Nursing Home Quality, COVID-19 Deaths, and Excess Mortality

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Very preliminary – but the paper will be done in time for the conference

Abstract

The COVID-19 pandemic in the US has been particularly devastating for nursing home residents, killing almost 4 percent of them nationwide through mid-September. A key research question is, how have some nursing homes been able to effectively protect their residents, while others have not? Using several data sets covering the universe of US nursing homes, we examine whether nursing home quality is predictive of COVID-19 mortality. Results indicate that higher quality nursing homes, as measured by inspection rating, have substantially lower COVID-19 mortality rates. Nursing home quality does not predict the ability to prevent any COVID-19 resident or staff cases, but higher-quality establishments prevent the spread of the confirmed cases among residents conditional on having a case. Unfortunately, preventing COVID-19 cases and deaths may come at some cost, as high-quality homes have substantially higher non-COVID death rates, a result consistent with high excess non-COVID mortality among the elderly since March. The positive correlation between nursing home quality and non-COVID mortality is driven entirely by nursing homes located in counties with COVID-19 case rates that are below the median for US counties. As a result, high-quality homes in these counties have experienced significantly more total deaths than their low-quality counterparts. These results suggest that the social isolation generated by efforts to control the spread of the disease within nursing homes may have had some negative consequences. Given the concentration of these excess deaths in high-risk areas, it is likely that future suffering could be avoided with more nuanced policy such as the one recently suggested by CMS that outlines a role for in-person visits in areas with low disease incidence rates.

I. Introduction

The COVID-19 pandemic in the US has been particularly devastating for residents of nursing homes. As of September 14, 2020, there have been a total of 192,221 COVID-related deaths in the US. We estimate that 39 percent of these deaths are among nursing home residents. The death rate for non-nursing home residents is about 41 per 100,000.[1] The death rate for nursing home residents is more than 140 times that number at roughly 5,700 per 100,000. The death rate in nursing homes is even orders of magnitude larger than the death rate for those 65 and over outside of nursing homes, which we calculate to be about 200 per 100,000. In at least three states, Connecticut, Massachusetts, and New Jersey, more than 8 percent of the nursing home population at the beginning of the year has died as a result of the pandemic.

These horrific figures likely understate the true number of nursing home deaths associated with the pandemic. Quickly after the pandemic hit the US, most nursing homes banned all visitors, disrupting the daily routines of many residents.[2] An abundance of qualitative evidence from nursing home staff, administrators, and resident family members suggests that the lack of in-person contact with loved ones and other residents is not only generating feelings of loneliness, isolation, and despair, but may also expedite death.[3] Population-wide death trends support this claim. Figure 1 uses provisional data from the Centers for Disease Control (CDC) to show average weekly total deaths for the population 65 and older in 2017-2019, compared to 2020, where the latter are decomposed into total and non-COVID deaths. The figure highlights that in addition to COVID-19 deaths, there

[1] We outline the data used in these calculations in the next section.
[2] On March 13, 2020, the Centers for Medicare and Medicaid recommended that nursing homes to restrict visitors and non-essential personnel (https://www.cms.gov/newsroom/press-releases/cms-announces-new-measures-protect-nursing-home-residents-covid-19). The Kaiser Family Foundation notes that early in the pandemic, 27 states banned visitors and 22 states recommended that nursing homes ban visitors. Two states provided no guidance (https://www.kff.org/report-section/state-data-and-policy-actions-to-address-coronavirus-maps-and-data/).
[3] NYT (https://www.nytimes.com/2020/06/08/opinion/coronavirus-elderly-suicide.html), AARP (https://www.aarp.org/caregiving/health/info-2020/covid-isolation-killing-nursing-home-residents.html), KFF(https://khn.org/news/for-seniors-covid-19-sets-off-a-pandemic-of-despair/)

has been a dramatic increase in non-COVID deaths among seniors. While all seniors do not live in nursing homes, many of the most fragile do, suggesting that many of these excess deaths may very well occur in nursing homes. For example, excess mortality for Alzheimer's is particularly high. While only 12.5 percent of Alzheimer patients live in nursing homes (Lepore et al., 2017), just under half of nursing home residents have Alzheimer's.[4] In 2018, 50.6 percent of all deaths listing Alzheimer's as an underlying cause occurred in nursing homes.[5] In Figure 2, we report some provisional data through September 26th for excess Alzheimer's deaths as estimated by the CDC. They estimate there are almost 30,000 excess deaths during the pandemic with an Alzheimer's diagnosis, but only 23 percent have a corresponding positive COVID-19 diagnosis, leaving 77 percent of these deaths as not directly related to the disease but to other aspects of the pandemic.

COVID-19 deaths of nursing home patients is heavily influenced by infection and transmission rates in the surrounding community, which varies substantially by region. For example, non-nursing home COVID-19 deaths rates vary from a low of 4 per 100,000 in Vermont to a high of 143 per 100,000 in New York. Yet, community risk alone cannot explain the vast variation in nursing home death rates. Even in the three states mentioned above with the highest death rate, 23 percent of nursing homes with over 100 beds have not experienced a single COVID-19 mortality by the beginning of September. A key research question is then how have some nursing homes been able to effectively protect their residents, while others have not?

In this work, we focus on one particular dimension of the problem: nursing home quality. Starting in 2008, the Centers for Medicare and Medicaid (CMS) began providing a "five star" rating of nursing home quality based on three elements: health inspection results, staff-to-resident ratios, and quality metrics such as rates of falls and bed sores, with the first element having the greatest

[4] https://www.cdc.gov/nchs/fastats/alzheimers.htm.
[5] Authors' calculations from CDC Wonder Multiple Cause of Death data.

weight in an "overall" rating, which is also provided. We merge this quality data with data on COVID-19 cases and mortality that is reported weekly by nursing homes to CMS starting the week ending May 24th. In count-data models that control for local risk factors and nursing home characteristics, we find that the inspection ranking is highly predictive of mortality, with five-star homes having 27 percent fewer resident COVID-19 deaths by September 26th than one-star homes. The inspection rating is more correlated with COVID-19 deaths than the overall rating, the latter of which researchers used in earlier work (i.e., using data from early March) to argue that high quality homes were unable to prevent cases (Abrams et al., 2020). In addition to having less predictive power, we provide evidence that the overall quality metric has become more correlated with death over time, rationalizing these disparate findings by suggesting that the virulence of the disease caught all nursing homes by surprise, but that the best homes adjusted with time.

We attempt to identify the mechanisms by which quality nursing homes had lower mortality. First, we show that the chance of having any COVID-19 cases among residents or staff is not explained by nursing home quality, meaning even high-quality homes were unable to prevent COVID-19 from entering their facility. That said, in models that condition on having at least one confirmed case, we show that higher quality nursing homes seem to more successfully prevent the spread of the disease among residents. Unfortunately, we do not have detailed data on the policies and procedures that enabled these establishments to prevent the spread of the disease. We do show that quality homes experience fewer outages in personal protective equipment (PPE) and fewer staff shortages, which may help with patient monitoring and isolation efforts. Furthermore, we show that conditional on quality, homes avoiding PPE outages and staff shortages have fewer COVID-19 deaths.

A likely scenario is that higher quality establishments did a better job at isolating residents both from outside risks from visitors and other residents. This may have come at a cost. When we

change the outcome in the count-data model from COVID-19 deaths to non-COVID deaths, we find that higher-quality nursing homes have much higher non-COVID mortality and that aggregate mortality is not generally impacted by nursing home quality. Moreover, when we conduct this analysis separately for nursing homes in high and low risk counties, as measured by cumulative cases per capita, we find that (i) quality is not consistently associated with non-COVID deaths in high risk counties, (ii) high quality homes have significantly and substantially more non-COVID deaths than low quality homes in low risk counties, and (iii) in low risk counties, aggregate mortality is increasing in nursing home quality.

One possible explanation is that there is incomplete reporting of COVID-19 or strategic use of defining COVID-19 deaths by nursing homes to mitigate the damage to their reputation from the CMS reports. To lessen concerns that our results are driven by these problems, we estimate an additional model for nursing homes with no COVID-19 deaths at the county, meaning risk of infection within a nursing homes is very low. There are roughly 700 nursing homes in this sample and there can be little strategic use of redefining deaths in areas that have no COVID-19 mortality. In these counties, we find that non-COVID deaths are increasing monotonically with nursing home quality and the highest quality establishments have 30 percent more non-COVID deaths than the lowest quality ones.[6]

Given the number of deaths and an early understanding that the elderly die at higher rates, there is surprisingly little research on deaths in nursing homes. As a result, this paper contributes to the literature on COVID-19 along several dimensions. A number of papers have examined the general relationship between CMS five-star ratings and COVID-19 cases and/or deaths in nursing homes but much of this work was either in a single state (Bui et al., 2020; Harrington et al., 2020; He et al.,

[6] We also show that, conditional on nursing home quality, staff shortages and PPE outages do *not* predict non-COVID deaths. One would expect a positive relationship if non-COVID deaths were truly misreported COVID deaths.

2020; Li et al., 2020a) or occurred very early in the pandemic (Abrams et al., 2020). Some studies have used various versions of the CMS data used in this study. Gorges and Konetzka (2020) show that county incidence rates are the strongest predictor of resident mortality and staff levels have modest impacts on the spread of the disease. Li et al. (2020b) document much higher COVID-19 death rates in homes with greater minority patients. Chen et al. (2020) show that contractors that service multiple nursing homes in a local area helped spread the disease. The data from the CDC showing large excess death rates for the elderly and especially Alzheimer's patients has helped put this issue into the public discussion, yet there is little research other than efforts to document the extent of the problem and almost no research on the factors that lead to excess mortality.

Although others have shown higher-quality nursing homes have fewer COVID-19 deaths, our work identifies that this is most likely from reducing the spread of the virus once it enters the homes and it is not due to a home's ability to prevent the entry of the disease. Our paper is the first to establish a negative link between nursing home quality and non-COVID-19 mortality. This latter result is particularly pronounced in areas with low COVID risks. This is not surprising. The initial CMS directives about nursing home operations during COVID-19 recommended prohibiting visitors regardless of the underlying risk. As these nursing homes had little COVID-19 risk to prevent, they assumed many of the negative of the costs. CMS has recently begun to recognize that that these restrictions have taken a toll on residents. In a memo released September 17 outlining revised procedures for nursing homes during the pandemic, CMS notes that "…we recognize that physical separation from family and other loved ones has taken a physical and emotional toll on residents. Residents may feel socially isolated, leading to increased risk for depression, anxiety, and other expressions of distress. Residents living with cognitive impairment or other disabilities may find visitor restrictions and other ongoing changes related to COVID-19 confusing or upsetting."[7]

[7] https://www.cms.gov/files/document/qso-20-39-nh.pdf

In this memo, they outline policies for outdoor visitation and relaxed policies for indoor visitation in lower-risk settings such as counties with low positivity rates in the general population. The goal of reducing COVID-19 risks is laudable but as economists are want to point out, all policies have costs and we have just begin to recognize the costs of these restrictions Our results suggests that efforts to control the spread of the virus may have come at some cost. A more general discussion about reducing COVID-19 risks without disrupting the lives of vulnerable seniors is in order.

II. Data Sources and Reporting Accuracy

There are two primary sources of information about COVID-19 case and mortality incidence at the nursing home level. The first is a weekly data set released by the Centers for Medicare and Medicaid (CMS) that has COVID-19 surveillance information by nursing home. On May 8, 2020, CMS released a final ruling that required nursing homes to report confirmed and suspected COVID-19 cases of residents and staff to both the residents and their representatives. The ruling also required that nursing homes report weekly totals of surveillance items to the Centers for Disease Control (CDC) National Healthcare Safety Network, starting with the week ending May 24, 2020. Reporting was mandatory with $1000 fines issued after four-weeks of non-reporting. Fines increased by $500 per week of non-reporting.[8]

The first weekly file was released by CMS in early June and updates are released on Thursdays, 11 days after the end of the reporting period which is a Monday to Sunday period. The initial release of this data set was in a word, messy. There were obvious key-punch errors and variable were frequently reported in the wrong columns. Subsequent releases of the data corrected many of these recording errors and the most recent releases of the data are now relatively free from these obvious errors. Reporting has always been high. In the first release of the data, 13,965

[8] https://www.cms.gov/files/document/qso-20-29-nh.pdf

nursing homes reported data that passed a quality assurance check. This number increased to 15,215 for the week ending September 13, which is about 98 percent of all nursing homes.

The CMS nursing home data reports weekly and cumulative values for confirmed COVID-19 cases for residents and staff, suspected cases for these two groups, COVID-19 deaths (which includes suspected and confirmed), plus all deaths among residents. All these variables are reported weekly and cumulatively since January 1, 2020. Deaths are for residents regardless of the location, so if a nursing home resident is moved to a hospital and dies there, the deaths is counted as a nursing home resident death. The survey asks nursing homes if they have shortages of key staff including nursing staff, clinical staff, and aids, and whether they have adequate supplies of specific personal protective equipment (PPE) such as N95 masks, surgical masks, gowns, etc.

A second source of data are state COVID-19 dashboards. Each state has a frequently-updated web page that provide detailed information about the progression of the pandemic in their state. The data provided varies across states, with some reporting information on nursing homes and others not. Once CMS began releasing their data, some states dropped their nursing home reports. We checked all state COVID-19 dashboards starting at noon on Monday, September 14 and found 33 states that reported data on nursing home mortality. In many cases, the states report only nursing home deaths (e.g., AZ, MI, ME), some report these totals combined with assisted living centers (e.g., NJ, IL, IN, VA, MN, WA), and some report these two groups separately (e.g., CA, NY, FL, MA, PA, RI, TX). We collected data on what they report as nursing home deaths, regardless of whether they include assisted living. In general, assisted living deaths are a minority of deaths. In two hard-hit states, NY and PA, assisted living deaths are only 2 and 10 percent of combined fatalities of the two groups.

COVID-19 nursing home mortality from these two sources is reported in Table 1. We report data as of September 13 from both sources. In the top third of the table, we report data from

the 33 states that report nursing home COVID-19 mortality on their dashboard. In the first column, we report all COVID-19 deaths as reported on state webpages, in the second, what states are reporting on dashboards, and in the third, death counts in the CMS data. The states reporting nursing home data on web pages report 68,180 COVID-19 nursing homes deaths, which is 39 percent of all COVID-19 deaths. The number of deaths as reported by CMS is 33 percent lower than what states are reporting. The differences in reporting a driven primarily by a lack of reported deaths in high count states. In Figure 3, we plot the 33 observations with data from both sources with the counts from state web pages on the x axis and counts from CMS on the y axis. Most states lie along the 45 degree line with the undercount in the CMS data greatest for the 6 states with the highest counts of deaths: NY, NJ, MA, PA, FL and IL.

The undercount appears to be driven by differences in what nursing homes are reporting to the two entities rather than response rates, as the response rate is rather high for the CMS data. These six states account for 72 percent of the undercount. One explanation for this undercount in the CMS data is that at the time of the first report (May 24), CMS allowed nursing homes the choice to report cases and deaths from the prior week *or* cumulative cases and deaths since January 1. Thereafter, homes report weekly counts and a cumulative count is calculated by CMS; thus, if a home fails to report the cumulative count since January 1 on May 24, the cumulative count that CMS calculates in future weeks is incorrect. It is clear from the abundance of cases and deaths reported in the first week, particularly from nursing homes located in areas hit hard by the virus that most nursing homes chose to report cumulative figures; however, some surely did not.

To demonstrate this point, we matched nursing homes that reported to both the May 24th and September 19th CMS surveys to nursing homes listed by the state of New York to their May 25th and September 14th reports of COVID-19 deaths among residents. We matched 372 nursing homes which represents 93.2 percent of deaths in the New York data at the later date and 94.4 percent of

deaths in the CMS data for the week ending September 13. In Figure 4, we report a scatter plot of cumulative counts as of September 13th for nursing homes with 10 or more deaths in the New York data. We restrict the sample to these nursing homes as this makes the data easier to see. This is 192 nursing homes. Circles of larger size represent multiple establishments reporting the same pair of numbers. There is a pronounced undercount in the data with 64 percent below the 45 degree line, 34 percent above the line and only 2 percent on the line. The total deaths in the state data in this limited sample are 50 percent larger than the CMS counts which is consistent with the notion outlined above that many nursing homes were reporting weekly counts for the first CMS survey.

We address this potential source of measurement error later in our robustness analysis, where we re-estimate our main model using cases and deaths since May 24. The change in deaths from these two dates appears to be more accurately reported across the two samples. In Figure 4, we report the scatter plot of the difference in counts between September 13th and May 24th for the sample reported in Figure 4. Larger circles are multiple nursing homes with the same set of couts. Here the points are more evenly spaces across the 45 degree line with 21 percent below, 34 percent above and 45 percent on the line. This last number is driven by the fact that 32 percent of these establishments report no more deaths between May 24th and September 13th in both data sets. The average change in deaths in this sample is now 17 percent higher in the CMS data, possibly reflecting the fact that New York nursing homes are only required to report the death of residents from COVID-19 that occur within the nursing home and not in hospitals, etc.

In the last third of Table 1, we report aggregate data for the nation. We assume that the degree of undercount is the same in the 18 states not reporting on their state web pages as in the 27 states that are not the 6 largest death count states from Figure 3 and estimate total nursing home deaths in the nation to be 73,949. The numbers in this row suggest that COVID-19 nursing home deaths are between 29 and 39 percent of aggregate mortality. Given the systematic undercount of

deaths in the CMS data, we believe the actual fraction of COVID-19 deaths in nursing homes is closer to the larger rather than the smaller number.

The staggering consequences of the pandemic for nursing home residents can be seen when we calculate COVID-19 death rates for nursing home residents and compare to the general population. The death rate (per 100,000 people) for non-nursing home residents is roughly 41. Dividing the imputed numbers by the nursing home residents alive at the beginning of the year,[9] the death rate for nursing home residents is about 5700, or about 140 times then rate for the general population. We calculate that the COVID-19 death rate for people 65 and over living outside of nursing homes is 208,[10] meaning this nursing home death rate is at least 25 times this number.[11]

III. Heterogeneity Across Nursing Homes in COVID-19 Mortality

There is tremendous variation across states in the severity with which the pandemic struck nursing homes. In Figure 6, we graph deaths of nursing home residents from COVID-19 (deaths per 100,000) by state using the CMS data as of September 13. By using CMS data, we are potentially under-reporting deaths by 33 percent, most notably in states with the highest death rate but these at least give a ranking using the same samples for all states. We define the denominator as occupied beds at that time plus the total number of deaths that have occurred up to that point in the year.

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[9] The CMS data indicates there are 1.1 million nursing home residents as of September 12 and there were about 200,000 deaths for all causes in nursing homes since the beginning of the year. Adding these two numbers together gives us roughly 1.3 million nursing home residents at the beginning of the year.

[10] Census estimates a US population of 328.2 million in 2019 including 54 million people 65 and older (https://data.census.gov/cedsci/table?q=United%20States&tid=ACSDP1Y2019.DP05&hidePreview=false). One estimate suggests 15.5 percent of the nursing home population is under 65 (https://health.usnews.com/health-news/best-nursing-homes/articles/nursing-home-facts-and-statistics#:~:text=This%20means%2015.5%25%20of%20the,a%20surgical%20procedure%20or%20injury), leaving 1.1 million 65 and over in nursing homes and 52.9 million people aged 65 or over outside of nursing homes. The CDC estimates that by September 19, the deaths of the elderly outside of nursing homes totaled 110,163, leaving a death rate for the out if nursing home population at 208.

[11] The non-nursing home death rate for people 65 and over is likely overstated as the CDC reports place of death (e.g., hospital, at home, nursing home) so the counts for people outside nursing homes in places like hospitals, emergency rooms and hospice facilities would include some nursing home residents as well.

This population number is roughly the number of people in a nursing home on January 1, 2020. The crisis is heavily concentrated in a small handful of states. In ten states, more than five percent of the nursing home population has died, while in 3 states, more than 8 percent are dead. The top 15 states represent 35 percent of the nursing home population but half of all COVID-19 nursing home deaths.

The risk nursing home residents face from the disease is strongly correlated to the underlying risk in their state. In Figure 7, we graph the non-nursing home COVID-19 death rate at the state level versus the same value for nursing home residents. The correlation coefficient between the two series is 0.78. The outlying observation in the bottom right section of the figure represents New York, which we showed above underreports deaths in the CMS data. If New York is removed from this analysis, the correlation coefficient increases to 0.87.

Despite the strong correlation between underlying risk and nursing home deaths, many nursing homes successfully avoid high death rates, even in the hardest hit areas. In Figure 8, we show the COVID-19 death rate distribution in nursing homes that have more than 100 beds and are located in counties in the top 10^{th} percentile for total COVID-19 deaths. The top panel shows that by May 24, just under 60 percent of nursing homes in these areas observe fewer that one COVID-19 death per 50 beds. By September 13, this figure is still in excess of 30 percent. Moreover, a disproportionately small share of nursing homes account for the majority of COVID-19 deaths. As of September 13, the top 5 (1) percent of nursing homes, which is just 754 (151) homes or 8.2 (2.3) percent of the nation's beds, accounts for 40 (14) percent of all COVID-19 deaths in nursing homes.

IV. Analysis Sample

The goal of this project is to explore whether observed nursing home characteristics can explain low COVID-19 death rates in high risk areas. In particular, we test whether high-quality nursing homes, as measured by the CMS five-star ratings, did a better job of preventing deaths from COVID-19. Our initial sample contains all 15,066 nursing homes reporting data to CMS on September 13. Summary statistics for these data are shown in column 1 of Table 2.

Several variables require explanation. Data on nursing home characteristics comes from Long-term Care: Facts on Care in the US, a research center at Brown University that provides data on nursing home care in the US.[12] Sample statistics are reported for observations with non-missing data. The acuity index ranges from zero to 23 in the data and is a measure of the amount of care needed by the average nursing home residents (higher values suggest more care). For the three variables share of residents using Medicaid, acuity index, and for-profit status, the data contains values for all or none of them.

Nursing home star ratings come from a separate CMS source. There are three separate ratings – inspection, quality measures (QM), and staffing – which are aggregated by CMS into an overall rating. All three ratings, as well as the overall rating, measure quality in integer "star" values, where 5-star is the best possible rating and 1-star is the worst. The inspection rating is based on results from the home's three most recent state health inspections in a three-year period, with more weight given to the most recent inspections, as well as investigations stemming from formal complaints. The QM rating is based on a home's self-reported ability to manage and prevent certain negative health outcomes (e.g., bed sores, ED visits, chronic pain, major injuries resulting from falls, urinary tract infections, etc.). The staff rating is a function of the reported number of registered

[12] More information can be found at http:// http://ltcfocus.org/.

nurses and total staffing hours relative to the number of residents. As the inspection rating is the only measure calculated from data that is not self-reported, it is viewed as the most objective and, thus, is given greater weight in the calculation of the overall star rating (Williams et al. 2010). More details, as well as the method for calculating the overall rating, can be seen here.

All case and death measures should be interpreted as cumulative, since January 1, 2020. Resident and staff case variables measure the sum of confirmed and suspected cases reported to CMS. Nursing homes report both total deaths (from any cause) and COVID-19 deaths each week, which allows us to calculate deaths not from COVID-19.[13] Note that case (and death) rates are calculated as (cases/total beds)*50, meaning rates are biased toward zero when nursing homes with fewer than 50 beds are included, as in Column 1. County-level COVID-19 cases and death totals comes from the CDC.

In Table 2, we present nursing home characteristics and relevant COVID-19 summary statistics for nursing homes with different inspection star ratings.[14] Compared to residents at lower quality homes, high quality home residents are younger and are more likely to be white and female. The homes also have fewer beds, are less likely to be for-profit and have a smaller share of Medicaid residents. Regarding COVID-19, high quality homes have lower resident case rates, but higher staff case rates. Moreover, these homes have notably smaller COVID-19 death rates, but higher non-COVID death rates. On average, higher quality homes have experienced fewer staff shortages and

[13] CMS memo QSO-20-29-NH instructs homes are to report all deaths regardless of location (e.g., in the home or in a hospital). The module instructions (CDC 57.144) define a COVID-19 death as "a resident with suspected or a positive COVID-19 test result who died in the facility or another location as a result of COVID-19 related complications." The instructions state the following regarding the reporting of marginal COVID-19 deaths: (i) suspected deaths are those that are being managed for COVID-19 symptoms, but do not have a positive test, and these symptoms play a role in their death; (ii) someone without a positive test or symptoms who dies from complications associated with COVID-19 and later has COVID-19 diagnosed in autopsy, should be coded (retrospectively) as a COVID-19 death; (iii) someone previously diagnosed or suspected to be COVID-19 positive, who dies after recovery should *not* be counted as a COVID-19 death.

[14] We also conduct analysis on the sample of nursing homes reporting data to CMS on May 24. Summary statistics for this sample are presented in Table 1A of the appendix.

PPE outages than lower quality homes since May 24. High quality homes also seem to conduct more COVID-19 tests.

V. Model and results

We estimate the effect of nursing home quality on the total number of nursing home deaths due to COVID-19 using a negative binomial model. That is, we write the probability of nursing home i having COVID-19 deaths Y_i as

$$\Pr(Y_i) = \frac{\Gamma(Y_i + \gamma_i)}{\Gamma(Y_i + 1)\Gamma(\gamma_i)}\left(\frac{\theta}{1+\theta}\right)^{Y_i}\left(\frac{1}{1+\theta}\right)^{\gamma_i} \quad (1)$$

where $\Gamma(\cdot)$ is a gamma function and γ_i and θ are the shape and scale parameters, respectively, of a gamma distribution. We allow γ_i to vary with nursing home and county characteristics, X_i, such that $\ln(\gamma_i) = X_i\beta$. The parameters (θ, β) are estimated via maximum likelihood. All models include state fixed effects and standard errors are clustered at the state level.

We are primarily interested in the impact that nursing home quality has on COVID-19 deaths; however, we also control for the following: (logged) total number of beds, percent female, percent under 65 years old, percent black, percent Hispanic, percent on Medicaid, whether for or not for profit, acuity index,[15] (logged) county population, and county COVID-19 cases per 1,000 residents.[16]

VI. Results

As discussed above, nursing homes are rated using 3 metrics (home inspection, QM, and staff), as well as an aggregate (overall) metric, each of which is measured on a 1-5 scale – 5 indicating

[15] Nursing home characteristics are missing for some homes; thus, we include indicators for whether these variables are missing.

[16] County-level COVID-19 cases are included as a measure of the intensity of the virus locally. As death occurs on average 18.5 days after symptom onset (Zhou et al. 2020) and the incubation period is 4-5 days on average (CDC), we measure cases 23 days prior to death. All models are robust to controlling for the non-nursing home death rate, as measured on September 13, rather than the case rate.

high quality. We estimate equation (1) four times, one for each quality metric. Parameter estimates are presented in Table 4. In the top third of the table, we report resu;ts as of May 24th and in the middle third, we report results as of September 13th.

Our results show that higher quality nursing homes have experienced fewer deaths from COVID-19; however, this relationship is highly dependent on the quality metric used. The QM rating, which is determined using data that is self-reported by nursing homes, has no impact on COVID-19 deaths at either point in time. The staff rating, which is also determined via self-reported data, yields mixed results. Relative to 1-star homes, 2-star homes have significantly *more* COVID-19 deaths, while 5-star homes have significant fewer. This last results grew considerably as the pandemic aged. The inspection rating is strongly associated with lower death counts with a high degree of statistical precision. For example, nursing homes with a 5-star inspection rating have a COVID-19 death rate that is 26.7 percent lower than those with a 1-star inspection rating as of September 13th. As the overall rating is an agglomeration of the three sub-categories, it is not surprising that it is negatively associated with COVID-19 deaths, but less-so than the inspection rating.[17]

We discuss above that the CMS data likely under counts the true number of COVID-19 deaths in nursing homes, as homes were given the choice on May 24 to report deaths from the prior week or cumulative deaths since January 1. To show that our results are not somehow driven by this measurement error, we conduct two robustness tests. In our second robustness test, we change the dependent variable to deaths since May 24, which should be measured accurately in the CMS data. The quality effects are presented in the final third of Table 4. Again, these results are similar to our main findings, though nearly all quality effects are notably larger. For example, we estimate that

[17] Across the four specifications, we find that homes with more beds, larger black populations, and located in larger cities with higher case rates have more COVID-19 deaths, while homes with younger populations have fewer deaths. We also find that for-profit homes have significantly more deaths.

homes with a 5-star inspection rating have had 38 percent fewer COVID-19 deaths since May 24 than observationally similar 1-star homes. Using cumulative deaths, this difference was 28.3 percent.

In a second test, we re-estimate our model without nursing homes located in the six states with the most substantial measurement error, as detailed in Figure 3 (NY, NJ, PA, MA, FL, IL). The estimated quality effects are qualitatively similiar, though the impact of the overall rating and inspection rating is somewhat smaller, while the impact of the staff rating is larger.

The weak results in the May 24th sample may explain why some early research on the relationship between nursing home quality and COVID-19 incidence found no relationship (Abrams et al. 2020). Abrams and coauthors estimate the relationship between a nursing home's overall star rating and the probability of any COVID-19 *case* (as well as outbreak size) as of May 11. Our results suggest that the impact of quality has likely grown over time and that the inspection rating is more predictive of deaths than the overall rating.

Both results are sensible. The fact that the virus was unexpected and unprecedented likely explains why high-quality homes could not prevent infections early in the pandemic but learned to do so with time.[18] Moreover, there is an abundance of evidence to suggest that the inspection rating is the most objective of the three, in fact CMS weighs it most heavily when calculating the overall rating for this very reason (Williams et al. 2010). Fuller et al. (2019) show that the overall rating is not associated with lower emergency department visits or hospital admissions. Neuman et al. (2014) study the ratings separately and show that only the inspection rating is statistically associated with a lower likelihood of hospital readmission and death. Çalikoglu et al. (2011) show that family satisfaction is positively correlated with the inspection and staff rating, but not the QM rating. Perraillon et al. (2017) suggest that the QM and staff ratings, which are calculated from information reported by nursing homes, are easily manipulated.

[18] In more recent research, XXX

VII. Mechanisms

How did high quality nursing homes managed to prevent COVID-19 deaths? The CDC first offered nursing homes and assisted living facilities guidelines for preventing and managing COVID-19 cases on May 13. Since then, these guidelines have been updated and expanded repeatedly as the public health community has learned more about the virus. The CDCs advice is expansive but is linked by several common themes: First, keep COVID-19 out by limiting visitors and encouraging staff to stay home when ill. Second, clean hands, surfaces, and equipment thoroughly and repeatedly. Third, staff should closely monitor residents for signs of the virus, test symptomatic individuals and close contacts, and isolate those who are symptomatic. Fourth, staff should use personal protective equipment (PPE) at all times.

These recommendations guide our exploration of the potential mechanisms that enabled higher quality nursing homes to prevent COVID-19 deaths. First, we examine whether higher quality nursing homes were better able to prevent COVID-19 from entering the home at all. In Table 5 we report results from linear probability models that regress an indicator of whether a home has a single COVID-19 case among its staff (column 1) or among its residents (column 3) on the home's 5-star inspection rating and the same set of covariates from our earlier analysis. These results show that higher quality nursing homes, despite lowering the death rate, were not able to prevent COVID-19 from entering the home. Second, we test whether higher quality nursing homes were able to prevent the spread of the virus, conditional on having at least one case. In columns 2 (4) of Table 5, we report estimates from a linear regression of log staff (resident) cases on inspection rating and covariates, only for homes with at least one staff (resident) case. The results show that while high quality nursing homes were not effective in preventing the spread of COVID-19 among their staff (if anything, they may have experienced more staff cases); however, these homes were effective

at preventing the virus' spread among their residents – e.g., conditional on having at least one case, all else equal 5-star homes saw roughly 17 percent fewer cases than 1-star homes. As of September 13, the average home in this sample has 13.4 cases per 50 beds, meaning this difference amounts to about 2.3 cases per 50 beds.

If high quality nursing homes prevented deaths not by keeping COVID-19 out of the nursing home entirely, but by preventing its spread within the home, the next obvious question is: how? We test several plausible theories. First, both identifying and isolating residents with COVID-19 symptoms requires a capable staff that is of an adequate size; thus, we first test whether high quality nursing homes have had fewer staffing shortages during the pandemic, which may explain their ability to prevent COVID-19 cases among their residents. In Panel A of Table 6, we present results from three linear probability models that regress indicators for self-reported staffing shortages (nurses, aides, and clinical staff) at any point between May 24 and September 13 on 5-star inspection rating and other controls. Row 1 shows that, all else equal, 5-star facilities were 5.8 percentage points less likely to have a nursing shortage over this time period than a 1-star facility. The gap is 7 percentage points for aides (row 2). For clinical staff (row 3), 1-star facilities seem to have more shortages, but the effect is small and not always statistically distinguishable from zero.

Nursing homes may also prevent the spread of COVID-19 by following the CDC recommendation that all nursing home staff use PPE and wash their hands frequently. While these behaviors cannot be observed in our data, we are able to measure shortages in PPE (n95 masks, surgical masks, eye protection, gowns, gloves) and hand sanitizer; thus, we test whether higher quality facilities were less likely to have experienced such shortages between May 24 and September 13. We again use linear probability models and control for the same set of potential confounders. Results are presented in Panel B of Table 6. For all five forms of PPE and hand sanitizer, we find that the likelihood of a shortage is falling monotonically in nursing home quality.

Finally, we test whether higher quality homes simply do a better job of testing residents for the virus. In particular, the CMS data allows us to generate four measures of testing intensity and speed. First, nursing homes report for the week ending September 13 that receiving test results takes "less than a day", "between one and two days", "three to seven days", or "more than seven days." Second, nursing homes report whether they tested any asymptomatic residents during the week ending September 13 *in response to* a new positive case.[19] Third, homes report whether they have *ever* tested asymptomatic residents when there is no knowledge of exposure. Finally, homes report whether they have their own testing machine.

In Panel C of Table 6, we present estimates of the effect of nursing home quality on these testing measures. Results are mixed. 3- and 4-star homes seem to receive test results faster than 1-star homes (row 1), though these effects are not precisely estimated (p-values of 0.098 and 0.054, respectively). Higher quality homes are not statistically more likely to test asymptomatic residents following a new case (row 2); however, they are generally more likely to have ever tested asymptomatic residents without knowledge of exposure. Finally, 2-5 star homes are between 1.6 and 2.9 percentage points more likely than 1-star homes have their own testing machine, but these effects are only significant at the 5 percent level for 2- and 3-star homes.

Overall, these results are quite sensible. Higher quality nursing homes prevent COVID-19 deaths, not by preventing the disease from entering the home, but by preventing its spread. Moreover, the methods by which they prevent the spread are consistent with CDC guidelines. High quality homes have significantly fewer staff shortages and PPE outages. We also provide some evidence that higher quality facilities get test results quicker, potentially because they have their own

[19] Note that nursing homes can only report such testing if a new positive case arises; thus, we condition our analysis on facilities with a new positive case, as higher quality facilities have already been shown to have fewer positive cases.

testing machines, and are more likely to test non-exposed asymptomatic residents, though these relationships are less precisely estimated.

Finally, in an effort to understand exactly how much of the inverse relationship between COVID-19 deaths and nursing home quality is explained by higher quality nursing homes avoiding staff and PPE shortages, we return to our baseline model, but add controls for shortages. In particular, among the nine staff and PPE measures, we calculate for each nursing home the number of shortages experienced between May 24 and September 13 (e.g., if a home experienced a nursing shortage and n95 mask shortage over this period, we would measure their total as 2). Results can be found in Column 1 of Table 7. First, note that for each additional shortage reported, the nursing home's COVID-19 death rate increases by XXX percent. Second, compared to the second column in Table XXX 9_13 XXX, the estimated quality effects are XX-XX percent smaller, suggesting that in addition to avoiding staff and PPE shortages, high quality nursing homes are taking other precautions to prevent the spread of the virus.

VIII. Isolation and Non-Covid Deaths

In addition to PPE use, adequate staffing, and robust testing, a prevention method used by virtually all nursing homes was to refuse all outside visitors. On March 13, the CDC issued memorandum QSO-20-14-NH recommending that all facilities nationwide "should restrict visitation of all visitors and non-essential health care personnel, except for certain compassionate care situations, such as an end-of-life situation." The memorandum also advised cancelling "communal dining and all group activities, such as internal and external group activities." On May 18, the CDC issued memorandum QSO-20-30-NH, which provided a three-phase reopening plan for nursing homes. The plan did not allow for outside visitors until a nursing home entered phase three, which

(loosely) requires (i) that COVID-19 cases in the outside community have declined for 14 consecutive days, (ii) no new cases within the nursing home for 28 days, (iii) no staff or PPE shortages, and (iv) homes have the capacity and supplies to test residents and staff weekly. In light of the continued spread of the virus and the strict reopening criteria, many nursing homes are still closed to visitors months later.

An unfortunate downside of these guidelines is that residents have experienced extreme isolation. In the introduction, we used data on excess deaths among the over 65 population and among individuals with Alzheimer's to argue that this isolation may be deadly. Thus, we now aim to test whether high-quality nursing homes, in their efforts to prevent the spread of COVID-19, also managed the non-COVID risks created by isolation.

In particular, we estimate equation (1) above, but with non-COVID deaths as our dependent variable. As the early guidelines treated all nursing homes alike, our initial analysis includes all nursing homes in the US with more than 50 beds. In Table 8 (column 1 panel A) we first show, for this sample, that the nursing home inspection rating is negatively associated with COVID-19 deaths. In Panel B, we show that homes with a higher inspection rating experienced significantly *more* non-COVID deaths. In other words, high quality homes, who presumably did the best job of following CDC guidelines, were successful in their efforts to prevent COVID-19 deaths, but in doing so, saw significantly more non-COVID deaths than low quality homes.[20] In Panel C, we show that the impact of inspection ratings on *total* deaths is typically positive, but is only statistically different from zero for the 4-star home.[21]

[20] Non-COVID deaths may be measured with error for the same reason as COVID-19 deaths. Thus, in Appendix table XXX, we show that this result is robust to (i) dropping the 6 states with the most substantial measurement error (i.e., NY, NJ, PA, MA, IL, FL) and (ii) measuring non-COVID deaths since May 24.

[21] A full set of results is available upon request. Note, these estimates suggest that a 5-star home saw 23.3 percent fewer COVID-19 deaths than a 1-star home. As the mean number of COVID-19 deaths in this sample is 3.96, this amounts to 0.92 COVID-19 deaths prevented. The same 5-star home saw 10.7 percent more non-COVID deaths than a 1-star home. The mean number of non-COVID deaths is 11.09, meaning 5-star homes had 1.2 additional non-COVID deaths on average. This explains why the parameter estimates in Panel C are positive.

In Columns 2 and 3 of Table 8, we repeat our analysis, but divide the sample by the number of COVID-19 cases per 1,000 residents in the county where the nursing home is located. Column 2 contains results for nursing homes in counties with a COVID-19 case rate that is greater than the population median – i.e., high risk counties. Panels A and B show that high quality nursing homes in these counties managed to lower the number of COVID-19 deaths, while only experiencing significantly more (at the 5% level) non-COVID deaths in 4-star homes. The total death rate, however, is not associated with nursing home quality. Column 3 shows results for nursing homes located in counties with a COVID-19 rate below the population median – i.e., low risk counties. In these counties, high-quality nursing homes do not experienced fewer COVID-19 deaths. Meanwhile, high-quality nursing homes saw significantly more non-COVID deaths than their low-quality counterparts. For example, 5-star homes saw 20.8 percent more non-COVID deaths than 1-star homes, which amounts to 2.4 additional deaths at the sample mean. Overall, high quality homes saw substantially more *total* deaths in these counties (Panel C).

We estimate several auxiliary models to address concerns that higher quality nursing homes may intentionally misreport COVID-19 deaths as non-COVID deaths in an effort to protect their reputation. In the final column of Table 8, we limit the sample to the 700 nursing homes in counties with zero COVID-19 deaths as of September 13. As COVID-19 has yet to spread to these counties, it is highly unlikely that the reported non-COVID deaths are indeed misreported COVID-19 deaths. That said, the positive relationship is only significant for 5-star homes, partly because there are so few areas that have not been affected by the virus by September 13. Thus, in Column 5 (not in the paper yet), we repeat this analysis, using deaths reported by July 26. At this time, there were still 1,030 nursing homes located in counties with zero COVID-19 deaths. These results show non-COVID deaths are increasing monotonically in nursing home quality.

Finally, if it were the case that non-COVID deaths were truly misreported COVID-19 deaths, we would expect homes experiencing more staff and PPE shortages to also have more non-COVID deaths. Similar to the analysis above, we thus re-estimate our non-COVID death model, controlling for the number of staff and PPE shortages experienced between May 24 and September 13. Results are presented in Column 4 of Table 7. Here, we find that shortages have no impact on non-COVID deaths and the impact of quality on non-COVID deaths is unaffected by the inclusion of this variable.

IV. Conclusion

These findings are sobering. While high quality nursing homes have successfully prevented the spread of COVID-19 and deaths caused by COVID-19, their efforts have come at a cost. High quality nursing homes have also witnessed significantly more deaths not associated to COVID-19. Our hypothesis is that the latter represent deaths of loneliness – i.e., that these homes exposed their residents to severe isolation in an attempt to prevent infection, subsequently leading to deaths by other causes. Our findings also suggest that many of these non-COVID-19 deaths may have been avoided with more nuanced guidelines, as the relationship between nursing home quality and deaths not from COVID-19 is driven almost entirely by homes in low-risk areas.[22] Were isolation guidelines more closely aligned with infection rates at the local level, nursing homes facing little COVID-19 risk would have avoided exposing their residents to extreme isolation.

[22] It is possible that isolation would have also significantly increased mortality in high risk areas were it not for harvesting – i.e., the most fragile patients, who are the most susceptible to death by loneliness, are also the most likely to died upon contracting COVID-19.

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Figure 1
Deaths by Week for Ages 65 and Over, Average of 2017-2019 and 2020,
Provisional Data, CDC

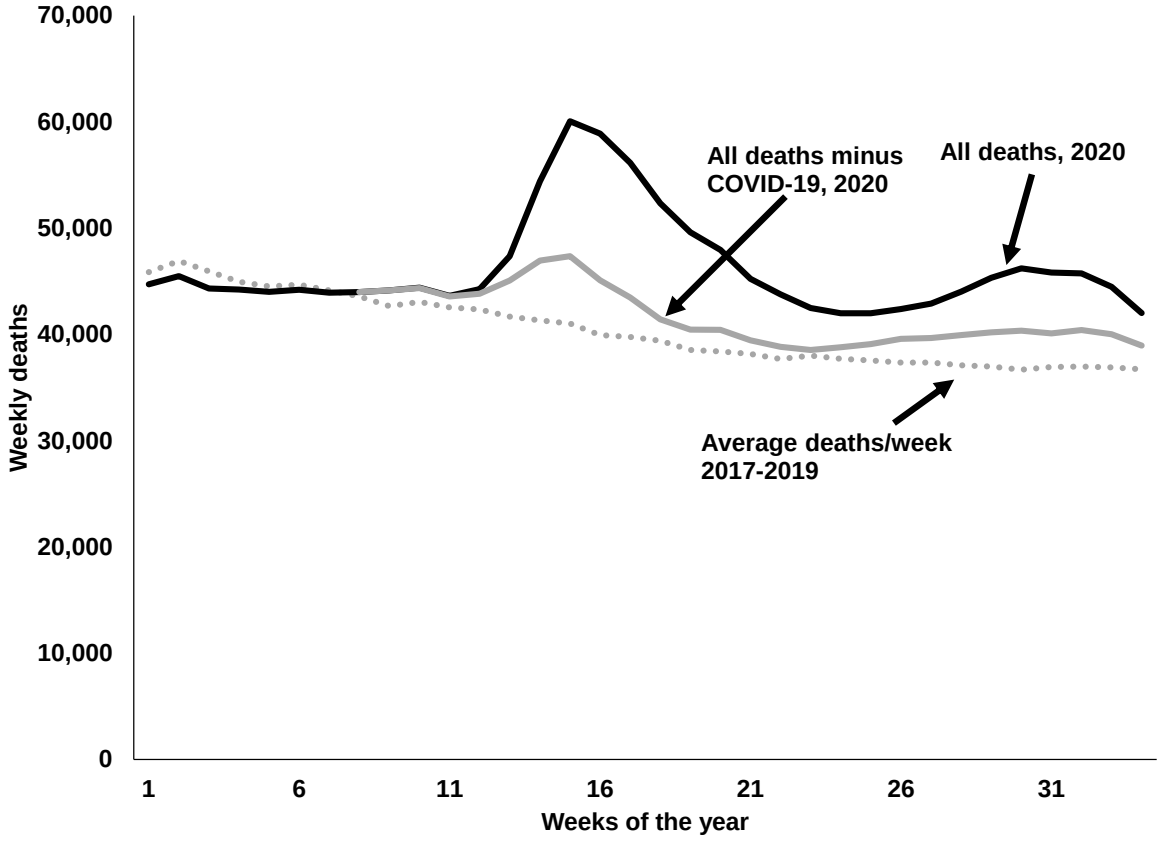


Figure 2
CDC Provisional Estimates of Excess Deaths Among Alzheimer's Patients,
With and Without a COVID-19 Diagnosis, Through September 26, 2020

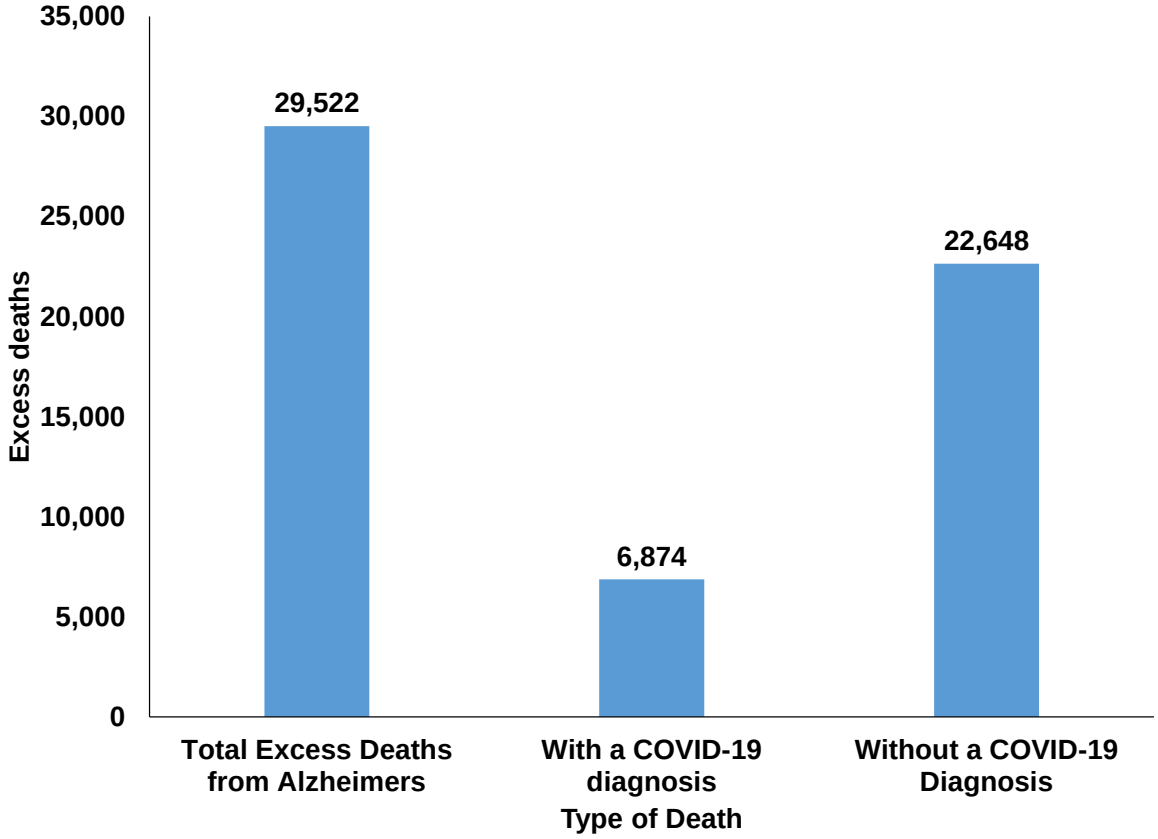


Figure 3
Counts of COVID-19 Deaths in Nursing Homes for 33 States,
From States Reports and CMS Data, As of September 13, 2020

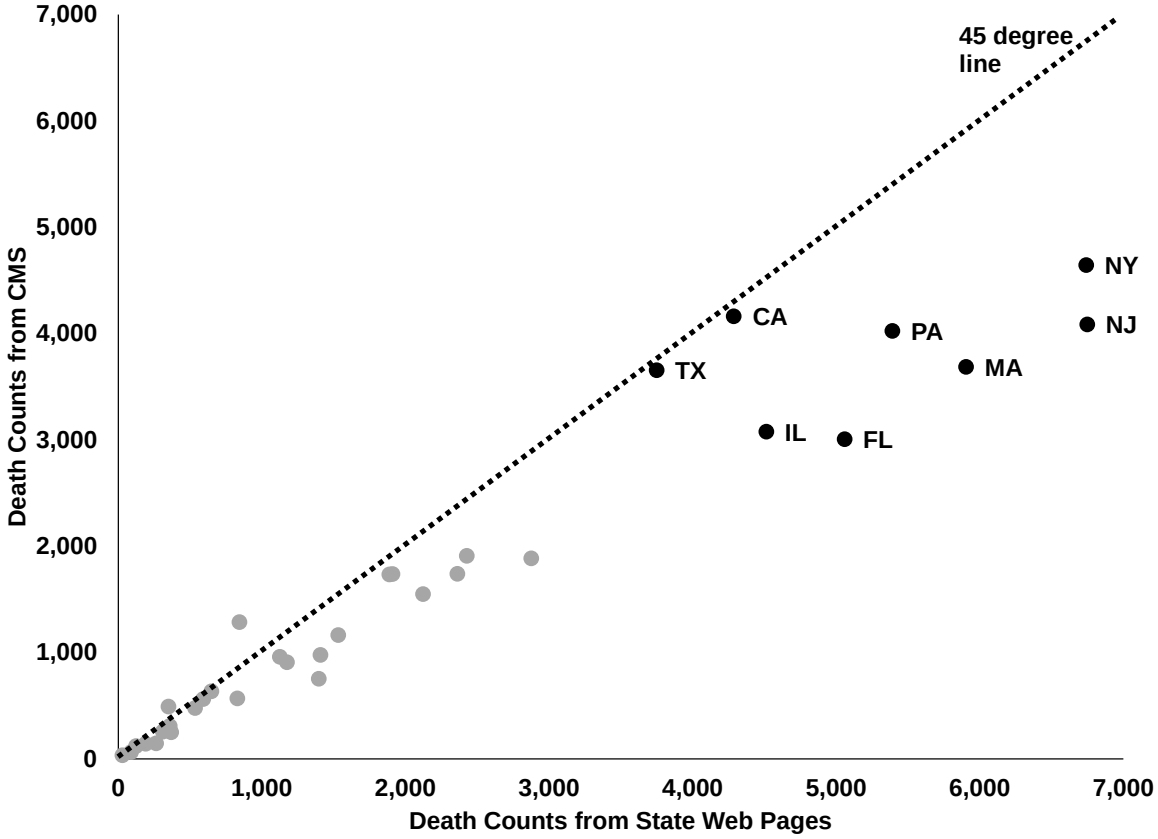


Figure 4
Scatter Plot of Cumulative Deaths in Nursing Homes as of September 13th
from New York and CMS Data

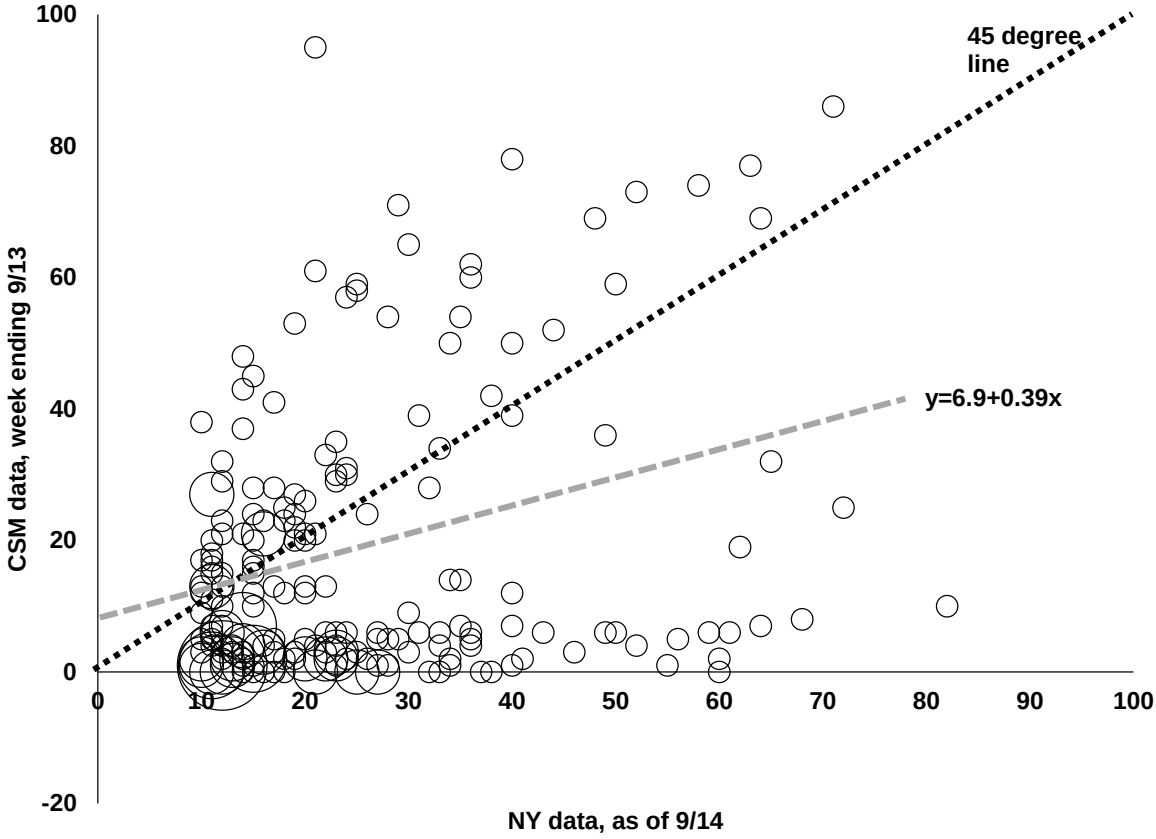


Figure 5
Scatter Plot of Change in Deaths in Nursing Homes Between May 24th and September 13th
from New York and CMS Data

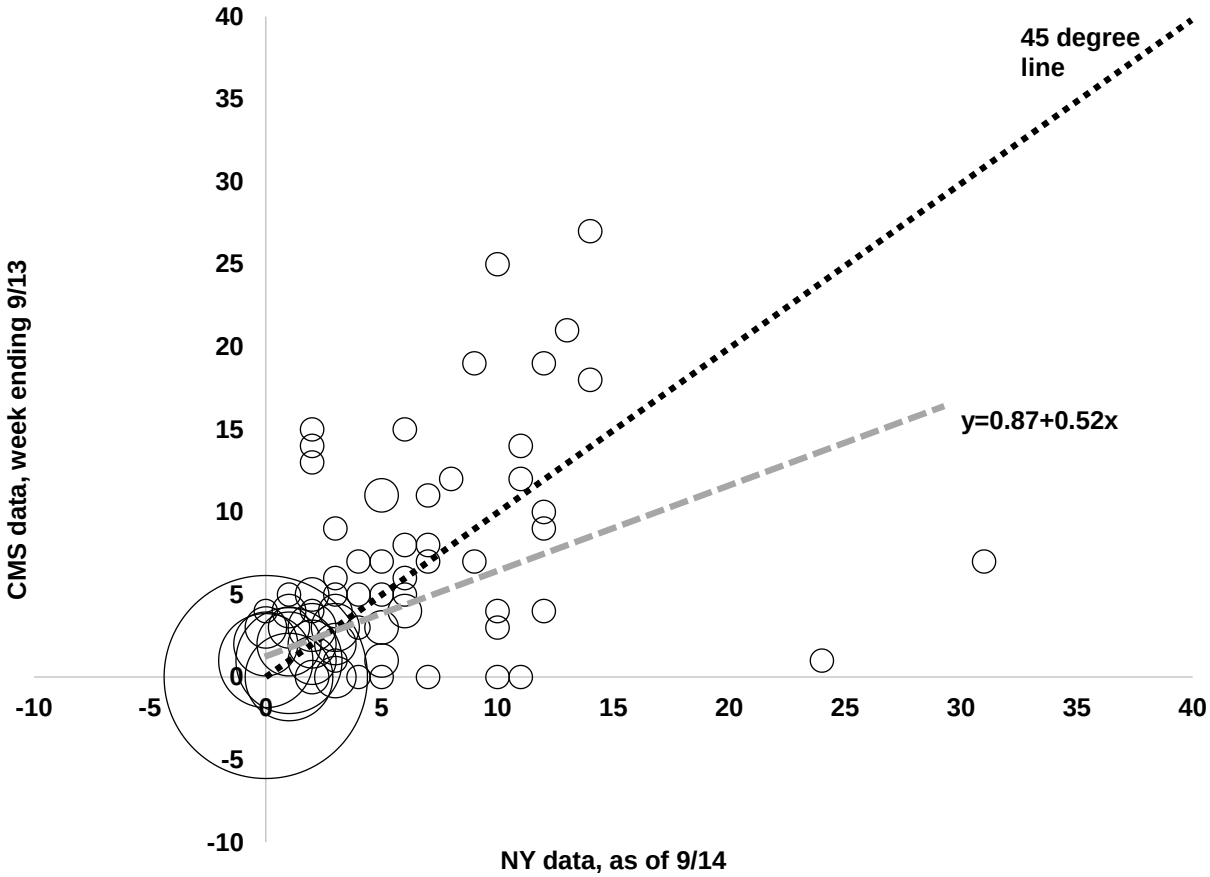


Figure 6
Nursing Home COVID-19 Deaths per 100,000 Residents, CMS Data as of September 13, 2020

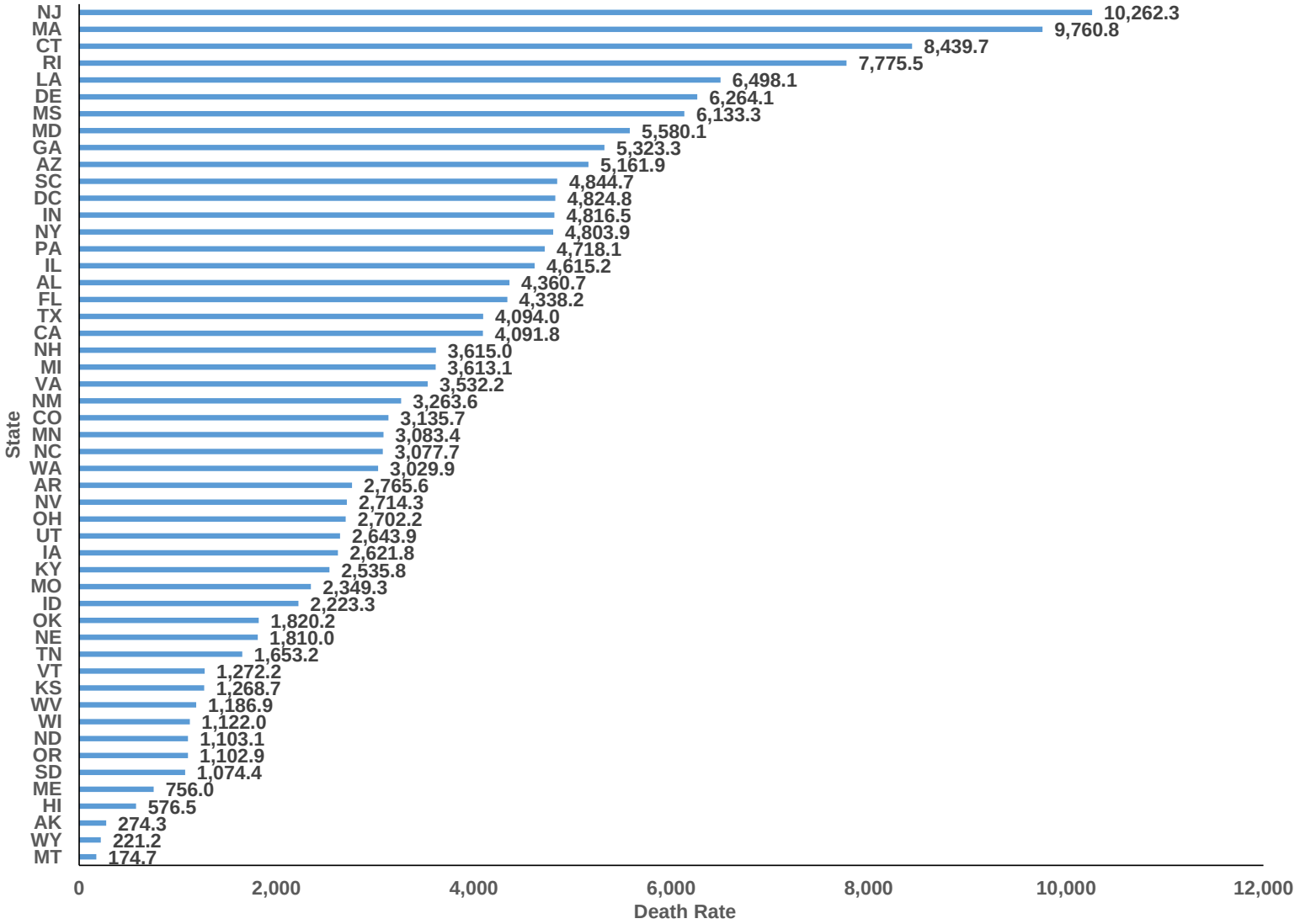


Figure 7
Scatter Plot, Non-Nursing Home COVID-19 Death Rate vs.
Nursing Home COVID-19 Death Rate, As of September 13, 2020

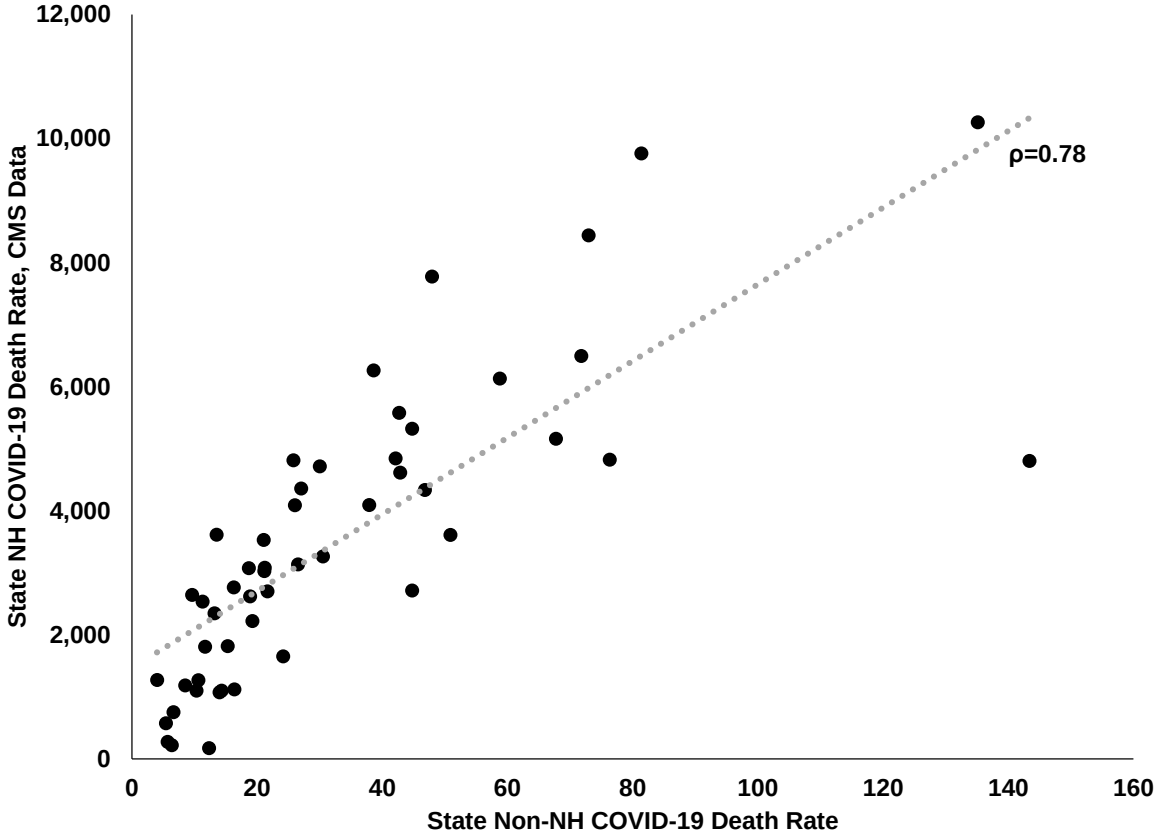
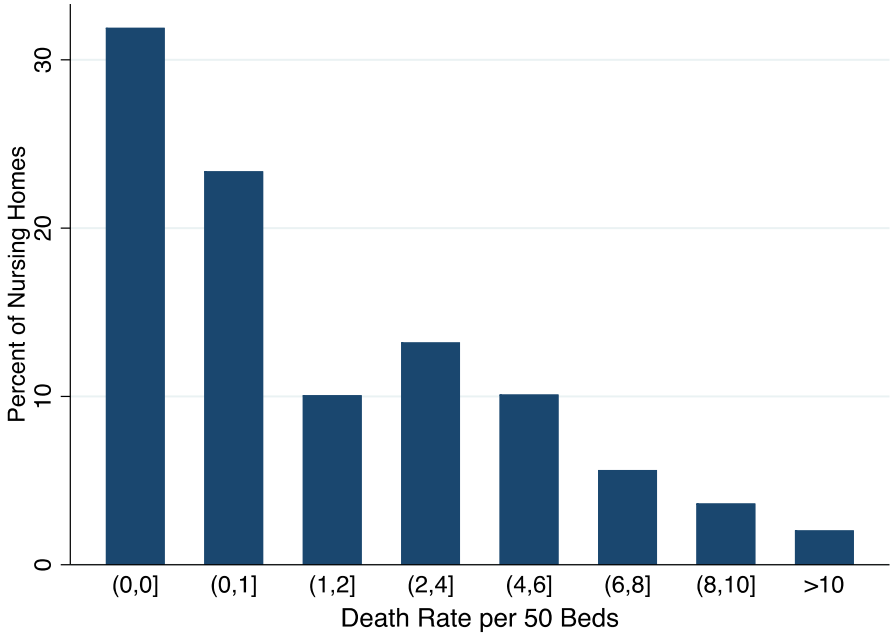


Figure 8
COVID-19 Death Rate Distribution in Nursing Homes that have More Than 100 Beds and are Located in Counties in the Top 10th Percentile for Total COVID-19 Deaths

Panel A: Distribution as of May 24



Panel B: Distribution as of September 13

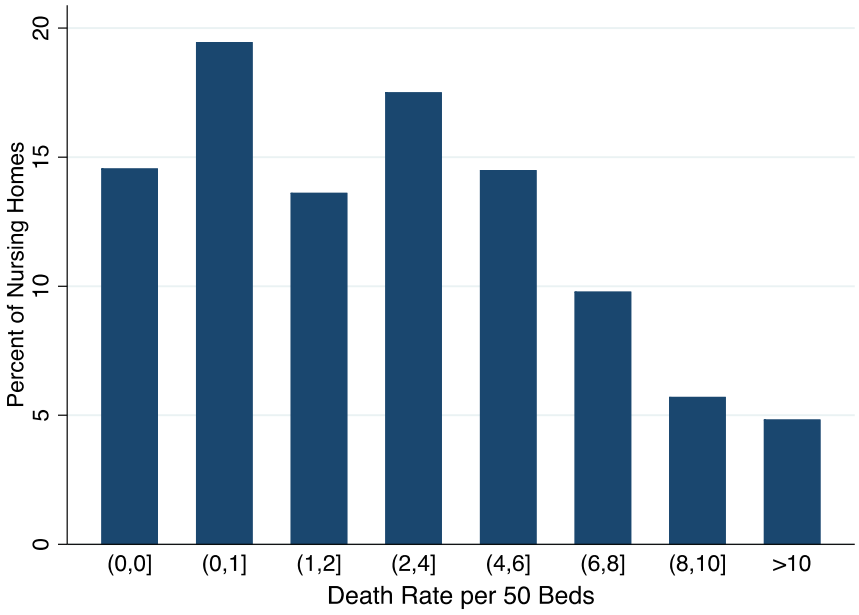


Table 1
COVID-19 Deaths as of September 13, 2020
by Reporting Agency and Nursing Home Status

Total	Deaths in NH as reported by states	Deaths in NH as reported by CMS
33 States Reporting Separate Counts for Nursing Home Residents (% of total)		
173,694	68,180 (39.3%)	50,973 (29.3%)
18 States not Reporting Separate Counts for Nursing Home Residents		
18,525		4,856 (26.2%)
	All States	
192,221	73,949,* (38.5%)	55,829 (29.0%)

* Estimated by assuming that the 18 states NOT reporting numbers on webpages would report numbers at the same rate above CMS numbers as the 27 reporting states with the lowest death rates.

Table 2
Sample Characteristics, CMS Data on Nursing Homes, as of September 13th

Variable	mean	s.d.
Nursing home characteristics		
total beds	106.0	61.5
share of female residents	0.663	0.119
share of female residents, missing	0.090	0.287
share of residents < 65 years of age	0.225	0.176
share of residents < 65 years old, missing	0.550	0.498
share of black residents	0.164	0.220
share of black residents, missing	0.449	0.497
share of Hispanic residents	0.050	0.136
share of black residents, missing	0.424	0.494
share of residents on Medicaid	0.598	0.230
for profit	0.704	0.457
acuity index	12.195	1.481
Medicaid, profit, and acuity missing	0.067	0.250
Nursing home quality		
overall star rating		
2	0.198	0.398
3	0.177	0.382
4	0.213	0.409
5	0.244	0.429
Inspection star rating		
2	0.240	0.427
3	0.228	0.419
4	0.235	0.424
5	0.103	0.303
QM star rating		
2	0.136	0.342
3	0.201	0.401
4	0.252	0.434
5	0.352	0.478
Staff star rating		
2	0.252	0.434
3	0.280	0.449
4	0.217	0.412
5	0.115	0.319
Cases and Death rates (per 50 beds)		
resident COVID-19 case rate	10.061	13.113
staff COVID-19 case rate	9.482	10.038
resident COVID-19 death rate	1.456	2.909
resident non-COVID-19	4.478	5.627
County Characteristics		
COVID-19 cases per 1,000 residents (7/3)	15.337	9.965
COVID-19 deaths per 1,000 residents	0.537	0.541
Population (x 1000)	816	1,746
Observations	15,066	

Table 3
Descriptive Statistics for Nursing Homes. As of September 13th

	1-star		2-star		3-star		4-star		5-star	
	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
NH characteristics										
total beds	131.32	59.66	126.08	68.42	119.99	61.89	110.17	54.52	105.62	52.81
share of female residents	0.624	0.115	0.649	0.122	0.667	0.118	0.678	0.118	0.693	0.115
share of residents < 65 years old	0.268	0.145	0.242	0.154	0.213	0.160	0.198	0.186	0.174	0.211
share of black residents	0.260	0.230	0.219	0.228	0.188	0.225	0.143	0.201	0.144	0.223
share of hispanic residents	0.081	0.164	0.079	0.165	0.059	0.140	0.048	0.128	0.038	0.113
share of residents on Medicaid	0.664	0.181	0.631	0.198	0.603	0.216	0.560	0.233	0.515	0.260
for profit	0.844	0.363	0.761	0.426	0.732	0.443	0.676	0.468	0.624	0.485
acuity index	12.29	1.26	12.30	1.34	12.33	1.24	12.33	1.29	12.38	1.47
Cummulative Cases and Deaths										
any resident COVID-19 cases	0.84	0.37	0.85	0.36	0.83	0.37	0.81	0.39	0.81	0.39
resident COVID-19 case rate/50 beds	11.72	13.55	11.88	13.58	10.98	13.29	10.64	13.05	9.69	12.79
any staff COVID-19 cases	0.95	0.23	0.96	0.20	0.94	0.24	0.94	0.23	0.93	0.26
staff COVID-19 case rate/50 beds	8.82	8.90	9.45	9.28	9.41	9.18	10.44	10.60	10.28	10.64
any resident COVID-19 deaths	0.54	0.50	0.51	0.50	0.48	0.50	0.46	0.50	0.42	0.49
resident COVID-19 death rate/50 beds	1.84	3.03	1.77	3.21	1.59	2.88	1.62	2.94	1.45	2.78
any resident deaths not from COVID-19	0.84	0.36	0.87	0.34	0.86	0.34	0.86	0.35	0.87	0.34
resident death rate not from COVID-19/50 beds	4.04	5.71	4.47	5.59	4.50	5.25	4.96	5.52	5.23	5.90
NH Staff (since week ending 5/24)										
any nursing staff shortage	0.443	0.497	0.389	0.488	0.363	0.481	0.366	0.482	0.368	0.483
any aide staff shortage	0.484	0.500	0.434	0.496	0.400	0.490	0.397	0.489	0.397	0.490
any clinical staff shortage	0.207	0.405	0.183	0.386	0.173	0.378	0.174	0.379	0.188	0.391
NH Supplies (since week ending 5/24)										
n95 mask outage	0.325	0.468	0.297	0.457	0.272	0.445	0.257	0.437	0.263	0.440
surgical mask outage	0.260	0.439	0.227	0.419	0.212	0.409	0.191	0.393	0.179	0.384
eye protection outage	0.260	0.439	0.238	0.426	0.214	0.410	0.199	0.400	0.185	0.388
gown outage	0.267	0.443	0.250	0.433	0.224	0.417	0.211	0.408	0.201	0.401
glove outage	0.221	0.415	0.180	0.384	0.169	0.375	0.155	0.362	0.157	0.364
hand sanitizer	0.227	0.419	0.175	0.380	0.164	0.371	0.156	0.363	0.159	0.366

Table 3 (continued)
Descriptive Statistics for Nursing Homes. As of September 13th

	1-star		2-star		3-star		4-star		5-star	
Variable	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
COVID-19 Testing (week ending 9/13)										
average time to test results										
<1 day	0.084	0.277	0.067	0.250	0.064	0.246	0.067	0.251	0.058	0.233
1-2 days	0.414	0.493	0.434	0.496	0.484	0.500	0.484	0.500	0.469	0.499
3-7 days	0.468	0.499	0.473	0.499	0.433	0.496	0.433	0.496	0.465	0.499
>7 days	0.034	0.182	0.026	0.159	0.018	0.134	0.016	0.126	0.008	0.088
any resident test in past week	0.464	0.499	0.517	0.500	0.511	0.500	0.509	0.500	0.529	0.499
any asymp. res. test this week | new case in home	0.291	0.454	0.312	0.464	0.317	0.466	0.297	0.457	0.298	0.458
any asymp. res. Test without exposure (ever)	0.283	0.451	0.321	0.467	0.308	0.462	0.318	0.466	0.307	0.462
any staff test in past week	0.665	0.472	0.678	0.467	0.676	0.468	0.661	0.473	0.692	0.462
any asymp. staff test this week | new case in home	0.252	0.434	0.270	0.444	0.284	0.451	0.270	0.444	0.279	0.449
any asymp. staff Test without exposure (ever)	0.524	0.500	0.517	0.500	0.526	0.499	0.524	0.500	0.527	0.500
testing machine on site	0.665	0.472	0.682	0.466	0.691	0.462	0.666	0.472	0.670	0.471
Observations	2,471		2,831		2,503		2,404		899	

Table 4
Negative Binomial Estimates, Death Counts in Nursing Homes,
as of May 24th, September 13th, and Cumulative Deaths Between Those Dates

Star Rating	Overall Rating	Inspection Rating	QM Rating	Staff Rating
		Deaths as of May 24th (Mean deaths=)		
2 stars	-0.042	-0.169	-0.047	0.126
	(0.051)	(0.066)	(0.085)	(0.058)
3 stars	-0.196	-0.205	-0.062	0.028
	(0.077)	(0.067)	(0.104)	(0.078)
4 stars	-0.016	-0.190	-0.026	-0.066
	(0.081)	(0.071)	(0.095)	(0.098)
5 stars	-0.173	-0.250	-0.041	-0.128
	(0.089)	(0.089)	(0.097)	(0.099)
-2 LL	-12,274.6	-2,272.5	-12,277.5	-12,219.7
Observations	10,580	10,580	10,574	10,538
		Deaths as of September 13th (Mean deaths=)		
2 stars	-0.084	-0.124	-0.027	0.120
	(0.035)	(0.049)	(0.067)	(0.049)
3 stars	-0.124	-0.152	-0.011	0.003
	(0.052)	(0.046)	(0.062)	(0.058)
4 stars	-0.167	-0.145	-0.002	-0.092
	(0.048)	(0.041)	(0.057)	(0.067)
5 stars	-0.211	-0.267	-0.060	-0.252
	(0.064)	(0.064)	(0.058)	(0.085)
-2 LL	-23,025.7	-23,023.6	-23,031.9	-22,922.3
Observations	11,054	11,054	11,048	11,009
		Deaths between May 24th and September 13th		
2 stars	-0.124	-0.113	-0.106	0.138
	(0.043)	(0.046)	(0.061)	(0.044)
3 stars	-0.107	-0.169	-0.053	0.002
	(0.060)	(0.059)	(0.058)	(0.050)
4 stars	-0.239	-0.200	-0.098	-0.071
	(0.055)	(0.055)	(0.058)	(0.059)
5 stars	-0.298	-0.381	-0.171	-0.283
	(0.072)	(0.078)	(0.062)	(0.086)
-2 LL	-17,499.1	-17,499.2	-17,514.0	-17,429
Observations	10,497	10,497	10,495	10,459

Table 5
OLS Estimates of Within-Nursing Home Incidence of Staff and Resident Cases, Using Deaths as of July 26, 2020

Inspection Star Rating	Any staff cases	Ln(staff cases | staff cases>0)	Any resident cases	Ln(resident cases | resident cases>0)
2 stars	0.009	-0.045	0.022	-0.060
	(0.009)	(0.022)	(0.011)	(0.034)
3 stars	0.012	-0.070	0.010	-0.515
	(0.010)	(0.034)	(0.012)	(0.038)
4 stars	-0.006	-0.041	0.008	-0.113
	(0.012)	(0.030)	(0.013)	(0.034)
5 stars	-0.008	-0.058	-0.013	-0.212
	(0.014)	(0.051)	(0.017)	(0.0083)
Mean of Dep. Var.				
Observations	10,516	10,516	10,510	10,473

Table 6
OLS and Maximum Likelihood where Outcomes are Different Measures of Nursing Home Quality, As of September 13th

Dependent variable	Mean of dependent variable	R^2/ -2 LL	Coefficient (Standard error) on Inspection rating dummy variables			
			1-star	2-star	3-star	4-star
Staff shortages						
Any nursing shortage?		0.067	-0.045	-0.066	-0.057	-0.058
			(0.012)	(0.015)	(0.018)	(0.017)
Any aide shortage?		0.074	-0.042	-0.073	-0.068	-0.070
			(0.012)	(0.015)	(0.017)	(0.017)
Any clinical staff shortage?		0.029	-0.021	-0.029	-0.025	-0.013
			(0.011)	(0.025)	(0.016)	(0.013)
PPE shortages						
N95 outage?		0.060	-0.018	-0.041	-0.055	-0.032
			(0.012)	(0.014)	(0.015)	(0.013)
Surgical mask outage?		0.047	-0.025	-0.038	-0.056	-0.068
			(0.012)	(0.014)	(0.014)	(0.019)
Eye protection outage?		0.050	-0.015	-0.037	-0.050	-0.065
			(0.011)	(0.013)	(0.014)	(0.017)
Gown outage?		0.044	-0.011	-0.037	-0.049	-0.060
			(0.011)	(0.014)	(0.014)	(0.020)
Glove outage?		0.034	-0.036	-0.047	-0.061	-0.062
			(0.011)	(0.013)	(0.015)	(0.017)
Hand sanitizer outage?		0.038	-0.045	-0.056	-0.063	-0.062
			(0.012)	(0.012)	(0.014)	(0.018)
Testing procedures						
Time to test		-9,147	0.014	-0.117	-0.117	0.031
			(0.082)	(0.071)	(0.061)	(0.093)
Test asymptomatic residents after a new resident case?		0.045	0.024	0.028	0.009	0.001
			(0.019)	(0.019)	(0.025)	(0.031)
Test asymptomatic staff after a new resident case?		0.036	0.024	0.041	0.026	0.034
			(0.023)	(0.018)	(0.022)	(0.029)
Have in-home testing machine?		0.098	0.021	0.029	0.016	0.016
			(0.011)	(0.014)	(0.018)	(0.018)

All models are linear probability models and have 11,054 observations except the model for the "Time to test" which is an ordered probit and has 9,626 observations. Standard errors allow for arbitrary correlation across observations within a state. Other controls in the models include…

Table 7
Negative Binomial Estimates, Death Counts in Nursing Homes from COVID-19 and non-COVID-19 Causes, as of September 13th

	COVID-19 Deaths		Non-COVID-19 Deaths	
Covariate	(1)	(2)	(1)	(2)
Inspection star rating				
2 stars	-0.124	-0.117	0.027	0.041
	(0.049)	(0.050)	(0.027)	(0.027)
3 stars	-0.152	-0.143	0.056	0.051
	(0.046)	(0.047)	(0.027)	(0.029)
4 stars	-0.145	-0.135	0.095	0.096
	(0.041)	(0.042)	(0.033)	(0.039)
5 stars	-0.267	-0.254	0.107	0.104
	(0.064)	(0.065	(0.047)	(0.051)
Counts of PPE and		0.022		-0.003
staff shortages		(0.006)		(0.003)
-2 LL	-23,023.6			
Observations	11,054	11,054	10,549	10,459

Table 8
Negative Binomial Estimates, Death Counts in Nursing Homes as of September 13th

Inspection star Rating	All Nursing Homes	Nursing home by County COVID-19 Case Rate: Above Median	Nursing home by County COVID-19 Case Rate: At or below Median	Counties with no COVID-19 Deaths
		Panel A: COVID-19 Deaths		
2 stars	-0.136	-0.093	-0.251	
	(0.056)	(0.064)	(0.095)	
3 stars	-0.147	-0.149	0.005	
	(0.052)	(0.057)	(0.009)	
4 stars	-0.165	-0.135	-0.086	
	(0.052)	(0.056)	(0.124)	
5 stars	-0.265	-0.197	-0.265	
	(0.069)	(0.070)	(0.166)	
Mean of Dep. Var.	2.90	4.57	0.47	
-2 LL	-19,245.5	-16,220.9	-2,667.1	
Observations				
		Panel B: Non-COVID-19 Deaths		
2 stars	0.030	-0.009	0.110	0.092
	(0.034)	(0.035)	(0.065)	(0.050)
3 stars	0.058	0.016	0.148	0.169
	(0.037)	(0.033)	(0.056)	(0.044)
4 stars	0.100	0.072	0.174	0.208
	(0.038)	(0.040)	(0.060)	(0.050)
5 stars	0.126	0.056	0.271	0.242
	(0.051)	(0.055)	(0.078)	(0.063)
Mean of Dep. Var.	8.21	9.32	6.58	10.54
-2 LL	-37,447.7	-23,865.2	-13,513.1	
Observations				
		Panel C: All Deaths		
2 stars	0.010	-0.019	0.102	
	(0.034)	(0.039)	(0.060)	
3 stars	0.029	-0.015	0.154	
	(0.027)	(0.031)	(0.054)	
4 stars	0.061	0.038	0.163	
	(0.037)	(0.036)	(0.063)	
5 stars	0.064	0.002	0.254	
	(0.053)	(0.059)	(0.082)	
Mean of Dep. Var.	11.20	13.79	7.04	
-2 LL	-4,0842.8	-26,812.2	-13,876.1	
Observations				