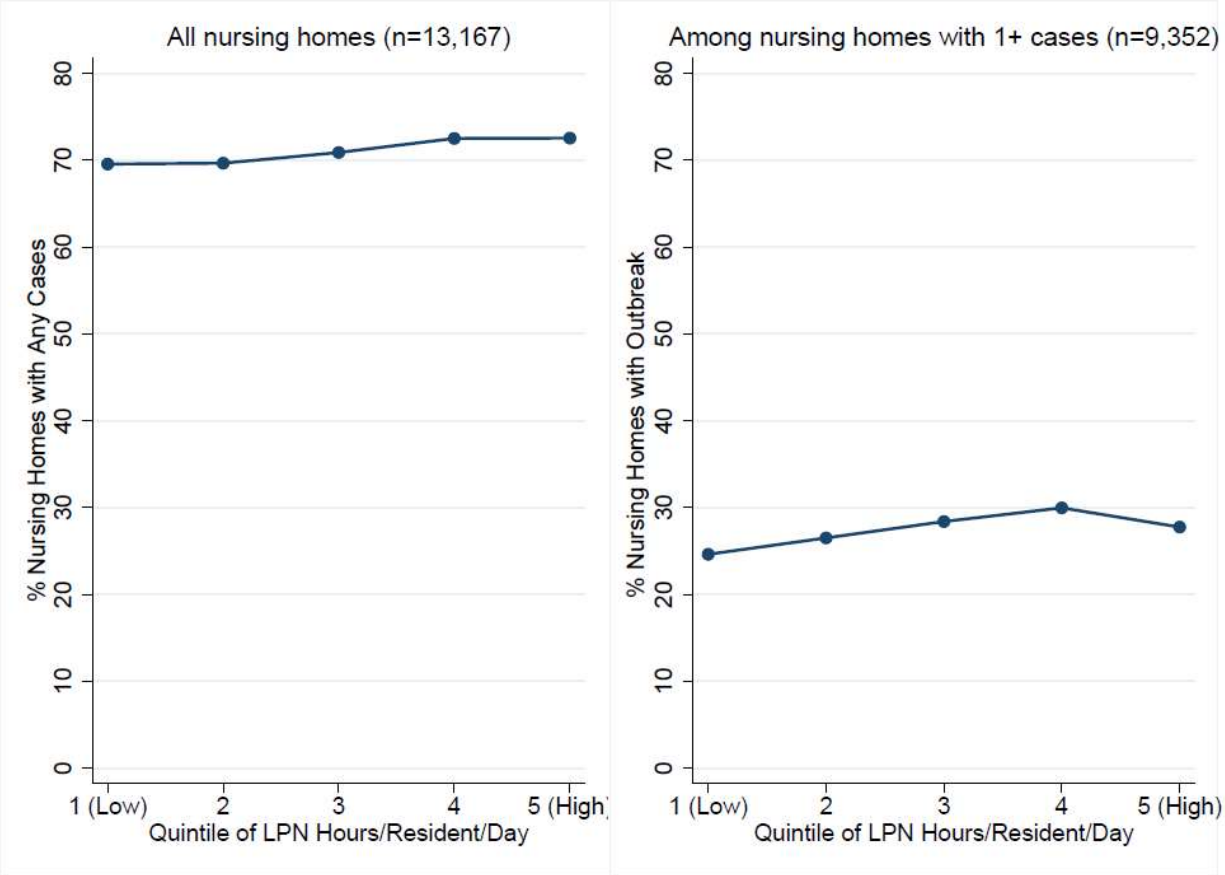
# Supplementary Appendix

## Contents

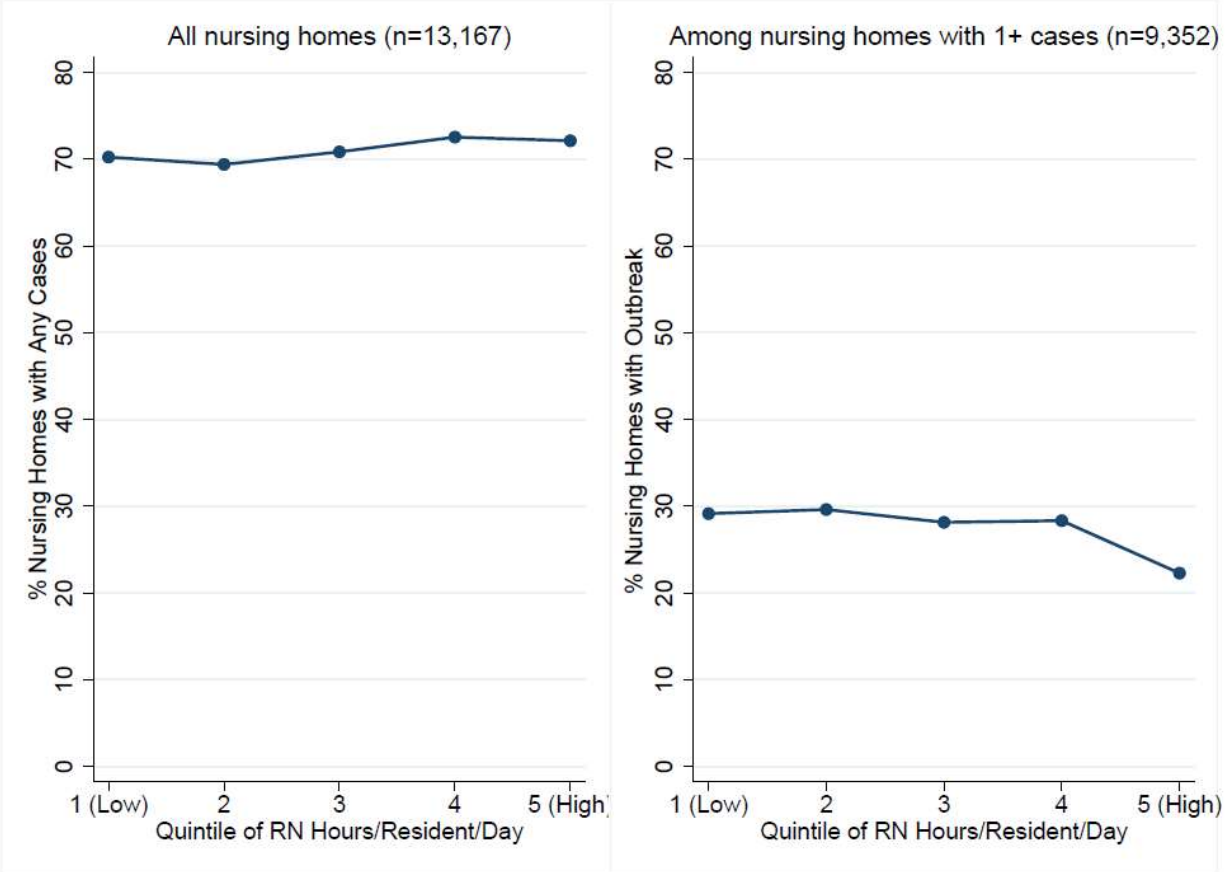
## Repeat Main Figure 1 for other staffing measures

### Figure S1: Unadjusted Percent of Nursing Facilities with Any Cases and Outbreak by LPN Hours Quintile



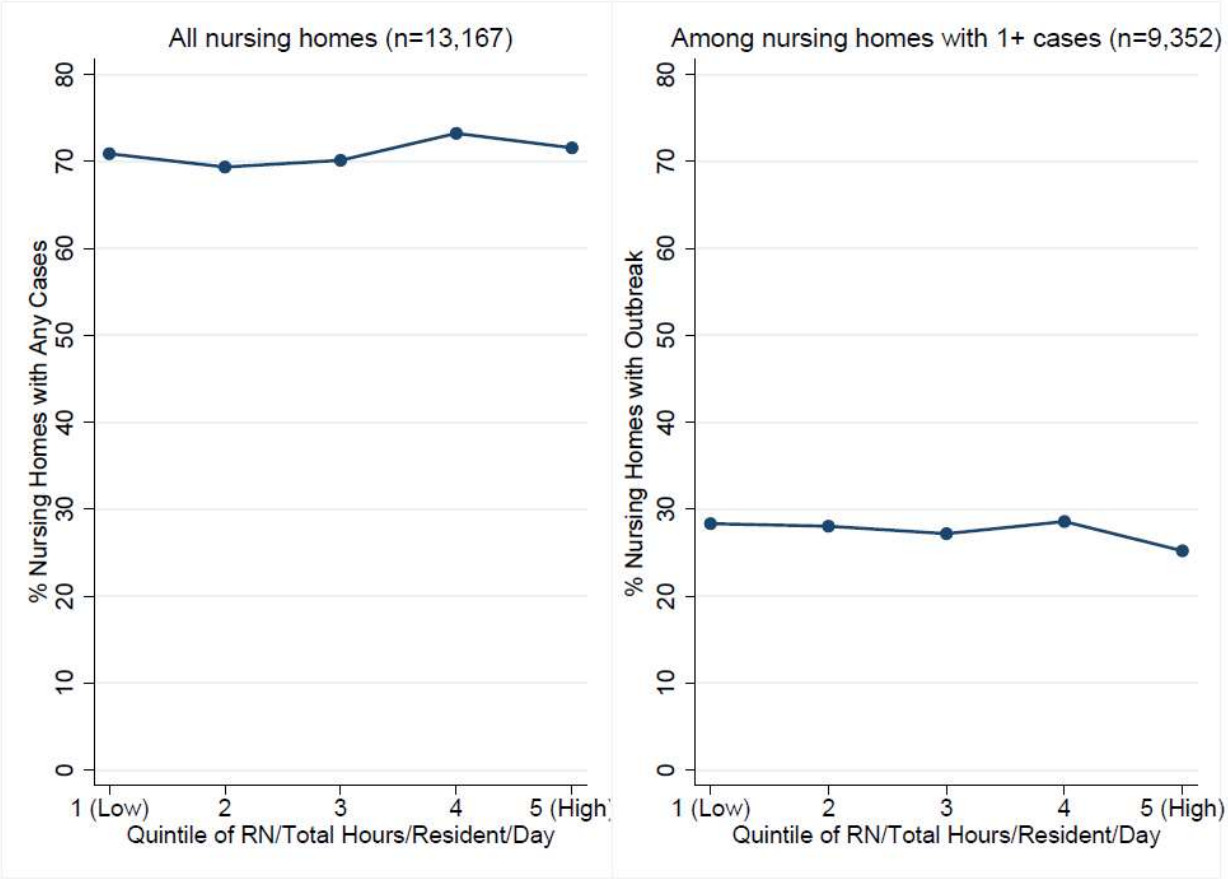

LPN = Licensed practial nurse.
Outbreak = >10%confirmed cases/beds or >20% confirmed + suspected cases/beds or 10+ deaths.
Quintiles calculated using case mix adjusted hours.

Figure S2: Unadjusted Percent of Nursing Facilities with Any Cases and Outbreak by RN Hours Quintile




RN = Registered Nurse.
Outbreak = >10%confirmed cases/beds or >20% confirmed + suspected cases/beds or 10+ deaths.
Quintiles calculated using case mix adjusted hours.

Figure S3: Unadjusted Percent of Nursing Facilities with Any Cases and Outbreak by RN/Total Nursing Hours Quintile




RN = Registered nurse.
Outbreak = >10%confirmed cases/beds or >20% confirmed + suspected cases/beds or 10+ deaths.
Quintiles calculated using case mix adjusted hours.

## Additional regression results

In Table 2, we report the coefficients for the staffing measures only. These regressions include additional controls for nursing home characteristics and county characteristics that were not reported in the main Table. Here we report odds ratios/marginal effects for all independent variables.

### Table S1: Full regression results Main Table 2

| | Any cases | | Outbreak: >10%confirmed cases/beds or >20% confirmed + suspected cases/beds or 10+ deaths) | | Number of Deaths | |
|---|---|---|---|---|---|---|
| | Odds Ratios | | Odds Ratios | | Marginal Effects | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Low NA Hours | 0.887 | | 1.001 | | -0.034 | |
| | (0.058) | | (0.078) | | (0.184) | |
| High CNA Hours | 1.027 | | 0.790 | | -0.981 | |
| | (0.071) | | (0.058)** | | (0.229)** | |
| Low LPN Hours | 0.975 | | 0.847 | | -0.702 | |
| | (0.052) | | (0.073) | | (0.203)** | |
| High LPN Hours | 1.083 | | 1.064 | | -0.183 | |
| | (0.066) | | (0.081) | | (0.197) | |
| Low RN Hours | 0.838 | | 0.974 | | -0.415 | |
| | (0.069)* | | (0.070) | | (0.196)* | |
| High RN Hours | 1.341 | | 1.031 | | -0.243 | |
| | (0.088)** | | (0.079) | | (0.217) | |
| Low Total Nursing Hours | | 0.827 | | 0.924 | | -0.371 |
| | | (0.071)* | | (0.073) | | (0.186)* |
| High Total Nursing Hours | | 1.153 | | 0.822 | | -1.059 |
| | | (0.109) | | (0.057)** | | (0.229)** |
| Low RN/Total Nursing Hours | | 0.887 | | 1.018 | | -0.389 |
| | | (0.052)* | | (0.062) | | (0.207) |
| High RN/Total Nursing Hours | | 1.218 | | 1.034 | | -0.296 |
| | | (0.078)** | | (0.069) | | (0.195) |
| Metro county | 1.206 | 1.202 | 1.754 | 1.768 | 0.858 | 0.850 |
| | (0.096)* | (0.095)* | (0.158)** | (0.164)** | (0.316)** | (0.329)** |

| | | | | | | |
|---|---|---|---|---|---|---|
| Number of certified beds | 1.011 | 1.011 | 1.003 | 1.002 | 0.023 | 0.023 |
| | (0.001)** | (0.001)** | (0.000)** | (0.001)** | (0.002)** | (0.002)** |
| For-profit | 0.837 | 0.825 | 1.285 | 1.290 | 0.604 | 0.588 |
| | (0.053)** | (0.055)** | (0.100)** | (0.094)** | (0.226)** | (0.222)** |
| Government | 0.692 | 0.696 | 0.762 | 0.762 | -0.760 | -0.773 |
| | (0.108)* | (0.110)* | (0.121) | (0.118) | (0.433) | (0.435) |
| Part of Chain | 1.195 | 1.199 | 0.961 | 0.977 | -0.148 | -0.088 |
| | (0.083)* | (0.086)* | (0.070) | (0.075) | (0.169) | (0.172) |
| High % Medicaid | 0.970 | 0.971 | 1.115 | 1.118 | 0.222 | 0.217 |
| | (0.049) | (0.049) | (0.055)* | (0.055)* | (0.171) | (0.172) |
| High % White Race | 1.008 | 1.006 | 0.983 | 0.973 | 0.737 | 0.749 |
| | (0.073) | (0.071) | (0.078) | (0.082) | (0.186)** | (0.188)** |
| County cases/residents Q2 | 1.344 | 1.345 | 1.210 | 1.230 | 0.076 | 0.059 |
| | (0.117)** | (0.117)** | (0.168) | (0.173) | (0.209) | (0.208) |
| County cases/residents Q3 | 1.838 | 1.858 | 2.059 | 2.138 | 1.206 | 1.226 |
| | (0.169)** | (0.169)** | (0.254)** | (0.270)** | (0.233)** | (0.236)** |
| County cases/residents Q4 | 3.316 | 3.320 | 3.890 | 4.013 | 2.687 | 2.719 |
| | (0.521)** | (0.518)** | (0.496)** | (0.510)** | (0.252)** | (0.254)** |
| County cases/residents Q5 (high) | 6.190 | 6.204 | 6.171 | 6.318 | 5.033 | 5.096 |
| | (1.085)** | (1.079)** | (1.052)** | (1.114)** | (0.274)** | (0.279)** |
| *N* | 12,117 | 12,117 | 8,626 | 8,626 | 8,626 | 8,626 |

Excludes facilities with no COVID19 reporting or with staffing rating footnote
Logit regression, odds ratios reported for binary outcomes of any cases, outbreak. Marginal effects reported for hurdle negative binomial-2 regression for count outcome of deaths. Standard errors clustered by state.
Columns 1-2 include all NHC facilities with COVID-19 reporting and complete staffing rating information
Columns 3-6 limited to facilities with at least 1 case
Low [High] hours (ratio) = less [greater] than 33rd [66th] percentile of case-mix adjusted hours (ratio)

Table S1 shows that larger facility size, non-profit ownership, and per capita COVID-19 cases are associated with higher probability of a facility experiencing one or more cases. Facilities with more beds and in counties with high COVID-19 prevalence are also associated with higher probability of an outbreak and more deaths among facilities with cases. For-profit ownership is associated with higher

probability of outbreak and more deaths while a higher share of Medicaid residents is associated with higher probability of outbreak only and more non-white residents is associated with more deaths.

In addition to cases and deaths, nursing homes are asked to report whether they experienced staffing or PPE shortages in the past week and whether residents have access to COVID-19 testing at the facility. In addition to the facility characteristics included in the main regression specifications, these concurrent measures of shortages and testing may also be predictive of cases and outbreak severity. We repeat the main analyses including these additional variables as controls and report the results in Table S2 below.

Table S2: Including controls for shortages of staffing, PPE, testing access

| | Any cases | | Outbreak | | Number of Deaths | |
|---|---|---|---|---|---|---|
| | Odds Ratios | | Odds Ratios | | Marginal Effects | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Low NA Hours | 0.887 | | 1.011 | | -0.017 | |
| | (0.056) | | (0.079) | | (0.184) | |
| High CNA Hours | 1.047 | | 0.805 | | -0.967 | |
| | (0.071) | | (0.062)** | | (0.231)** | |
| Low LPN Hours | 0.976 | | 0.839 | | -0.724 | |
| | (0.052) | | (0.072)* | | (0.203)** | |
| High LPN Hours | 1.091 | | 1.063 | | -0.198 | |
| | (0.066) | | (0.080) | | (0.197) | |
| Low RN Hours | 0.837 | | 0.963 | | -0.450 | |
| | (0.065)* | | (0.068) | | (0.197)* | |
| High RN Hours | 1.326 | | 1.031 | | -0.204 | |
| | (0.087)** | | (0.082) | | (0.217) | |
| Low Total Nursing Hours | | 0.837 | | 0.915 | | -0.408 |
| | | (0.068)* | | (0.072) | | (0.188)* |
| High Total Nursing Hours | | 1.187 | | 0.826 | | -1.073 |
| | | (0.105) | | (0.056)** | | (0.231)** |
| Low RN/Total Nursing Hours | | 0.889 | | 1.025 | | -0.405 |
| | | (0.050)* | | (0.062) | | (0.207) |

| | | | | | | |
|---|---|---|---|---|---|---|
| High RN/Total Nursing Hours | | 1.199 | | 1.041 | | -0.262 |
| | | (0.076)** | | (0.071) | | (0.196) |
| COVID-19 testing | 2.239 | 2.226 | 1.836 | 1.861 | 0.031 | 0.115 |
| | (0.387)** | (0.391)** | (0.705) | (0.727) | (0.594) | (0.592) |
| PPE Shortage | 1.371 | 1.373 | 0.901 | 0.897 | -0.484 | -0.548 |
| | (0.080)** | (0.080)** | (0.085) | (0.084) | (0.195)* | (0.194)** |
| Nursing Staff Shortage | 1.277 | 1.275 | 1.504 | 1.499 | 0.358 | 0.323 |
| | (0.120)** | (0.118)** | (0.191)** | (0.190)** | (0.359) | (0.366) |
| Clinical Staff Shortage | 1.168 | 1.174 | 0.869 | 0.869 | -0.319 | -0.334 |
| | (0.240) | (0.243) | (0.115) | (0.113) | (0.537) | (0.547) |
| Aide Shortage | 0.806 | 0.806 | 0.818 | 0.830 | -0.204 | -0.127 |
| | (0.065)** | (0.066)** | (0.107) | (0.110) | (0.364) | (0.375) |
| Other Staff Shortage | 1.242 | 1.243 | 1.427 | 1.414 | 0.492 | 0.520 |
| | (0.126)* | (0.127)* | (0.156)** | (0.155)** | (0.346) | (0.364) |
| *N* | 11,989 | 11,989 | 8,565 | 8,565 | 8,565 | 8,565 |

Excludes facilities with no COVID19 reporting or with staffing rating footnote
Logit regression, odds ratios reported for binary outcomes of any cases, outbreak. Marginal effects reported for hurdle negative binomial-2 regression for count outcome of deaths. Standard errors clustered by state.
Outbreak = >10%confirmed cases/beds or >20% confirmed + suspected cases/beds or 10+ deaths.
Regression also controls for nursing facility and county characteristics (omitted here for brevity).
Columns 1-2 include all NHC facilities with COVID-19 reporting and complete staffing rating information
Columns 3-6 limited to facilities with at least 1 case
Low [High] hours (ratio) = less [greater] than 33rd [66th] percentile of case-mix adjusted hours (ratio)

The associations between the baseline staffing measures from NHC and outcomes are similar to those in the main specifications: higher RN hours are associated with higher probability of a facility having any cases while higher NA and total nursing hours are associated with lower probability of outbreaks and fewer deaths (Table S2). Facilities that report that residents have access to COVID-19 testing have a higher probability of having any cases than facilities that report no access. However, once cases are detected at a facility, testing has no association with the development of more severe outbreaks or number of deaths. PPE shortages (as defined as having less than one-week supply of any of the PPE types that are reported) are associated with higher probability of any cases and fewer deaths.

Shortages of nursing staff concurrent with the pandemic are associated with higher probability of any cases and higher probability of outbreak, conditional on the facility having at least one case. Similarly, higher shortages of other staff (staff that are not classified as nursing, clinical, or nurse aides, including custodial staff) are associated with higher probability of an outbreak.

It is important to note that for all these measures of concurrent testing and shortages, the direction of any underlying causal relationship is unclear. For example, PPE shortages could be due to a COVID-19 outbreak or the development of an outbreak could cause a PPE shortage.

While the focus of the current study is the relationship between staffing levels and COVID-19 cases and deaths, we also repeat the analyses examining the associations between NHC star ratings and the outcomes. Table S3 reports these results.

Table S3: Relationship between Nursing Home Compare Ratings and Cases/Outbreaks

| | Any cases | | Outbreak | | Number of Deaths | |
|---|---|---|---|---|---|---|
| | Odds Ratios | | Odds Ratios | | Marginal Effects | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| NHC Overall Star Rating=2 | 1.181 | | 1.047 | | 0.244 | |
| | (0.075)** | | (0.079) | | (0.267) | |
| NHC Overall Star Rating=3 | 1.135 | | 0.890 | | -0.235 | |
| | (0.092) | | (0.067) | | (0.294) | |
| NHC Overall Star Rating=4 | 1.256 | | 1.047 | | -0.035 | |
| | (0.110)** | | (0.075) | | (0.256) | |
| NHC Overall Star Rating=5 | 1.344 | | 0.869 | | -0.239 | |

| | | | |
|---|---|---|---|
| | (0.137)** | (0.079) | (0.281) |
| Inspection Rating=2 | 1.064 | 0.967 | -0.298 |
| | (0.066) | (0.080) | (0.242) |
| Inspection Rating=3 | 1.058 | 0.817 | -0.646 |
| | (0.077) | (0.076)* | (0.243)** |
| Inspection Rating=4 | 1.026 | 0.978 | -0.330 |
| | (0.060) | (0.102) | (0.250) |
| Inspection Rating=5 | 0.994 | 0.785 | -0.384 |
| | (0.087) | (0.112) | (0.379) |
| Quality Measures Rating=2 | 1.129 | 1.011 | 0.376 |
| | (0.097) | (0.129) | (0.397) |
| Quality Measures Rating=3 | 0.967 | 1.007 | 0.850 |
| | (0.088) | (0.134) | (0.398)* |
| Quality Measures Rating=4 | 1.029 | 1.056 | 0.755 |
| | (0.093) | (0.127) | (0.379)* |
| Quality Measures Rating=5 | 1.159 | 1.054 | 0.691 |
| | (0.103) | (0.136) | (0.371) |
| Staffing Rating=2 | 1.015 | 1.292 | 0.758 |
| | (0.112) | (0.179) | (0.303)* |
| Staffing Rating=3 | 1.200 | 1.149 | 0.534 |
| | (0.177) | (0.151) | (0.295) |
| Staffing Rating=4 | 1.481 | 1.104 | 0.192 |
| | (0.227)* | (0.192) | (0.311) |
| Staffing Rating=5 | 1.969 | 1.015 | -0.366 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | (0.397)** | | (0.190) | | (0.353) |
| *N* | 12,117 | 12,115 | 8,626 | 8,625 | 8,626 | 8,625 |

Excludes facilities with no COVID-19 reporting or with staffing rating footnote
Logit regression, odds ratios reported for binary outcomes of any cases, outbreak. Marginal effects reported for hurdle negative binomial-2 regression for count outcome of deaths. Standard errors clustered by state.
Outbreak = >10%confirmed cases/beds or >20% confirmed + suspected cases/beds or 10+ deaths.
Regression also controls for nursing facility and county characteristics (omitted here for brevity).
Columns 1-2 include all NHC facilities with COVID-19 reporting and complete staffing rating information
Columns 3-6 limited to facilities with at least 1 case

Generally, these results agree with the conclusions from prior studies that low NHC ratings are not associated with worse COVID-19 outcomes. Earlier studies used data reported by state public health departments for a subset of states; we confirm those findings in the national CMS/CDC data.

While CMS provides staffing recommendations, minimum staffing levels and enforcement are often made at the state level. Similarly, CMS has provided COVID-19 guidance, but largely left implementation and enforcement of that guidance up to the states. To see whether the relationships between baseline staffing are due primarily to between or within state differences, we run a version of the main regression specification including indicator variables for each state in addition the original set of facility and county level controls. Results of this final alternative specification are reported in Table S4 below.

Table S4 - Adding state indicators

| | Any cases Odds Ratios | | Outbreak Odds Ratios | | Number of Deaths Marginal Effects | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Low NA Hours | 0.906 | | 0.956 | | -0.111 | |
| | (0.045)* | | (0.072) | | (0.185) | |
| High NA Hours | 1.060 | | 0.912 | | -0.620 | |
| | (0.075) | | (0.059) | | (0.245)* | |
| Low LPN Hours | 0.954 | | 0.956 | | -0.318 | |
| | (0.049) | | (0.070) | | (0.210) | |

| | | | | | | |
|---|---|---|---|---|---|---|
| High LPN Hours | 1.088 | | 1.068 | | -0.169 | |
| | (0.061) | | (0.077) | | (0.192) | |
| Low RN Hours | 0.958 | | 1.117 | | 0.085 | |
| | (0.072) | | (0.069) | | (0.202) | |
| High RN Hours | 1.181 | | 0.972 | | -0.449 | |
| | (0.058)** | | (0.068) | | (0.220)* | |
| Low Total Nursing Hours | | 0.886 | | 0.976 | | -0.105 |
| | | (0.049)* | | (0.086) | | (0.195) |
| High Total Nursing Hours | | 1.151 | | 0.918 | | -0.742 |
| | | (0.102) | | (0.069) | | (0.233)** |
| Low RN/Total Nursing Hours | | 1.000 | | 1.121 | | -0.057 |
| | | (0.055) | | (0.077) | | (0.210) |
| High RN/Total Nursing Hours | | 1.078 | | 1.016 | | -0.394 |
| | | (0.068) | | (0.063) | | (0.193)* |
| *N* | 12,117 | 12,117 | 8,603 | 8,603 | 8,626 | 8,626 |

Excludes facilities with no COVID19 reporting or with staffing rating footnote.
Logit regression, odds ratios reported for binary outcomes of any cases, outbreak. Marginal effects reported for hurdle negative binomial-2 regression for count outcome of deaths. Standard errors clustered by state.
Regression also controls for nursing home and county characteristics and state indicators (omitted here for brevity).
Columns 1-2 include all NHC facilities with COVID-19 reporting and complete staffing rating information
Columns 3-6 limited to facilities with at least 1 case
Outbreak = (a) >10% confirmed cases/beds, (b) >20% confirmed+suspected cases/beds, or (c) >10 deaths.
Low [High] hours (ratio) = less [greater] than 33rd [66th] percentile of case-mix adjusted hours (ratio)

Adding indicators for states to the models reduces the magnitude of the estimated odds ratios and marginal effects for the staffing measures. The overall conclusions remain consistent: facilities with high RN hours are associated with a higher probability of having any cases. High NA, RN and total nursing hours are associated with fewer deaths.

## Examining weekly versus cumulative cases and deaths

The main analyses derive outcomes using the cumulative case and death counts reported by nursing homes. After the initial reporting period (week ending May 24), nursing homes have been reporting weekly case and death counts. It is possible that the relationship between baseline staffing and cases and outbreak severity has changed over time as the pandemic progresses. We explore this possibility by creating a new set of outcomes based on these weekly counts. For the outcome of any cases, we examine the binary outcome of one or more cases the week ending June 14. Conditional on at least one total case in the facility, we determine if there is a current, again using weekly case and death counts for the week ending June 14. We then repeat the main analyses with these outcomes derived from the weekly data.

Table S5: Weekly Cases, Active Outbreak

| | Any cases (1) | Any cases (2) | Outbreak (3) | Outbreak (4) |
|---|---|---|---|---|
| Low NA Hours | 0.854 | | 0.962 | |
| | (0.065)* | | (0.212) | |
| High CNA Hours | 1.041 | | 0.753 | |
| | (0.072) | | (0.239) | |
| Low LPN Hours | 1.057 | | 1.062 | |
| | (0.081) | | (0.238) | |
| High LPN Hours | 1.048 | | 1.064 | |
| | (0.059) | | (0.193) | |
| Low RN Hours | 1.019 | | 0.791 | |
| | (0.093) | | (0.182) | |
| High RN Hours | 1.098 | | 0.751 | |
| | (0.091) | | (0.172) | |
| Low Total Nursing Hours | | 0.958 | | 0.854 |
| | | (0.077) | | (0.170) |
| High Total Nursing Hours | | 1.138 | | 0.542 |
| | | (0.096) | | (0.108)** |
| Low RN/Total Nursing Hours | | 1.073 | | 0.683 |
| | | (0.105) | | (0.170) |
| High RN/Total Nursing Hours | | 1.148 | | 0.855 |
| | | (0.084) | | (0.171) |
| *N* | 11,027 | 11,027 | 8,626 | 8,626 |

Excludes facilities with no COVID19 reporting week ending June 14 or with staffing rating footnote.

Logit regression, odds ratios reported for binary outcomes of any cases, outbreak. Standard errors clustered by state.
Regression also controls for nursing home and county characteristics (omitted here for brevity).
Columns 1-2 include all NHC facilities with COVID-19 reporting and complete staffing rating information.
Columns 3-4 limited to facilities with at least 1 case.
Outbreak = (a) >10% confirmed cases/beds, (b) >20% confirmed+suspected cases/beds, or (c) >10 deaths.
Low [High] hours (ratio) = less [greater] than 33rd [66th] percentile of case-mix adjusted hours (ratio)

None of the staffing measures are statistically significant for the outcome of any cases derived from the weekly data. However, the odds ratios point estimate patterns (greater than one for high staffing and less than one for low staffing) are similar to those in the main results suggesting that there have not been large changes in the relationship between staffing levels and which facilities experience cases over time. For the outcome of current outbreak, high total nursing staffing hours are associated with lower odds of an outbreak, consistent with the original findings using the cumulative case and death counts.