	−0.281	−0.248	0.490	.000	0.466	0.515	−0.101	.000	−0.130	−0.073
IV: CNA HPRD	0.055	.000	0.045	0.065	−0.003	.545	−0.014	0.008	0.535	.000	0.517	0.554
Constant	−0.038	.618	−0.187	0.111	1.018	.000	0.849	1.187	1.566	.000	1.269	1.864
Partial F	620.55				761.38				785.85			
Number of observations	25,653				25,653				25,653			
Number of NHs	11,261				11,261				11,261			

HHI, Herfindahl-Hirschman Index; NH, nursing home.

Supplementary Table 3
First-Stage Equation Hospitalizations (Long- and Short-Stay)

	RN HPRD				LPN HPRD				CNA HPRD			
	Coefficient	*P* Value	[95% CI]		Coefficient	*P* Value	[95% CI]		Coefficient	*P* Value	[95% CI]	
Case mix index	0.063	.000	0.048	0.078	0.086	.000	0.069	0.103	−0.007	.555	−0.032	0.017
Percent of residents who are male	0.001	.000	0.001	0.001	−0.001	.004	−0.001	0.000	0.002	.000	0.001	0.002
Percent of residents younger than 65	−0.001	.000	−0.002	−0.001	0.001	.000	0.001	0.002	−0.005	.000	−0.006	−0.005
Percent of residents age 65–74	−0.004	.000	−0.005	−0.004	0.000	.157	−0.001	0.000	−0.009	.000	−0.009	−0.008
Percent of residents age 75–84	−0.003	.000	−0.003	−0.002	−0.001	.045	−0.001	−0.000	−0.005	.000	−0.006	−0.004
Percent of residents who are short stay	0.005	.000	0.005	0.006	0.002	.000	0.002	0.003	0.002	.000	0.001	0.003
Total number of beds	0.000	.000	0.000	0.000	0.000	.000	0.000	0.000	0.000	.573	0.000	0.000
Percent occupancy	−0.001	.000	−0.001	0.000	−0.001	.000	−0.001	−0.001	0.001	.000	0.001	0.002
NH is for-profit	−0.042	.000	−0.048	−0.035	−0.020	.000	−0.028	−0.013	−0.148	.000	−0.160	−0.136
NH is hospital-based	0.153	.000	0.119	0.188	0.038	.022	0.005	0.070	0.081	.000	0.038	0.124
NH is part of a chain	0.003	.222	−0.002	0.008	−0.016	.000	−0.021	−0.010	−0.084	.000	−0.093	−0.075
Percent of residents whose payer is Medicare	−0.001	.001	−0.001	0.000	0.000	.211	−0.001	0.000	0.000	.198	0.000	0.001
Percent of residents whose payer is Medicaid	−0.001	.000	−0.001	0.000	0.000	.000	−0.001	0.000	−0.002	.000	−0.002	−0.002
HHI	0.007	.579	−0.018	0.032	−0.021	.144	−0.050	0.007	−0.127	.000	−0.173	−0.081
Hospital wage index	0.033	.039	0.002	0.064	0.052	.005	0.016	0.088	0.275	.000	0.225	0.325
Percent of county population that is male	0.001	.318	−0.001	0.004	−0.010	.000	−0.012	−0.007	0.001	.576	−0.004	0.006
Percent of the county population younger than 65	0.001	.117	0.000	0.002	0.001	.139	0.000	0.002	0.004	.000	0.003	0.006
Percent of the county population not White	0.000	.076	0.000	0.000	0.000	.006	0.000	0.001	0.002	.000	0.001	0.002
County median income	0.013	.000	0.010	0.015	0.000	.980	−0.003	0.003	−0.010	.000	−0.015	−0.006
Percent of females in the labor force	0.004	.000	0.003	0.005	−0.003	.000	−0.004	−0.002	−0.006	.000	−0.007	−0.004
County unemployment rate	0.007	.000	0.004	0.009	0.002	.177	−0.001	0.004	0.006	.003	0.002	0.010
Year: 2018	0.022	.000	0.017	0.026	0.007	.006	0.002	0.012	0.023	.000	0.015	0.030
Year: 2019	0.027	.000	0.023	0.032	0.006	.021	0.001	0.012	0.023	.000	0.015	0.032
IV: RN HPRD	0.246	.000	0.226	0.266	−0.134	.000	−0.154	−0.114	−0.083	.000	−0.111	−0.055
IV: LPN HPRD	−0.263	.000	−0.279	−0.246	0.485	.000	0.460	0.510	−0.103	.000	−0.131	−0.074
IV: CNA HPRD	0.055	.000	0.045	0.065	−0.004	.487	−0.015	0.007	0.529	.000	0.511	0.548
Constant	−0.047	.545	−0.198	0.104	1.033	.000	0.862	1.205	1.568	.000	1.267	1.870004
Partial F	615.26				745.64				772.57			
Number of observations	25,653				25,653				25,653			
Number of NHs	11,261				11,261				11,261			

HHI, Herfindahl-Hirschman Index; NH, nursing home.

Supplementary Table 4
First-Stage Equation Outpatient ER visit (Long- and Short-Stay)

	RN HPRD				LPN HPRD				CNA HPRD			
	Coefficient	*P* Value	[95% CI]		Coefficient	*P* Value	[95% CI]		Coefficient	*P* Value	[95% CI]	
Case mix index	0.063	.000	0.048	0.079	0.086	.000	0.070	0.103	−0.007	.550	−0.032	0.017
Percent of residents who are male	0.001	.000	0.001	0.001	−0.001	.004	−0.001	0.000	0.002	.000	0.001	0.002
Percent of residents younger than 65	−0.001	.000	−0.002	−0.001	0.001	.000	0.001	0.002	−0.005	.000	−0.006	−0.005
Percent of residents age 65−74	−0.004	.000	−0.005	−0.004	0.000	.154	−0.001	0.000	−0.009	.000	−0.009	−0.008
Percent of residents age 75−84	−0.003	.000	−0.003	−0.002	−0.001	.043	−0.001	−0.000	−0.005	.000	−0.006	−0.004
Percent of residents who are short stay	0.005	.000	0.005	0.006	0.002	.000	0.002	0.003	0.002	.000	0.001	0.003
Total number of beds	0.000	.000	0.000	0.000	0.000	.000	0.000	0.000	0.000	.585	0.000	0.000
Percent occupancy	−0.001	.000	−0.001	0.000	−0.001	.000	−0.001	−0.001	0.001	.000	0.001	0.002
NH is for-profit	−0.042	.000	−0.049	−0.035	−0.020	.000	−0.028	−0.013	−0.149	.000	−0.160	−0.137
NH is hospital-based	0.154	.000	0.120	0.189	0.038	.023	0.005	0.070	0.081	.000	0.038	0.124
NH is part of a chain	0.003	.229	−0.002	0.008	−0.016	.000	−0.022	−0.010	−0.085	.000	−0.094	−0.076
Percent of residents whose payer is Medicare	−0.001	.001	−0.001	0.000	0.000	.205	−0.001	0.000	0.000	.189	0.000	0.001
Percent of residents whose payer is Medicaid	−0.001	.000	−0.001	0.000	0.000	.000	−0.001	0.000	−0.002	.000	−0.002	−0.002
HHI	0.007	.575	−0.018	0.032	−0.021	.154	−0.049	0.008	−0.126	.000	−0.172	−0.080
Hospital wage index	0.033	.040	0.002	0.064	0.052	.005	0.016	0.088	0.274	.000	0.224	0.324
Percent of county population that is male	0.001	.326	−0.001	0.004	−0.010	.000	−0.012	−0.007	0.001	.577	−0.003	0.006
Percent of the county population younger than 65	0.001	.121	0.000	0.002	0.001	.137	0.000	0.002	0.004	.000	0.003	0.006
Percent of the county population not White	0.000	.074	0.000	0.000	0.000	.006	0.000	0.001	0.002	.000	0.001	0.002
County median income	0.013	.000	0.010	0.015	−0.000	.997	−0.003	0.003	−0.010	.000	−0.015	−0.006
Percent of females in the labor force	0.004	.000	0.003	0.005	−0.003	.000	−0.004	−0.002	−0.006	.000	−0.007	−0.004
County unemployment rate	0.007	.000	0.004	0.009	0.002	.178	−0.001	0.004	0.006	.003	0.002	0.010
Year: 2018	0.022	.000	0.017	0.026	0.007	.006	0.002	0.012	0.023	.000	0.015	0.030
Year: 2019	0.027	.000	0.023	0.032	0.006	.021	0.001	0.012	0.023	.000	0.015	0.032
IV: RN HPRD	0.247	.000	0.227	0.267	−0.134	.000	−0.154	−0.114	−0.083	.000	−0.111	−0.055
IV: LPN HPRD	−0.263	.000	−0.280	−0.247	0.487	.000	0.4619	0.511	−0.102	.000	−0.131	−0.074
IV: CNA HPRD	0.055	.000	0.045	0.065	−0.004	.504	−0.015	0.007	0.531	.000	0.512	0.550
Constant	−0.044	.566	−0.195	0.106	1.029	.000	0.858	1.200	1.568	.000	1.267	1.868
Partial F	616.93				750.34				776.61			
Number of observations	25,653				25,653				25,653			
Number of NHs	11,261				11,261				11,261			

HHI, Herfindahl-Hirschman Index; NH, nursing home.

Supplementary Table 5
First-Stage Equation Short-stay Decline or No Change in Functioning

	RN HPRD				LPN HPRD				CNA HPRD			
	Coefficient	*P* Value	[95% CI]		Coefficient	*P* Value	[95% CI]		Coefficient	*P* Value	[95% CI]	
Case mix index	0.062	.000	0.046	0.077	0.085	.000	0.068	0.101	−0.007	.595	−0.031	0.018
Percent of residents who are male	0.001	.000	0.000	0.001	−0.001	.006	−0.001	0.000	0.002	.000	0.001	0.002
Percent of residents younger than 65	−0.001	.000	−0.002	−0.001	0.001	.000	0.001	0.002	−0.006	.000	−0.006	−0.0049982
Percent of residents age 65–74	−0.004	.000	−0.005	−0.004	0.000	.190	−0.001	0.000	−0.008	.000	−0.009	−0.008
Percent of residents age 75–84	−0.003	.000	−0.003	−0.002	0.000	.066	−0.001	0.000	−0.005	.000	−0.006	−0.004
Percent of residents who are short stay	0.005	.000	0.005	0.006	0.002	.000	0.002	0.003	0.002	.000	0.002	0.003
Total number of beds	0.000	.000	0.000	0.000	0.000	.000	0.000	0.000	0.000	.493	0.000	0.000
Percent occupancy	−0.001	.000	−0.001	0.000	−0.001	.000	−0.001	−0.001	0.001	.000	0.001	0.001
NH is for-profit	−0.039	.000	−0.046	−0.033	−0.020	.000	−0.028	−0.013	−0.143	.000	−0.155	−0.131
NH is hospital-based	0.147	.000	0.112	0.181	0.039	.019	0.006	0.071	0.079	.000	0.036	0.122
NH is part of a chain	0.003	.176	−0.002	0.008	−0.014	.000	−0.020	−0.009	−0.078	.000	−0.087	−0.070
Percent of residents whose payer is Medicare	−0.001	.004	−0.001	0.000	0.000	.268	−0.001	0.000	0.000	.264	0.000	0.001
Percent of residents whose payer is Medicaid	−0.001	.000	−0.001	0.000	0.000	.000	−0.001	0.000	−0.002	.000	−0.002	−0.001
HHI	0.007	.614	−0.019	0.032	−0.026	.085	−0.056	0.004	−0.131	.000	−0.179	−0.084
Hospital wage index	0.035	.033	0.003	0.067	0.053	.006	0.015	0.090	0.285	.000	0.233	0.337
Percent of county population that is male	0.001	.261	−0.001	0.004	−0.010	.000	−0.013	−0.007	0.002	.56	−0.004	0.007
Percent of the county population younger than 65	0.001	.086	0.000	0.002	0.001	.151	0.000	0.002	0.005	.000	0.003	0.006
Percent of the county population not White	0.000	.096	0.000	0.000	0.000	.003	0.000	0.001	0.002	.000	0.001	0.002
County median income	0.013	.000	0.010	0.016	0.000	.805	−0.003	0.003	−0.010	.000	−0.014	−0.006
Percent of females in the labor force	0.004	.000	0.003	0.005	−0.003	.000	−0.004	−0.002	−0.005	.000	−0.007	−0.004
County unemployment rate	0.006	.000	0.004	0.008	0.002	.176	−0.001	0.004	0.006	.004	0.002	0.010
Year: 2018	0.022	.000	0.018	0.026	0.007	.004	0.002	0.012	0.023	.000	0.015	0.030
Year: 2019	0.027	.000	0.023	0.032	0.006	.021	0.001	0.011	0.022	.000	0.014	0.030
IV: RN HPRD	0.239	.000	0.219	0.259	−0.134	.000	−0.154	−0.113	−0.082	.000	−0.110	−0.055
IV: LPN HPRD	−0.257	.000	−0.274	−0.241	0.471	.000	0.446	0.497	−0.106	.000	−0.134	−0.077
IV: CNA HPRD	0.055	.000	0.045	0.065	−0.005	.365	−0.017	0.006	0.515	.000	0.496	0.534
Constant	−0.068	.389	−0.224	0.087	1.071	.000	0.894	1.248	1.570	.000	1.259	1.881
Partial F	598.86				706.91				737.14			
Number of observations	25653				25653				25653			
Number of NHs	11261				11261				11261			

HHI, Herfindahl-Hirschman Index; NH, nursing home.

Supplementary Table 6
First-Stage Equation High-Risk Long-Stay Residents With Pressure Sores

	RN HPRD				LPN HPRD				CNA HPRD			
	Coefficient	*P* Value	[95% CI]		Coefficient	*P* Value	[95% CI]		Coefficient	*P* Value	[95% CI]	
Case mix index	0.062	.000	0.047	0.078	0.085	.000	0.069	0.102	−0.007	.576	−0.032	0.018
Percent of residents who are male	0.001	.000	0.000	0.001	−0.001	.005	−0.001	0.000	0.002	.000	0.001	0.002
Percent of residents younger than 65	−0.001	.000	−0.002	−0.001	0.001	.000	0.001	0.002	−0.006	.000	−0.006	−0.005
Percent of residents age 65−74	−0.004	.000	−0.005	−0.004	0.000	.172	−0.001	0.000	−0.008	.000	−0.009	−0.008
Percent of residents age 75−84	−0.003	.000	−0.003	−0.002	−0.001	.054	−0.001	0.000	−0.005	.000	−0.006	−0.004
Percent of residents who are short stay	0.005	.000	0.005	0.006	0.002	.000	0.002	0.003	0.002	.000	0.002	0.003
Total number of beds	0.000	.000	0.000	0.000	0.000	.000	0.000	0.000	0.000	.532	0.000	0.000
Percent occupancy	−0.001	.000	−0.001	0.000	−0.001	.000	−0.001	−0.001	0.001	.000	0.001	0.002
NH is for-profit	−0.041	.000	−0.047	−0.034	−0.020	.000	−0.028	−0.013	−0.145	.000	−0.157	−0.134
NH is hospital-based	0.150	.000	0.115	0.185	0.038	.020	0.006	0.071	0.080	.000	0.037	0.123
NH is part of a chain	0.003	.199	−0.002	0.008	−0.015	.000	−0.021	−0.009	−0.081	.000	−0.090	−0.072
Percent of residents whose payer is Medicare	−0.001	.002	−0.001	0.000	0.000	.237	−0.001	0.000	0.000	.231	0.000	0.001
Percent of residents whose payer is Medicaid	−0.001	.000	−0.001	0.000	0.000	.000	−0.001	0.000	−0.002	.000	−0.002	−0.002
HHI	0.007	.595	−0.019	0.032	−0.024	.111	−0.053	0.005	−0.129	.000	−0.176	−0.082
Hospital wage index	0.034	.036	0.002	0.066	0.052	.005	0.016	0.089	0.280	.000	0.229	0.331
Percent of county population that is male	0.001	.288	−0.001	0.004	−0.010	.000	−0.013	−0.007	0.001	.570	−0.004	0.006
Percent of the county population younger than 65	0.001	.101	0.000	0.002	0.001	.144	0.000	0.002	0.005	.000	0.003	0.006
Percent of the county population not White	0.000	.085	0.000	0.000	0.000	.004	0.000	0.001	0.002	.000	0.001	0.002
County median income	0.013	.000	0.010	0.015	0.000	.890	−0.003	0.003	−0.010	.000	−0.014	−0.006
Percent of females in the labor force	0.004	.000	0.003	0.005	−0.003	.000	−0.004	−0.002	−0.006	.000	−0.007	−0.004
County unemployment rate	0.006	.000	0.004	0.009	0.002	.177	−0.001	0.0041	0.006	.004	0.002	0.010
Year: 2018	0.022	.000	0.018	0.026	0.007	.005	0.002	0.0117	0.023	.000	0.015	0.030
Year: 2019	0.027	.000	0.023	0.032	0.006	.021	0.001	0.0115	0.023	.000	0.014	0.031
IV: RN HPRD	0.243	.000	0.223	0.263	−0.134	.000	−0.154	−0.114	−0.083	.000	−0.111	−0.055
IV: LPN HPRD	−0.260	.000	−0.277	−0.243	0.478	.000	0.453	0.503	−0.104	.000	−0.133	−0.076
IV: CNA HPRD	0.055	.000	0.045	0.065	−0.005	.424	−0.016	0.007	0.522	.000	0.503	0.541
Constant	−0.057	.464	−0.210	0.096	1.052	.000	0.877	1.226	1.570	.000	1.263	1.876
Partial F	607.82				726.74				755.72			
Number of observations	25,653				25,653				25,653			
Number of NHs	11,261				11,261				11,261			

HHI, Herfindahl-Hirschman Index; NH, nursing home.

Supplementary Table 7
Balance Table - Comparing Mean Values of Covariates in Counties With Low (<50%) of IV and High (50%>) of IV

		RN HPRD		LPN HPRD		CNA HPRD	
		Low	High	Low	High	Low	High
Case mix index	Mean	1.6	1.6	1.6	1.6	1.6	1.6
	SD	0.3	0.3	0.3	0.3	0.3	0.3
Percent of residents who are male	Mean	34	35	34	35	34	35
	SD	10	10	10	10	10	10
Percent of residents younger than 65	Mean	15	14	13	16	15	15
	SD	12	12	11	12	12	12
Percent of residents age 65–74	Mean	19	18	17	20	18	19
	SD	7	8	8	8	8	8
Percent of residents age 75–84	Mean	28	27	27	27	27	27
	SD	6	6	6	6	6	6
Percent of residents who are short stay	Mean	16	19	17	18	16	19
	SD	11	13	12	12	11	13
Total number of beds	Mean	115	121	117	119	119	55
	SD	50	65	65	52	118	61
Percent occupancy	Mean	81	82	80	82	79	83
	SD	14	13	14	13	14	12
NH is for-profit	Mean	77	71	69	78	72	45
	SD	42	45	46	41	76	43
NH is hospital-based	Mean	1	1	2	1	1	2
	SD	12	11	13	11	11	12
NH is part of a chain	Mean	65	63	62	66	66	47
	SD	48	48	49	48	62	49
Percent of residents whose payer is Medicare	Mean	13	14	13	14	13	14
	SD	10	11	10	10	10	11
Percent of residents whose payer is Medicaid	Mean	61	58	58	21	60	59
	SD	20	22	61	21	21	21
HHI	Mean	0.16	0.11	0.15	0.12	0.15	0.12
	SD	0.15	0.12	0.14	0.13	0.14	0.13
Hospital wage index	Mean	0.93	0.99	0.96	0.96	0.92	1
	SD	0.11	0.12	0.1	0.13	0.08	0.14
Percent of county population that is male	Mean	49	49	49	49	49	49
	SD	1	1	1	1	1	1
Percent of the county population younger than 65	Mean	16	16	17	16	16	16
	SD	4	4	3	4	4	4
Percent of the county population not White	Mean	24	23	19	27	21	25
	SD	17	15	15	16	15	16
County median income in $10,000	Mean	5	7	6	6	6	6
	SD	1	2	2	2	1	2
Percent of females in the labor force	Mean	71	75	74	71	72	73
	SD	5	4	5	5	5	5
County unemployment rate	Mean	6	5	5	6	5	5
	SD	2	2	2	2	2	2

HHI, Herfindahl-Hirschman Index; NH, nursing home.

Supplementary Table 8
Full OLS Models

	Long-Stay ADL and Movement				Antipsychotic Medication				Hospitalizations				ER Visits				Short-Stay Functioning				Long-Stay High-Risk Pressure Sores			
	Coefficient	*P* Value	[95% CI]		Coefficient	*P* Value	[95% CI]		Coefficient	*P* Value	[95% CI]		Coefficient	*P* Value	[95% CI]		Coefficient	*P* Value	[95% CI]		Coefficient	*P* Value	[95% CI]	
RN HPRD	−0.016	.631	−0.084	0.051	0.023	.324	−0.023	0.069	−0.261	.000	−0.323	−0.200	−0.155	.000	−0.217	−0.094	−0.111	.003	−0.182	−0.039	0.160	.000	0.087	0.233
LPN HPRD	0.173	.000	0.114	0.232	−0.008	.693	−0.050	0.033	0.093	.001	0.039	0.146	0.009	.737	−0.045	0.063	0.064	.051	0.000	0.128	0.287	.000	0.221	0.353
CNA HPRD	−0.178	.000	−0.212	−0.143	0.007	.600	−0.019	0.032	0.013	.415	−0.019	0.045	−0.024	.154	−0.057	0.009	−0.153	.000	−0.192	−0.114	−0.108	.000	−0.145	−0.072
Case mix index	−0.072	.045	−0.142	−0.001	−0.196	.000	−0.247	−0.145	−0.166	.000	−0.226	−0.106	−0.281	.000	−0.341	−0.222	0.212	.000	0.129	0.295	0.216	.000	0.130	0.302
Percent of residents who are male	−0.004	.000	−0.006	−0.002	0.003	.001	0.001	0.004	−0.004	.000	−0.005	−0.002	−0.004	.000	−0.006	−0.003	0.001	.470	−0.001	0.003	−0.001	.468	−0.003	0.001
Percent of residents younger than 65	0.004	.000	0.002	0.006	0.009	.000	0.007	0.010	0.005	.000	0.004	0.007	0.008	.000	0.006	0.010	0.007	.000	0.004	0.009	0.015	.000	0.013	0.017
Percent of residents age 65−74	0.005	.000	0.003	0.008	0.007	.000	0.006	0.009	0.004	.001	0.002	0.006	0.005	.000	0.003	0.008	0.003	.028	0.000	0.006	0.009	.000	0.007	0.012
Percent of residents age 75−84	0.002	.052	0.000	0.004	0.009	.000	0.008	0.011	0.005	.000	0.003	0.007	0.001	.279	−0.001	0.004	0.005	.000	0.003	0.008	0.004	.001	0.002	0.007
Percent of residents who are short stay	−0.004	.000	−0.006	−0.002	−0.009	.000	−0.011	−0.008	0.001	.333	−0.001	0.003	0.001	.388	−0.001	0.002	−0.001	.594	−0.003	0.001	0.004	.001	0.002	0.006
Total number of beds	−0.001	.000	−0.001	0.000	−0.000	.934	0.000	0.000	−0.001	.000	−0.001	0.000	−0.002	.000	−0.002	−0.001	0.000	.528	0.000	0.000	0.000	.650	0.000	0.000
Percent occupancy	−0.004	.000	−0.004	−0.003	0.000	.469	−0.001	0.000	−0.004	.000	−0.005	−0.003	−0.006	.000	−0.007	−0.005	−0.002	.000	−0.003	−0.001	−0.003	.000	−0.004	−0.002
NH is for-profit	−0.026	.100	−0.057	0.005	−0.001	.911	−0.024	0.021	0.074	.000	0.045	0.102	0.058	.000	0.029	0.088	−0.037	.037	−0.071	−0.002	−0.008	.615	−0.040	0.023
NH is hospital-based	0.148	.007	0.041	0.256	−0.108	.002	−0.176	−0.040	−0.193	.000	−0.284	−0.102	0.060	.283	−0.049	0.169	0.132	.007	0.037	0.228	−0.012	.815	−0.112	0.088
NH is part of a chain	0.068	.000	0.042	0.093	0.006	.546	−0.013	0.024	−0.044	.000	−0.067	−0.022	0.006	.636	−0.018	0.029	0.042	.004	0.014	0.071	−0.018	.167	−0.044	0.008
Percent of residents whose payer is Medicare	0.001	.367	−0.001	0.002	0.003	.000	0.002	0.004	0.007	.000	0.005	0.008	0.004	.000	0.002	0.005	−0.006	.000	−0.007	−0.004	0.001	.153	−0.001	0.003
Percent of residents whose payer is Medicaid	0.001	.074	0.000	0.001	0.000	.183	−0.001	0.000	0.001	.002	0.000	0.002	0.001	.004	0.000	0.002	0.001	.004	0.000	0.002	−0.001	.000	−0.002	−0.001
HHI	0.447	.000	0.322	0.572	−0.017	.717	−0.108	0.074	−0.566	.000	−0.674	−0.458	1.022	.000	0.894	1.149	−0.726	.000	−0.855	−0.598	0.291	.000	0.171	0.410
Hospital wage index	−0.812	.000	−0.961	−0.663	−0.644	.000	−0.754	−0.534	−0.714	.000	−0.846	−0.582	0.126	.059	−0.005	0.256	−0.873	.000	−1.049	−0.697	−0.985	.000	−1.136	−0.835
Percent of county population that is male	−0.034	.000	−0.048	−0.020	−0.017	.001	−0.027	−0.007	−0.012	.068	−0.024	0.001	0.029	.000	0.014	0.043	−0.044	.000	−0.061	−0.027	−0.023	.001	−0.036	−0.009
Percent of the county population younger than 65	−0.004	.039	−0.008	0.000	−0.001	.721	−0.004	0.003	−0.002	.269	−0.006	0.002	0.005	.034	0.000	0.009	−0.019	.000	−0.024	−0.015	0.004	.069	0.000	0.008
Percent of the county population not White	−0.001	.156	−0.002	0.000	−0.003	.000	−0.004	−0.002	0.004	.000	0.003	0.005	−0.003	.000	−0.004	−0.002	0.000	.766	−0.002	0.001	0.009	.000	0.008	0.011
County median income	−0.021	.000	−0.033	−0.009	0.012	.006	0.004	0.021	0.027	.000	0.017	0.038	−0.023	.000	−0.034	−0.013	0.055	.000	0.041	0.070	0.017	.009	0.004	0.029
Percent of females in the labor force	0.016	.000	0.013	0.020	0.002	.080	0.000	0.005	−0.009	.000	−0.012	−0.006	−0.009	.000	−0.013	−0.006	−0.016	.000	−0.020	−0.012	−0.001	.568	−0.005	0.003
County unemployment rate	−0.002	.694	−0.014	0.009	0.010	.017	0.002	0.019	0.026	.000	0.016	0.036	0.017	.005	0.005	0.029	0.026	.000	0.013	0.039	0.026	.000	0.014	0.038
Year: 2018	−0.061	.000	−0.080	−0.041	−0.083	.000	−0.097	−0.068	0.053	.000	0.034	0.073	−0.282	.000	−0.304	−0.259	0.082	.000	0.060	0.103	0.0410	.000	0.019	0.063
Year: 2019	−0.150	.000	−0.173	−0.127	−0.116	.000	−0.134	−0.099	−0.079	.000	−0.101	−0.056	−0.360	.000	−0.385	−0.335	0.005	.720	−0.022	0.032	0.0211	.102	−0.004	0.046
Constant	2.145	.000	1.326	2.965	1.072	.000	0.490	1.655	1.898	.000	1.155	2.641	0.215	.621	−0.637	1.067	3.892	.000	2.941	4.843	0.953	.021	0.144	1.762
Number of observations	25,653				25,653				25,653				25,653				25,653				25,653			
Number of NHs	11,261				11,261				11,261				11,261				11,261				11,261			

HHI, Herfindahl-Hirschman Index; NH, nursing home.

Supplementary Table 9
Full 2SLS Models

	Long-Stay ADL and Movement				Antipsychotic Medication				Hospitalizations				ER Visits				Short-Stay Functioning				Long-Stay High-Risk Pressure Sores			
	Coefficient	*P* Value	[95% CI]		Coefficient	*P* Value	[95% CI]		Coefficient	*P* Value	[95% CI]		Coefficient	*P* Value	[95% CI]		Coefficient	*P* Value	[95% CI]		Coefficient	*P* Value	[95% CI]	
RN HPRD	0.103	.613	−0.296	0.503	0.279	.047	0.004	0.553	−1.328	.000	−1.673	−0.983	−1.098	.000	−1.500	−0.696	−0.080	.728	−0.530	0.370	−0.436	.033	−0.836	−0.035
LPN HPRD	0.290	.066	−0.019	0.599	0.096	.363	−0.110	0.302	−0.483	.001	−0.755	−0.211	−0.969	.000	−1.275	−0.663	0.079	.660	−0.274	0.432	−0.242	.124	−0.551	0.067
CNA HPRD	−0.313	.000	−0.416	−0.209	−0.125	.001	−0.198	−0.052	0.201	.000	0.109	0.293	0.191	.000	0.084	0.298	−0.481	.000	−0.598	−0.364	−0.008	.879	−0.111	0.095
Case mix index	−0.097	.033	−0.187	−0.008	−0.231	.000	−0.294	−0.167	−0.038	.347	−0.118	0.041	−0.115	.007	−0.198	−0.031	0.196	.000	0.090	0.303	0.309	.000	0.201	0.418
Percent of residents who are male	−0.004	.000	−0.006	−0.002	0.003	.000	0.001	0.004	−0.003	.000	−0.005	−0.001	−0.005	.000	−0.007	−0.003	0.002	.123	0.000	0.004	−0.001	.428	−0.003	0.001
Percent of residents younger than 65	0.003	.001	0.001	0.005	0.008	.000	0.006	0.009	0.006	.000	0.004	0.008	0.010	.000	0.008	0.011	0.005	.000	0.002	0.007	0.016	.000	0.014	0.018
Percent of residents age 65−74	0.005	.001	0.002	0.007	0.007	.000	0.005	0.009	0.001	.554	−0.002	0.003	0.003	.023	0.000	0.006	0.001	.741	−0.003	0.004	0.008	.000	0.005	0.011
Percent of residents age 75−84	0.002	.056	−0.000	0.005	0.009	.000	0.008	0.011	0.002	.045	0.000	0.005	−0.001	.673	−0.003	0.002	0.004	.009	0.001	0.007	0.003	.041	0.000	0.005
Percent of residents who are short stay	−0.005	.005	−0.008	−0.001	−0.011	.000	−0.013	−0.009	0.007	.000	0.005	0.010	0.007	.000	0.004	0.011	0.001	.650	−0.003	0.004	0.008	.000	0.005	0.012
Total number of beds	−0.001	.000	−0.001	0.000	0.000	.703	0.000	0.000	−0.001	.000	−0.001	0.000	−0.002	.000	−0.002	−0.002	0.000	.592	0.000	0.000	−0.000	.454	0.000	0.000
Percent occupancy	−0.003	.000	−0.004	−0.002	0.000	.760	−0.001	0.001	−0.005	.000	−0.006	−0.004	−0.007	.000	−0.009	−0.006	−0.001	.045	−0.003	0.000	−0.004	.000	−0.005	−0.003
NH is for-profit	−0.039	.037	−0.075	−0.002	−0.007	.593	−0.032	0.018	0.042	.012	0.009	0.075	0.028	.123	−0.008	0.063	−0.076	.000	−0.116	−0.036	−0.029	.114	−0.066	0.007
NH is hospital-based	0.168	.010	0.040	0.296	−0.143	.000	−0.221	−0.064	−0.028	.623	−0.138	0.082	0.221	.001	0.091	0.352	0.161	.010	0.039	0.284	0.088	.145	−0.030	0.2060
NH is part of a chain	0.070	.000	0.044	0.097	−0.005	.603	−0.024	0.014	−0.034	.006	−0.058	−0.010	0.016	.235	−0.010	0.041	0.016	.302	−0.014	0.046	−0.0159	.259	−0.044	0.012
Percent of residents whose payer is Medicare	0.001	.382	−0.001	0.002	0.004	.000	0.003	0.006	0.006	.000	0.004	0.008	0.003	.001	0.001	0.004	−0.006	.000	−0.007	−0.004	0.001	.436	−0.001	0.003
Percent of residents whose payer is Medicaid	0.001	.192	0.000	0.001	−0.001	.075	−0.001	0.000	0.001	.071	−0.000	0.002	0.001	.237	0.000	0.001	0.001	.032	0.000	0.002	−0.002	.000	−0.003	−0.001
HHI	0.428	.000	0.301	0.555	−0.050	.282	−0.140	0.041	−0.541	.000	−0.653	−0.430	1.013	.000	0.878	1.148	−0.784	.000	−0.916	−0.652	0.285	.000	0.164	0.407
Hospital wage index	−0.753	.000	−0.909	−0.597	−0.596	.000	−0.710	−0.481	−0.701	.000	−0.847	−0.555	0.158	.035	0.011	0.305	−0.682	.000	−0.868	−0.495	−0.955	.000	−1.114	−0.796
Percent of county population that is male	−0.033	.000	−0.047	−0.018	−0.016	.001	−0.026	−0.006	−0.014	.027	−0.027	−0.002	0.016	.041	0.001	0.031	−0.041	.000	−0.058	−0.023	−0.029	.000	−0.043	−0.015
Percent of the county population younger than 65	−0.002	.287	−0.007	0.002	0.000	.794	−0.003	0.004	−0.001	.486	−0.005	0.003	0.004	.125	−0.001	0.008	−0.015	.000	−0.019	−0.010	0.004	.073	0.000	0.009
Percent of the county population not White	0.000	.529	−0.002	0.001	−0.003	.000	−0.004	−0.002	0.003	.000	0.002	0.005	−0.003	.000	−0.004	−0.002	0.001	.262	−0.001	0.002	0.009	.000	0.008	0.011
County median income	−0.026	.000	−0.040	−0.011	0.006	.235	−0.004	0.016	0.048	.000	0.035	0.062	−0.005	.441	−0.018	0.008	0.050	.000	0.033	0.066	0.028	.000	0.013	0.043
Percent of females in the labor force	0.016	.000	0.012	0.020	0.000	.795	−0.003	0.003	−0.003	.102	−0.007	0.001	−0.009	.000	−0.013	−0.005	−0.017	.000	−0.022	−0.013	0.000	.996	−0.004	0.004
County unemployment rate	−0.004	.558	−0.016	0.008	0.010	.027	0.001	0.018	0.034	.000	0.024	0.045	0.024	.000	0.012	0.037	0.027	.000	0.013	0.041	0.031	.000	0.019	0.043
Year: 2018	−0.063	.000	−0.084	−0.041	−0.085	.000	−0.101	−0.069	0.078	.000	0.056	0.100	−0.257	.000	−0.282	−0.232	0.091	.000	0.067	0.115	0.057	.000	0.033	0.080
Year: 2019	−0.156	.000	−0.182	−0.129	−0.122	.000	−0.141	−0.103	−0.047	.000	−0.072	−0.022	−0.329	.000	−0.357	−0.300	0.006	.711	−0.024	0.036	0.040	.005	0.012	0.068
Constant	2.237	.000	1.350	3.124	1.305	.000	0.677	1.933	1.857	.000	1.053	2.662	1.261	.007	0.337	2.184	4.345	.0000	3.306	5.384	1.452	.001	0.573	2.330
Number of observations	25653				25,653				25,653				25,653				25,653				25,653			
Number of NHs	11261				11,261				11,261				11,261				11,261				11,261			

HHI, Herfindahl-Hirschman Index; NH, nursing home.

Supplementary Table 10
Comparison of Regression Results of Models With the Full Sample and Models With Higher Competition Counties With at Least 4 Nursing Homes

Full Sample, N = 11,261												
	OLS RN		OLS CNA		OLS LPN		2SLS RN		2SLS CNA		2SLS LPN	
	Coefficient	*P* Value	Coefficient	*P* Value	Coefficient	*P* Value	Coefficient	*P* Value	Coefficient	*P* Value	Coefficient	*P* Value
Long-stay ADLs and movement	−0.016	.631	−0.178	<.001	0.173	<.001	0.103	.613	−0.313	<.001	0.290	.066
Antipsychotic medication	0.023	.324	0.007	.600	−0.008	.693	0.279*	.047*	−0.125	.001	0.096	.363
Hospitalizations	−0.261	<.001	0.013	.415	0.093	.001	−1.328	<.001	0.201	<.001	−0.483	.001
Outpatient ER visits	−0.155	<.001	−0.024	.154	0.009	.737	−1.098	<.001	0.191	<.001	−0.969	<.001
Short-stay decline or no change in functioning	−0.111	.003	−0.153	<.001	0.064	.051	−0.080	.728	−0.481	<.001	0.079	.660
Long-stay high-risk pressure sores	0.160	<.001	−0.108	<.001	0.287	<.001	−0.436	.033	−0.008	.879	−0.242*	.124*
Counties with at least 4 nursing homes, n = 9746												
	OLS RN		OLS CNA		OLS LPN		2SLS RN		2SLS CNA		2SLS LPN	
	Coefficient	*P* Value	Coefficient	*P* Value	Coefficient	*P* Value	Coefficient	*P* Value	Coefficient	*P* Value	Coefficient	*P* Value
Long-stay ADLs and movement	−0.012	.750	−0.177	<.001	0.174	<.001	−0.064	.744	−0.273	<.001	0.144	.344
Antipsychotic medication	0.030	.229	0.012	.405	−0.017	.458	0.239*	.105*	−0.089	.020	0.057	.608
Hospitalizations	−0.230	<.001	0.000	.997	0.088	.002	−1.224	<.001	0.171	<.001	−0.481	.001
Outpatient ER visits	−0.149	<.001	−0.026	.132	0.010	.713	−1.344	<.001	0.200	<.001	−1.131	<.001
Short-stay decline or no change in functioning	−0.112	.004	−0.176	<.001	0.058	.098	−0.014	.946	−0.536	<.001	0.144	.393
Long-stay high-risk pressure sores	0.170	<.001	−0.091	<.001	0.305	<.001	−0.552	.006	0.068	.180	−0.333*	.031*

There are 2 significant differences between the full sample analysis and the analysis of the sample restricted to higher competition.
The finding for antipsychotic medications for RNs in the 2SLS model in both samples has a positive coefficient of more than 0.2; however, it is significant in the full sample at 0.047 and only trending toward significance at 0.105 in the sample of high competition.
This trend may suggest that this measure is either more noisy and therefore less significant in the smaller sample or that there might be different practices in less competitive counties.
The second finding that changes is for LPNs in the 2SLS model for long-stay high-risk pressure sores. The coefficient increases from −0.242 to −0.333 and becomes more significant, with a *P* value of .031. It is not likely that it is an issue of sample size but more likely an issue of differences in practice patterns.
*Cells are significantly different between the 2 samples.