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Characteristics of Skilled Nursing Facilities Associated with Resident COVID-19 Cumulative Incidence Rate in Georgia, USA: May 31, 2020 – January 31, 2021

By

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Master of Science in Public Health

Epidemiology

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Committee Member

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B.S., Seattle Pacific University, 2019

Thesis Committee Chair: Ben Lopman, PhD

An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
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Abstract

Characteristics of Skilled Nursing Facilities Associated with Resident COVID-19 Cumulative Incidence Rate in Georgia, USA: May 31, 2020 – January 31, 2021

By Cameron Ashton

Relevance
The ongoing Coronavirus Disease 2019 (COVID-19) pandemic has a disproportionate burden of cases and deaths among the residents and staff of skilled nursing facilities (SNFs). Evaluating facility outbreaks can inform effective public health policy and COVID-19 mitigation protocols to protect the vulnerable populations within SNFs.

Objective
This study aimed to determine characteristics of SNFs that are associated with resident COVID-19 cumulative incidence rate during the second and third Waves of the epidemic in the state of Georgia.

Design
We compiled publicly available data from the Centers for Medicare and Medicaid Services (CMS) regarding SNF characteristics and COVID-19 outcomes between May 31, 2020 and January 31, 2021. Then, regression analyses were used to examine the associations between nursing home characteristics and COVID-19 cumulative incidence among facility residents.

Findings
This study found meaningful associations between multiple facility-level characteristics and laboratory-confirmed COVID-19 cases amongst residents of SNFs in the state of Georgia between May 31, 2020 and January 31, 2021. These effects often varied between Waves Two and Three of the epidemic. In both Waves, larger numbers of staff cases and shortages of staff classified as "other" were associated with larger resident case rates, while increased daily staff hours per resident were generally associated with decreased resident case rates. Facilities with higher CMS 5-star ratings had smaller resident case rates in Wave Two but larger resident case rates in Wave Three. Similarly, facilities located in hospitals had smaller resident case rates in Wave Two and larger resident case rates in Wave Three. Finally, facilities in nonmetro-urban and nonmetro-rural areas, compared to metro-urban areas, had smaller resident case rates in Wave Two but larger resident case rates in Wave Three. Limitations in the data and unmeasured confounding may impact the findings of this study.

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Thank you,

Cameron Ashton

Table of Contents

Introduction

Background

The burden of cases and deaths attributable to Coronavirus Disease 2019 (COVID-19), the infectious respiratory disease caused by the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has been disproportionately high among the residents of long-term care facilities (LTCFs) throughout the COVID-19 pandemic.

The first COVID-19 infection in the United States was identified on January 20, 2020 in Washington state, and evidence of sustained community transmission followed shortly thereafter when a case was confirmed among the residents of a skilled nursing facility (SNF) within the Public Health – Seattle and King County catchment area on February 28, 2020. Active surveillance over the three weeks following index case detection linked a total of 167 persons with confirmed COVID-19 infection to this SNF, and 101 of the 118 residents who were tested for the disease yielded positive results. By March 18, 2020, a total of 30 LTCFs in King County were found to have at least one confirmed COVID-19 case among staff and residents, and 35 of the residents from the index case facility had died.[1] This case series, occurring at the very beginning of the United States COVID-19 epidemic, heralded a pattern that would persist throughout the months to follow as infection continued to spread across the country and the world: LTCFs are especially vulnerable to COVID-19 outbreaks, which frequently result in high case counts and loss of life.

SNFs, often referred to as nursing homes, are one of the provider types classified by the Centers for Medicare and Medicaid Services (CMS) as LTCFs, along with adult day service centers, home health agencies, hospice, and residential care communities.[2] As of 2016,

there were an estimated 15,600 certified nursing homes located across the United States, housing approximately 1.3 million residents.[2] Although these individuals comprise less than 0.5% of the total population, nursing homes have been linked to 4% of COVID-19 cases and 33% of COVID-19 deaths reported in the United States as of March 31, 2021.[3] Furthermore, the median case fatality ratio (CFR), calculated as the number of deaths divided by the number of cases, among nursing homes is estimated to be 10 percent, vastly greater than the national median CFR approximation of 2 percent.[3] As of June 14, 2020, 71% of nursing homes reporting COVID-19 data nationwide had experienced at least one case among residents and/or staff, with 27% of these experiencing an outbreak in which the number of confirmed cases surpassed 10% of the resident population size.[4]

When considering nursing homes and the population dynamics within facilities, it is perhaps unsurprising that LTCFs, including SNFs, are at heightened risk for infectious disease outbreaks and poor patient outcomes. Residents are particularly vulnerable to diseases such as COVID-19, as nursing homes house large numbers of elderly individuals in close quarters. Many residents experience multiple comorbidities, and both age and underlying medical conditions are associated with higher COVID-19 mortality.[5] Residents may require daily, hands-on care that puts them in frequent, direct contact with multiple staff members. Additionally, facilities are often understaffed and must compete with hospitals for personal protective equipment (PPE).[4] During a pandemic, these factors put additional risk of infection on nursing home residents and staff-members alike and create conditions conducive for transmission of infectious disease, particularly respiratory pathogens such as SARS-CoV-2 that can spread asymptomatically.

The first case of COVID-19 in the state of Georgia was reported on March 2, 2020.[6] On April 3, 2020, Governor Kemp declared a statewide shelter-in-place order that was followed by strict limitations on nursing homes such that residents were instructed not to leave the facility or receive visitors, in an attempt to curb COVID-19 transmission and protect the 'medically fragile' population.[7,8] Although case counts continued to climb throughout the nation, Georgia was among the first states to lift community COVID-19 restrictions, permitting some businesses to reopen as early as April 27, 2020 and lifting stay at home orders on May 1, 2020.[6] Surveillance as of March 31, 2021 has identified 682 LTCFs in Georgia reporting at least one case of COVID-19 and totaling 40,105 COVID-19 cases and 4,170 COVID-19 deaths among residents and staff. In context, this means that LTCFs are accountable for 23% of statewide COVID-19 fatalities.[3] In Fulton County, the most populous county in Georgia, LTCF residents represent less than 1% of the population. However, between the months of March and May in 2020, more than 50% of county COVID-19-related deaths occurred among facility residents.[9]

Objective

This study aimed to determine characteristics of SNFs located in the state of Georgia that are associated with resident COVID-19 incidence rates during the second and third Waves of the epidemic, for which complete cumulative incident case counts were available by means of regression analysis.

Methods

Study Sample and Data Sources

Data regarding nursing homes in the state of Georgia were compiled from the publicly available Centers for Medicare and Medicaid Services (CMS) online data repository.[10,11] The CMS Nursing Home COVID-19 Public File includes information reported by SNFs to the Centers for Disease Control and Prevention (CDC) National Healthcare Safety Network (NHSN) system regarding resident impact, facility capacity, staff and personnel, and supplies and personal protective equipment (PPE) during the COVID-19 pandemic.[10] CMS required that this reporting begin on May 8, and weekly updates were subsequently provided by the facilities.[10] We restricted the data such that the study sample only included entries that passed the CMS basic quality assurance review. Reports predating May 31, 2020 were excluded from the analysis due to inconsistent reporting of cumulative COVID-19 cases and deaths prior to that date, thus wave one was not considered in this analysis.[10] These data were then aggregated to the facility level.

Additional SNF features were extracted from the CMS Provider information dataset, which contains fixed characteristics of currently active nursing homes, such as number of certified beds, quality measure scores, staffing, and other information used in the CMS Five-Star Rating System.[11] Both the Nursing Home COVID-19 Public File and Provider Information Dataset were downloaded on February 15, 2021, merged, and grouped into two 18-week time periods: May 31, 2020 – September 30, 2020 and October 1, 2020 – January 31, 2021, corresponding with Wave Two and Wave Three of COVID-19 community incidence in the state of Georgia.[6]

Statistical Analysis

Following a literature review, a causal framework was constructed and a set of explanatory variables was selected a priori from the analytic dataset (Figure S1). The outcome of interest was cumulative incident laboratory-confirmed COVID-19 cases among SNF residents in the state of Georgia during Waves Two and Three of the epidemic, offset by facility-specific average resident censuses during each wave. Bivariable analyses were conducted to examine the empirical, unadjusted associations between the facility characteristics and resident COVID-19 case counts.

The outcome was tested for overdispersion, and negative binomial distribution was found to fit the data more appropriately than a Poisson distribution (Figure S2). Negative binomial regression models were created to perform multivariable assessments across each time period using the predetermined set of explanatory variables. Models were assessed for collinearity, and likelihood ratio testing was used to determine whether excluding or grouping variables was detrimental to model fit.[12] The final models of cumulative incident laboratory-confirmed COVID-19 cases per SNF average resident census controlled for: presence of physical therapy services; whether the SNF is located in a hospital; metro-urban status; CMS Overall 5-Star Rating; ownership type; hours per resident per day of aides, licensed practical nurses (LPNs), and registered nurses (RNs); total number of certified beds in the facility; shortages of hand sanitizer and N95 and surgical masks; average proportion of unoccupied beds; number of laboratory-confirmed COVID-19 cases amongst staff; proportion of reports with shortages of aides, licensed staff (LPNs and RNs), and other staff; and proportion of weeks testing all asymptomatic residents, all asymptomatic staff, symptomatic residents, and symptomatic staff (Table S1).

All data cleaning and analyses were performed using R statistical software version 4.0.2 and the following packages: dplyr, ggplot2, MASS, performance, tidyr.

Results

Descriptive

The final analytic dataset contained both fixed and time-varying continuous and categorical variables characterizing 332 SNFs. The majority of facilities were for-profit (65.4%), located in a metro, urban setting (60.8%), and offered physical therapy (PT) services (93.4%). The most common CMS 5-Star Overall Rating assessment among facilities was 1 (25.9%), wherein 1 indicates lowest quality and 5 indicates highest quality. On average, residents received 2.0 hours of daily contact with aides, 1.1 hours with licensed practical nurses (LPNs), and 0.4 hours with registered nurses (RNs). Few SNFs were located within a hospital (9.0%). The median number of certified beds per facility was 100 (IQR: 75.8, 107.8) (Table 1).

During Wave Two of the COVID-19 epidemic in the state of Georgia, 6,743 laboratory-reported resident cases were reported across the 332 facilities. The median number of resident COVID-19 cases per SNF was 8.0 (IQR: 1.0, 35.0) and the median number of resident COVID-19-associated deaths was 1.0 (IQR: 0.0, 6.3). The median number of COVID-19 cases among SNF staff members was 10.0 (IQR: 4.0, 22.0). On average, 23% of SNF beds were unoccupied. Additionally, SNFs indicated staffing shortages of aides for 11% of their Wave Two weeklyreports, shortages of licensed staff (clinical and nursing) for 11%, and shortages of other staff for 6% of reports. Most facilities had high rates of missingness regarding testing of symptomatic residents and staff or all asymptomatic residents and

staff following the detection of a COVID-19 case in a SNF. During Wave Two, a minority of facilities experienced shortages of hand sanitizer (18.8%) or N95 and surgical masks (9.1%) (Table 2).

During Wave Three of the COVID-19 epidemic in the state of Georgia, the 332 SNFs reported a total of 7,225 laboratory-confirmed resident case. The median number of SNF resident COVID-19 cases was 13.50 (IQR: 2.0, 34.0) and the median number of resident COVID-19-associated deaths was 1.0 (IQR: 0.0, 4.0). The median number of COVID-19 cases among SNF staff members was 13.0 (IQR: 6.0, 22.0). On average, 28% of SNF beds were unoccupied during this time period. Shortages of aides were indicated in 6% of reports, shortages of licensed staff (clinical and nursing) were indicated in 6% of reports, and on average there were no shortages of other staff during Wave Three. As in Wave Two, most facilities did not report testing of symptomatic residents or staff. On average, a SNF indicated that all asymptomatic residents and staff were tested following the detection of a COVID-19 case in 13% of reports. During Wave Three, few facilities experienced shortages of hand sanitizer (12.1%) or masks (7.6%) (Table 2).

Bivariable Analysis

In bivariable analyses, we found that few facility characteristics of SNFs in the state of Georgia were meaningfully associated with resident COVID-19 cumulative incidence rate ratio (IRR) among total facility residents throughout Wave Two and Wave Three of the epidemic. SNF CMS 5-Star Rating, staff hours per resident per day, ownership type, whether the facility was within a hospital, availability of physical therapists, total number

of certified beds, and staffing or supply shortages during the epidemic were not associated with resident IRR (Table 3).

During Wave Two, SNFs that were located in a nonmetro, urban setting experienced a 51% increase in resident case IRR (IRR = 1.51, 95% CI: 1.10 – 2.10) when compared to metro, urban facilities. The confidence intervals surrounding the difference in IRR between nonmetro, rural and metro, urban SNFs during Wave Two were too wide to yield any conclusions (IRR = 1.67, 95% CI: 0.83, 3.96). There were not meaningful associations between setting an IRR during Wave Three (Table 3).

Although the proportion of unoccupied beds at a facility was associated with an increase in resident IRR during Wave Two (IRR = 2.94, 95% CI: 0.68 – 13.60), a one-unit increase in the proportion of SNF emptiness corresponded to a 77% decrease in IRR (IRR = 0.23, 95% CI: 0.07 – 0.85) during Wave Three. In context, emptying one bed at a SNF with 100 total certified beds would increase facility emptiness by 1%. This value is associated with a 2.94% increase in resident COVID-19 case rates during Wave Two and less than 1% decrease in IRR during Wave Three.

During both Waves, increasing the proportion of weeks where testing was performed on symptomatic residents and staff or all asymptomatic residents and staff following the detection of a COVID-19 case at a SNF was associated with increases in resident IRR (Table 3). Similarly, the number of staff COVID-19 cases detected at a facility was associated with 6% and 7% increases in IRR respectively (IRR = 1.06, 95% CI: 1.05 – 1.07; IRR = 1.07, 95% CI: 1.06 – 1.08) during Waves Two and Three.

Multivariable Analysis

In multivariable analyses, we found several meaningful associations between facility characteristics and resident COVID-19 case rates and determined that associations were often different between Wave Two and Wave Three (Table 4).

During Wave Two, facilities underwent monotonic decreases in resident case rates as CMS 5-Star Rating scores increased from 1 (Table 4). IRR also differed by CMS 5-Star Rating during Wave Three, however resident case rates generally increased as 5-Star Rating scores increased from 1 (Table 4).

Overall, increases in average aide and LPN hours per resident per day were associated with decreasing resident COVID-19 case rates. Specifically, each additional daily aide hour correlated with IRR decreases of 19% and 28% during Waves Two and Three (IRR = 0.81, 95% CI: 0.68 – 0.97; IRR = 0.72, 95% CI: 0.64 – 0.82) respectively. Similarly, a one-unit increase in average daily LPN hours per resident was associated with a 34% decrease in IRR during Wave Two (IRR = 0.66, 95% CI: 0.51 – 0.85) and a 31% decrease in IRR during Wave Three (IRR = 0.69, 95% CI = 0.57 – 0.86). In contrast, a one-unit increase in average daily RN hours per resident was associated with a substantial increase in resident COVID-19 case rate during Wave Two (IRR = 2.19, 95% CI: 1.54 – 3.13) and a decrease in IRR during Wave Three (IRR = 0.76, 95% CI: 0.58 –1.01).

We observed that facilities within a hospital had a 36% decrease resident COVID-19 case rates during Wave Two (IRR = 0.64, 95% CI: 0.47 – 0.88), but experienced a 41% increase in IRR during Wave Three (IRR = 1.41, 95% CI: 1.11 – 1.80) when contrasted with SNFs that were not located in hospitals.

During Wave Two, facilities that were not located in metro, urban settings experienced increased case rates (Table 4). However, the reverse was observed during Wave Three: nonmetro, rural facilities had a 66% decrease in IRR (IRR = 0.34, 95% CI: 0.25 – 0.46) and nonmetro, urban facilities had a 21% decrease in IRR (IRR = 0.79, 95% CI: 0.70 – 0.89).

There did not appear to be meaningful differences in resident COVID-19 case rates between SNFs of different ownership types, although government facilities were associated with a decrease in IRR when compared to for-profit facilities during Wave Two (IRR = 0.71, 95% CI: 0.47 – 1.09) (Table 4).

While we observed no association between case counts and access to physical therapy in Wave Two, the IRR of COVID-19 among residents of facilities offering any physical therapy was 89% higher compared to facilities without PT services during Wave Three (IRR = 1.89, 95% CI: 1.27-2.77).

During both Waves of the COVID-19 epidemic, the total number of certified beds per SNF and the average proportion of occupied beds were significantly associated with resident cumulative IRR. Although the estimated effect on cumulative case rates associated with a one-unit increase in total beds per facility is extremely precise during both Waves, the IRR is approximately null (Table 4). As a result, changing the number of certified beds at a SNF did not have a meaningful impact on resident COVID-19 case rates. However, a one-unit increase in the proportion of unoccupied beds at a facility was associated with a substantial increase in IRR during Wave Two (IRR = 2.96, 95% CI: 1.42 – 6.19) and a decrease in IRR during Wave Three (IRR = 0.24, 95% CI: 0.14 – 0.40).

Facilities that experienced a shortage of hand sanitizer during Waves Two or Three were observed to have a decrease in case rates of 48% and 30% respectively (IRR = 0.52, 95% CI: 0.40 – 0.71; IRR = 0.70, 95% CI: 0.50 – 0.99). In marked contrast, SNFs that ever had shortages in masks (N95 and surgical) during Wave Two of the epidemic observed an 87% increase in case rates (IRR = 1.87, 95% CI: 1.30 – 2.67). Mask shortage was not associated with substantial changes in IRR during Wave Three (IRR = 0.85, 95% CI: 0.62 – 1.17).

The proportion of weekly reports in which facilities had indicated a shortages of aides (certified nursing assistants, nurse aides, medication aides, and medication technicians) during the 18-week data collection period was not meaningfully associated with case rates in Wave Two, but during Wave Three there was a 43% increase in IRR (IRR = 1.43, 95% CI: 1.14 – 1.80) for each one-unit increase in this proportion (Table 4). In a facility that submitted reports for all 18 collection points during Wave Three, for example, each additional week of aide shortages would be associated with a 2.4% increase in resident COVID-19 case rates. Conversely, a one-unit increase in the proportion of weeks in which a facility reported shortages of licensed clinical or nursing staff was associated with decreased case rates during both Waves (IRR = 0.72, 95% CI: 0.49 – 1.06 (Wave Two); IRR = 0.73, 95% CI: 0.53 – 1.02 (Wave Three)). Finally, increasing the proportion of weeks in which a facility reported shortages of other staff was associated with substantial increases in IRR during both Waves (IRR = 3.32, 95% CI: 2.42 – 4.57 (Wave Two); IRR = 3.34, 95% CI: 2.04 – 5.48 (Wave Three)).

Additionally, resident case rates were associated with the proportion of weekly reports during the 18-week data collection period that a facility tested its residents and staff.

During Wave Two, one-unit increases in the proportion of weeks that all asymptomatic residents, all asymptomatic staff, and symptomatic residents were tested for COVID-19 were associated with substantial increases in IRR (IRR = 1.59, 95% CI: 0.91 – 2.85 (all asymptomatic residents); IRR = 1.96, 95% CI: 1.05 – 3.60 (all asymptomatic staff); IRR = 3.69, 95% CI: 0.20 – 0.50 (symptomatic residents)). However, increased proportion of weeks that asymptomatic staff were tested during Wave Two was associated with a 69% decrease in resident case rates (IRR = 0.31, 95% CI: 0.20 – 0.50). In context, a facility that submitted reports for all 18 collection points during Wave Two might expect a 3.8% decrease in resident case rates with each additional week that asymptomatic staff were reported. Differing relationships between testing and resident case rates were observed during Wave Three. A one-unit increase in proportion of weeks that a facility tested all asymptomatic staff was associated with a 77% increase in IRR (IRR = 1.77, 95% CI: 1.36 – 2.28), but the other testing protocols had negative associations with cumulative COVID-19 IRR amongst residents. (Table 4).

Finally, staff cases were associated with greater COVID-19 case rates amongst facility residents. For each additional COVID-19 case detected amongst SNF staff during Wave Two and Wave Three, IRR increased by 7% and 8% respectively (IRR = 1.07, 95% CI: 1.06 – 1.07; IRR = 1.08, 95% CI: 1.08 – 1.09).

Discussion

Key Findings

We observed several meaningful associations between facility-level characteristics and COVID-19incidence among SNF residents during both Waves Two and Three of the COVID-

19 epidemic in the state of Georgia. Many of these associations differed between Waves Two and Three.

As expected, an increased number of laboratory-confirmed cases among SNF staff was associated with increased resident IRR during both Waves. Generally, increasing daily staffing hours per resident per day was associated with decreased resident case rates in both Waves, with the exception of RN hours during Wave Two, which was associated with increased resident case rates. Shortages of other staff was associated with larger case rates in both waves, and shortages of aides was associated with increased case rates in Wave Three, with no association in Wave Two. During both Waves, facility size and ownership type were not meaningfully associated with resident COVID-19 case rates.

During Wave Two we found that higher quality facilities, as indicated by CMS 5-Star Rating scores, were associated with lower resident IRRs. However, the opposite was true during Wave Three, where it was observed that resident case rates generally increased as 5-star ratings increased. We also found that the proportion of unoccupied beds in a SNF was associated with an increased IRR during Wave Two, but a decreased IRR in Wave Three. Furthermore, facilities located in nonmetro-rural and nonmetro-urban areas, compared to metro-urban areas, had larger resident case rates in Wave Two but smaller resident case rates in Wave Three. Finally, facilities located within hospitals experienced decreased case rates during Wave Two, but an increase in resident IRR during Wave Three.

Interpretations and Implications

Some of these findings are in agreement with research that has been conducted during the COVID-19 pandemic. Specifically, our observation that SNF ownership type was not

associated with resident COVID-19 infection rates was congruous with other recent study findings.[13]

Additionally, we observed that increasing staffing hours per resident per day was associated with decreased resident IRR, another finding that is supported by recent research.[4,14] Contrary to expectation, increasing RN hours per resident per day during Wave Two was an exception to this trend. Overall, this finding could indicate that facilities with longer average periods of contact between staff-members and residents are better able to implement infection-prevention measures and monitor the health of individual patients. It is also possible that daily staffing-hours could also be reflective of the type of resident that a SNF cares for. For example, SNFs housing residents with more comorbidities and other advanced health needs might require RNs to spend more individual time administering specialized care to these residents, and their condition would also make them more susceptible to SARS-CoV-2 infection, which might also explain the unexpected increased IRR associated with greater daily RN hours per resident during Wave Two.

We also found that facility size, represented by the total number of certified beds, was not associated with resident COVID-19 case rates. This observation appears to contrast other studies that concluded larger facilities experienced more cases throughout the pandemic.[4,14] However, it should be noted that our assessment considers the rate of resident COVID-19 cases among all residents at a facility during Waves Two and Three of the epidemic in the state of Georgia rather than outright case counts. Additionally, our study encompasses Wave Two and Wave Three of the epidemic only, and, as our analyses

suggest, facility-level risk factors for increased resident IRR appear to change throughout the epidemic.

Finally, some of the study findings could be explained by COVID-19 dynamics occurring in the larger community. For instance, SNFs located outside metro-urban settings experienced increases in resident case rates during Wave Two, yet decreases in IRR during Wave Three. This association could be reflective of larger geographic trends in COVID-19, as the disease first took root in rural counties in the state of Georgia and shifted to densely populated urban centers as the epidemic progressed. [3] Similarly, fluctuations in hospital capacity and the number of critically ill COVID-19 patients throughout the epidemic could explain the changing associations between a SNF being located in a hospital and resident case rates across Waves.

Limitations

There are several limitations of this research that should be acknowledged. Because facilities were given the option to provide COVID-19 case counts that occurred prior to mandatory reporting began on May 8, the COVID-19 burden reflected in the Nursing Homes COVID-19 Public File is likely an undercount.[10] The self-reported nature of these data could also contribute to inaccuracies or systemic bias if facilities experiencing outbreaks were disproportionately likely to indicate shortages in supplies or personnel at the facility, for example. Restricting the outcome of interest to only include laboratory-confirmed COVID-19 cases amongst SNF residents and staff may also have contributed to underrepresentation of true case counts. True cumulative COVID-19 case and death counts

remain unknown, so outbreaks that occurred early in the epidemic were not considered in this analysis.

This study is not able to detect causal relationships, but rather identifies associations between facility-level characteristics and COVID-19 outcomes. We did not consider changes in the proportion of residents susceptible to COVID-19 resulting from prior outbreaks, which may partially explain the observed associations. Furthermore, many of the explanatory variables considered in this modeling assessment are likely proxies for underlying indicators of resident experience in a SNF. For example, total number of certified beds could be reflective of the non-human capital and extent of resources available on-site at a SNF in addition to indicating facility size. Similarly, positive associations between COVID-19 testing and resident case counts could simply represent case detection, or the relationship could be reflective of personnel and clinical supplies available to a facility or the rigor of infection prevention at a particular SNF. It is apparent that there are complex dynamics driving COVID-19 outbreak outcomes within nursing home facilities, and additional unmeasured components may influence the associations considered in this analysis. Existing literature suggests that the racial composition of a SNF and the extent of community transmission are important factors in infection risk that were not considered in this study.[13, 14] Other unmeasured confounders could include policy-driven COVID-19 interventions, fluctuations in the PPE supply chain throughout the pandemic, and vaccine rollout.

Recommendations

This assessment was unable to examine facility-level risk factors for increased resident COVID-19 incidence throughout the entirety of the pandemic, including Wave One (which lasted from March, 2020 through May 2021), due to lack of early reporting and quality data prior to May, 2020.[6] As the data sources are updated to include more detailed regarding early case counts, it may be possible to examine these relationships in future research. This would allow for the analysis of temporal variation in risk factors while also considering the decreasing proportion of residents and staff that are susceptible as a result of previous outbreaks and could be accomplished via mixed models.

Conclusions

By examining public CMS data on SNF characteristics and COVID-19 outcomes, we found that both fixed and time-varying facility-level characteristics were associated with laboratory-confirmed COVID-19 cases amongst residents of SNFs in the state of Georgia between May 31, 2020 and January 31, 2021, and associations often varied between Waves Two and Three of the epidemic. In both waves, larger numbers of staff cases and shortages of staff classified as "other" were associated with larger resident case rates, and greater numbers of staff hours per resident were generally associated with decreased resident case rates. Facilities with higher CMS 5-star ratings had smaller resident case rates in Wave Two but larger resident case rates in Wave Three. Similarly, facilities located in hospitals had smaller resident case rates in Wave Two and larger resident case rates in Wave Three. Finally, facilities in nonmetro-urban and nonmetro-rural areas, compared to metro-urban areas, had smaller resident case rates in Wave Two but larger resident case rates in Wave Three. These findings are likely partially explained by facility-level changes in the

proportion of residents susceptible to COVID-19, geographic distribution of community cases, burden of COVID-19 cases in hospitals during this time, and improvements in interventions and infection control over time. Studies examining associations between facility-level characteristics and cumulative COVID-19 case counts in SNFs are needed to examine causality.

Figures and Tables

Figure 1. Weekly COVID-19 cases among residents of CMS-certified SNFs, Georgia, USA: May 31, 2020 – January 31, 2021

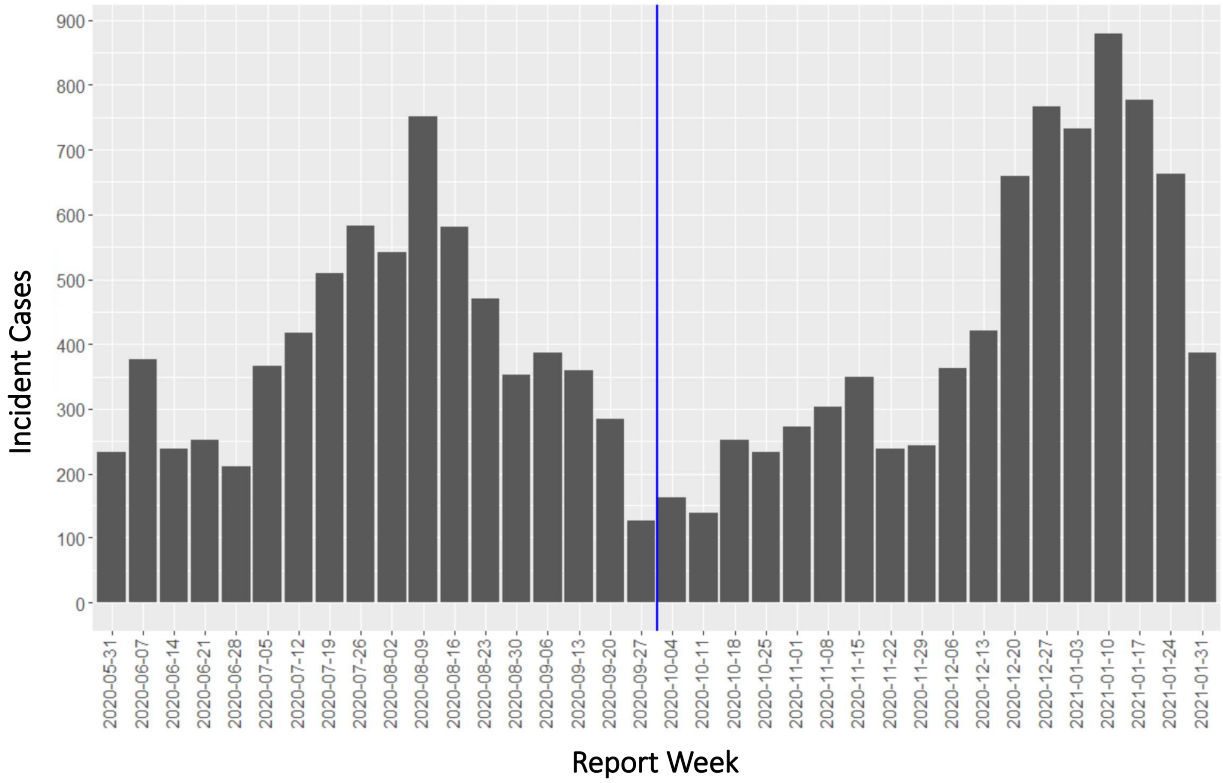

Fig 1. Epidemic curve representing laboratory-confirmed cases of COVID-19 among residents of CMS-certified SNFs between May 21, 2020 and January 31, 2021 in the state of Georgia. A vertical line separates between Waves two and three of the epidemic: cases to the left of the vertical line belong to Wave Two and cases to the right of the vertical line belong to wave three. Data were facility-reported and obtained from the CMS Nursing Home COVID-19 Public File.[10]

Table 1. Characteristics of CMS-Certified SNFs in Georgia, USA: May 31, 2020 - January 31, 2021

Facility Characteristic	Number of Facilities (%) (N = 332)
CMS 5-Star Rating	
1	86 (25.90)
2	65 (19.58)
3	71 (21.39)
4	60 (18.07)
5	47 (14.16)
Located in a Hospital	30 (9.04)
Metro-Urban Status	
Metro, Urban	202 (60.84)
Nonmetro, Rural	14 (4.22)
Nonmetro, Urban	116 (34.94)
Ownership	
For profit	217 (65.36)
Government	13 (3.92)
Non-profit	102 (30.72)
Physical Therapist Access	310 (93.37)
Hours per Resident per Day, median (IQR)	
Aides	1.96 (1.72, 2.21)
Licensed Practical Nurses	1.08 (0.93, 1.24)
Registered Nurses	0.43 (0.32, 0.58)
Total Beds, median (IQR)	100.00 (75.75, 107.76)

Facility-level characteristics that did not vary during the study period (May 31, 2020 to January 31, 2021).
Obtained from the publicly available CMS Provider Information dataset.[11]

Table 2. Time-Varying Characteristics of CMS-Certified SNFs in Georgia, USA: May 31, 2020 - January 31, 2021

	Wave 2	Wave 3
	Median (IQR) (N = 337)	**Median (IQR) (N = 337)**
Resident Cases	8.00 (1.00, 35.00)	13.50 (2.00, 34.00)
Resident Deaths	1.00 (0.00, 6.25)	1.00 (0.00, 4.00)
Staff Cases[a]	10.00 (4.00, 22.00)	13.00 (6.00, 22.00)
Proportion of Unoccupied Beds	0.23 (0.17, 0.32)	0.28 (0.22, 0.36)
Proportion of Weeks with Staff Shortages		
Aides	0.11 (0.00, 0.67)	0.06 (0.00, 0.83)
Licensed Staff (Clinical and Nursing)	0.11 (0.00, 0.58)	0.06 (0.00, 0.82)
Other Staff	0.06 (0.00, 0.17)	0.00 (0.00, 0.12)
Proportion of Weeks Testing[b]		
All Asymptomatic Residents	0.00 (0.00, 0.29)	0.13 (0.00, 0.38)
All Asymptomatic Staff	0.00 (0.00, 0.14)	0.13 (0.00, 0.25)
Symptomatic Residents	0.00 (0.00, 0.29)	0.00 (0.00, 0.13)
Symptomatic Staff	0.00 (0.00, 0.14)	0.00 (0.00, 0.13)
Supply Shortage, No. (%)		
Hand Sanitizer	62 (18.84)	40 (12.12)
Masks (N95 and surgical masks)	27 (9.09)	24 (7.55)

Facility-level characteristics that varied throughout the study period.
Wave 2 lasted from May 31, 2020 to September 30, 2020. Wave 3 lasted from October 1, 2020 to January 31, 2021.
Obtained from the publicly available CMS COVID-19 Nursing Home Dataset.[11]
[a] Laboratory-confirmed COVID-19 cases amongst SNF staff-members
[b] Proportion of SNF reports indicating that resident or staff-members were actively tested for COVID-19 based on symptomology

Table 3. Bivariable associations between explanatory variables and SNF resident laboratory-confirmed COVID-19 case incidence rate ratio, Georgia, USA: May 31, 2020 - January 31, 2021

	Wave 2		**Wave 3**	
Independent Variable	IRR	95% CI	IRR	95% CI
CMS 5-Star Rating				
1	*ref*	*ref*	*ref*	*ref*
2	0.77	(0.49, 1.23)	1.09	(0.72, 1.66)
3	1.03	(0.66, 1.63)	0.96	(0.64, 1.45)
4	0.99	(0.62, 1.61)	1.27	(0.83, 1.96)
5	0.82	(0.49, 1.38)	1.01	(0.64, 1.63)
Hours per Resident per Day				
Aides	0.86	(0.61, 1.25)	0.94	(0.71, 1.27)
Licensed Practical Nurses	1.00	(0.64, 1.63)	0.73	(0.49, 1.12)
Registered Nurses	1.18	(0.61, 2.42)	0.71	(0.40, 1.34)
Located in a Hospital	1.01	(0.61, 1.80)	1.01	(0.69, 1.85)
Metro-Urban Status				
Metro, Urban	*ref*	*ref*	*ref*	*ref*
Nonmetro, Rural	1.67	(0.83, 3.96)	0.69	(0.36, 1.50)
Nonmetro, Urban	1.51	(1.10, 2.10)	0.92	(0.69, 1.24)
Ownership				
For Profit	*ref*	*ref*	*ref*	*ref*
Government	0.71	(0.34, 1.77)	0.98	(0.50, 2.20)
Non-profit	1.00	(0.72, 1.42)	0.90	(0.67, 1.23)
Physical Therapist Access	1.40	(0.65, 2.66)	1.14	(0.57, 2.05)
Proportion of Unoccupied Beds	2.94	(0.68, 13.60)	0.23	(0.07, 0.85)
Proportion of Weeks with Staff Shortages				
Aides	1.28	(0.85, 1.95)	1.11	(0.79, 1.56)
Licensed Staff	1.34	(0.89, 2.08)	1.04	(0.74, 1.48)
Other Staff	1.62	(0.96, 2.86)	1.09	(0.73, 1.69)
Proportion of Weeks Testing[a]				
All Asymptomatic Residents	3.11	(1.56, 6.54)	2.35	(1.40, 4.05)
All Asymptomatic Staff	2.94	(1.41, 6.51)	2.59	(1.56, 4.45)
Symptomatic Residents	3.41	(1.69, 7.32)	4.51	(2.16, 10.29)
Symptomatic Staff	1.99	(0.94, 4.59)	2.58	(1.30, 5.59)
Staff Cases[b]	1.06	(1.05, 1.07)	1.07	(1.06, 1.08)
Supply Shortage				
Hand Sanitizer	1.13	(0.77, 1.71)	1.11	(0.74, 1.76)
Masks (N95 and Surgical)	1.07	(0.62, 2.00)	1.04	(0.62, 1.88)
Total Beds	1.00	(1.00, 1.00)	1.00	(0.99, 1.00)

[a] Proportion of SNF reports indicating that resident or staff-members were actively tested for COVID-19 based on symptomology
[b] Laboratory-confirmed COVID-19 cases amongst SNF staff-members
Abbreviations: CI = Confidence Interval; CMS = Centers for Medicare and Medicaid Services; COVID-19 = Coronavirus Disease 2019; IRR = Incidence Rate Ratio; SNF = Skilled nursing facility.
Wave 2 lasted from May 31, 2020 to September 30, 2020. Wave 3 lasted from October 1, 2020 to January 31, 2021.

Table 4. Multivariable associations between explanatory variables and SNF resident laboratory confirmed COVID-19 case incidence rate ratio, Georgia, USA: May 31, 2020 - January 31, 2021

	Wave 2		**Wave 3**	
Independent Variable	IRR	95% CI	IRR	95% CI
CMS 5-Star Rating				
1	*ref*	*ref*	*ref*	*ref*
2	0.79	(0.65, 0.96)	1.05	(0.90, 1.23)
3	0.67	(0.54, 0.83)	0.85	(0.73, 0.99)
4	0.62	(0.50, 0.77)	1.19	(1.00, 1.41)
5	0.53	(0.40, 0.70)	1.31	(1.08, 1.60)
Hours per Resident per Day				
Aides	0.81	(0.68, 0.97)	0.72	(0.64, 0.82)
Licensed Practical Nurses	0.66	(0.51, 0.85)	0.69	(0.57, 0.86)
Registered Nurses	2.19	(1.54, 3.13)	0.76	(0.58, 1.01)
Located in a Hospital	0.64	(0.47, 0.88)	1.41	(1.11, 1.80)
Metro-Urban Status				
Metro, Urban	*ref*	*ref*	*ref*	*ref*
Nonmetro, Rural	1.18	(0.85, 1.68)	0.34	(0.25, 0.46)
Nonmetro, Urban	1.46	(1.25, 1.70)	0.79	(0.70, 0.89)
Ownership				
For Profit	*ref*	*ref*	*ref*	*ref*
Government	0.71	(0.47, 1.09)	1	(0.71, 1.42)
Non-profit	1.11	(0.93, 1.32)	1.05	(0.92, 1.20)
Physical Therapist Access	1.05	(0.76, 1.42)	1.89	(1.27, 2.77)
Proportion of Unoccupied Beds	2.96	(1.42, 6.19)	0.24	(0.14, 0.40)
Proportion of Weeks with Staff Shortages				
Aides	0.93	(0.63, 1.38)	1.43	(1.14, 1.80)
Licensed Staff	0.72	(0.49, 1.06)	0.73	(0.53, 1.02)
Other Staff	3.32	(2.42, 4.57)	3.34	(2.04, 5.48)
Proportion of Weeks Testing[a]				
All Asymptomatic Residents	1.59	(0.91, 2.85)	0.31	(0.20, 0.48)
All Asymptomatic Staff	1.96	(1.05, 3.60)	1.77	(1.36, 2.28)
Symptomatic Residents	3.69	(2.40, 5.72)	0.88	(0.56, 2.37)
Symptomatic Staff	0.31	(0.20, 0.50)	0.79	(0.51, 1.22)
Staff Cases[b]	1.07	(1.06, 1.07)	1.08	(1.08, 1.09)
Supply Shortage				
Hand Sanitizer	0.52	(0.40, 0.71)	0.7	(0.50, 0.99)
Masks (N95 and Surgical)	1.87	(1.30, 2.67)	0.85	(0.62, 1.17)
Total Beds	1.00	(1.00, 1.00)	1.00	(1.00, 1.00)

[a] Proportion of SNF reports indicating that resident or staff-members were actively tested for COVID-19 based on symptomology
[b] Laboratory-confirmed COVID-19 cases amongst SNF staff-members
Abbreviations: CI = Confidence Interval; CMS = Centers for Medicare and Medicaid Services; COVID-19 = Coronavirus Disease 2019; IRR = Incidence Rate Ratio; SNF = Skilled nursing facility.
Wave 2 lasted from May 31, 2020 to September 30, 2020. Wave 3 lasted from October 1, 2020 to January 31, 2021.

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Supplementary Materials

Figure S1. Directed Acyclic Graph (DAG) representing causal relationships among variables considered for multivariable assessment

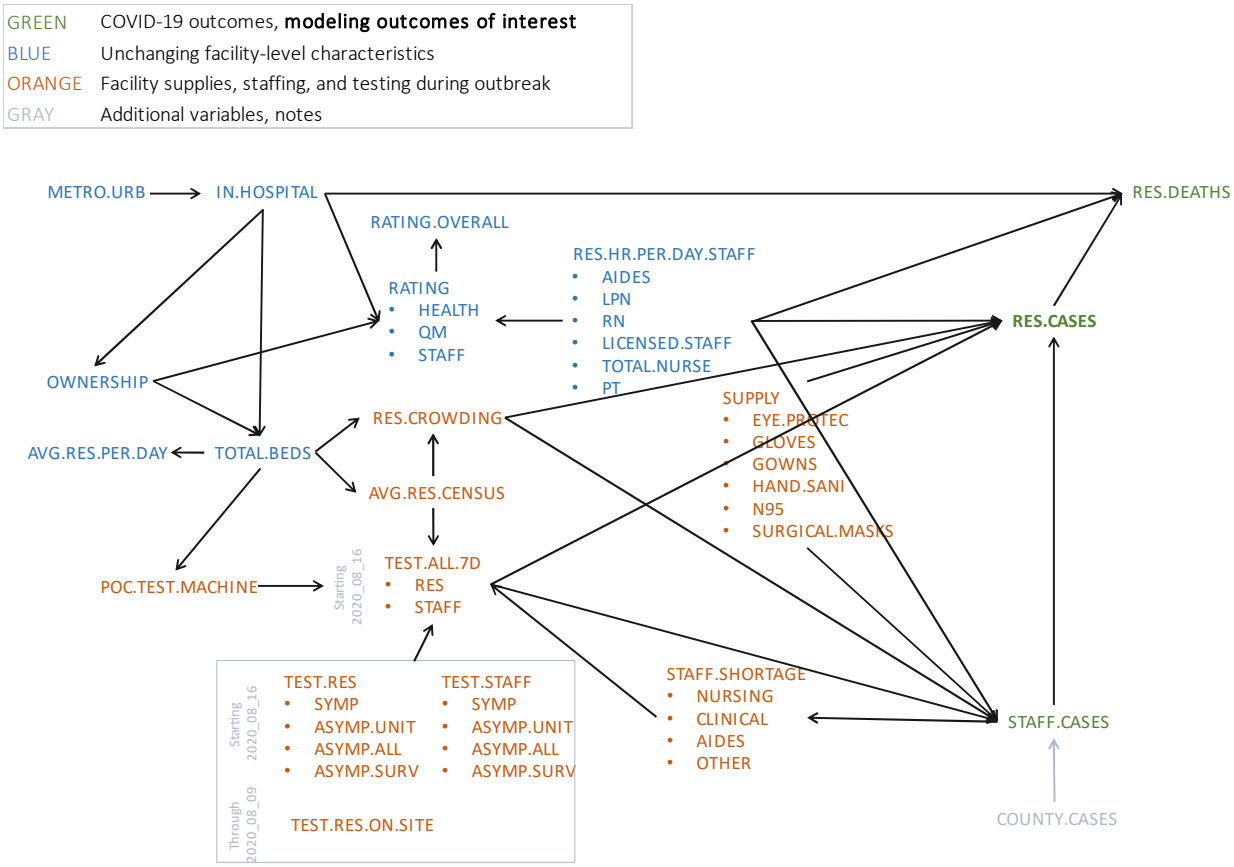

Fig S1. Causal relationships between fixed and time-varying exposures and COVID-19-related outcomes of skilled nursing facilities that are included in the CMS Nursing Home COVID-19 Public File and Provider Information datasets.[10,11]

Figure S2. Weekly COVID-19 deaths among residents of CMS-certified SNFs, Georgia, USA: May 31, 2020 – January 31, 2021

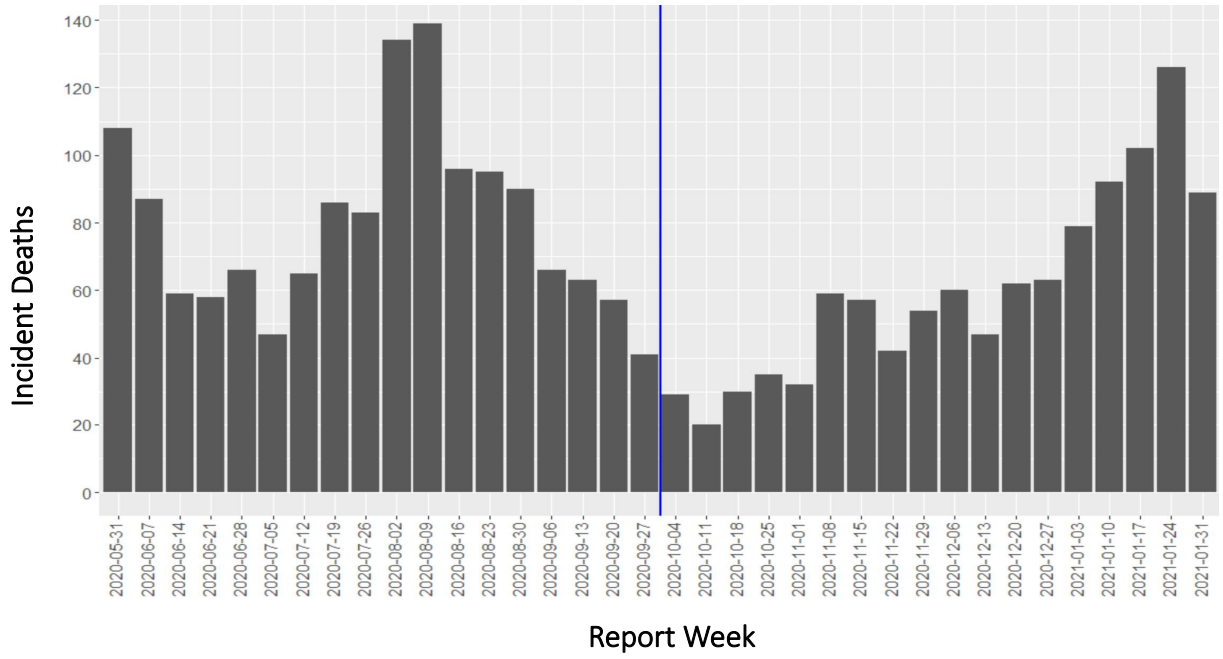

Fig S2. Epidemic curve representing deaths attributed to laboratory-confirmed COVID-19 among residents of CMS-certified SNFs between May 21, 2020 and January 31, 2021 in the state of Georgia. A vertical line separates between Waves two and three of the epidemic: deaths to the left of the vertical line belong to Wave Two and deaths to the right of the vertical line belong to wave three. Data were facility-reported and obtained from the CMS Nursing Home COVID-19 Public File.[10]

Figure S3. Overdispersion of Resident COVID-19 Case Counts among CMS-certified SNFs, Georgia, USA: May 31, 2020 – January 31, 2021

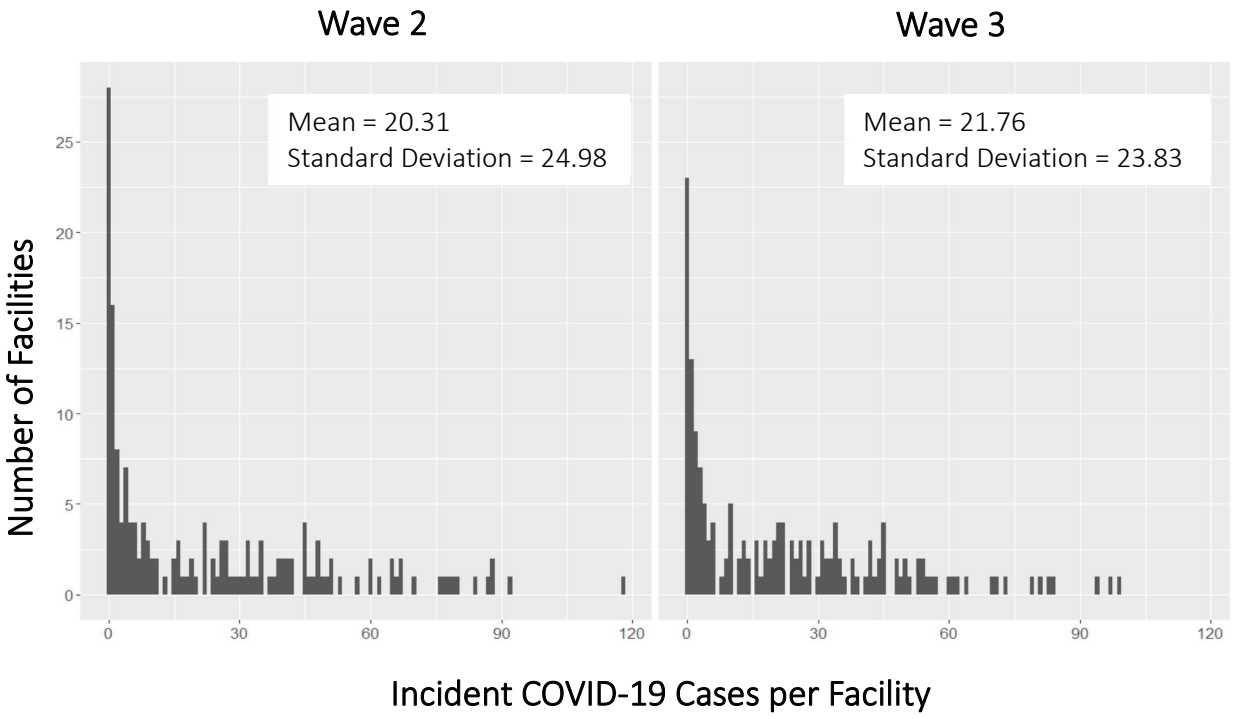

Fig S3. Distribution of the outcome variable, laboratory-confirmed incident COVID-19 cases among CMS-certified SNFs (N = 332), during Waves two and three of the epidemic exhibit overdispersion. Wave Two lasted from May 31, 2020 to September 30, 2020. Wave three lasted from October 1, 2020 to January 31, 2021. Data were facility-reported and obtained from the CMS Nursing Home COVID-19 Public File.[10]

Table S1. Codebook of Variables included in Negative Binomial Regression Models

Variable	Definition	Classification
Resident Cases	Cumulative incident laboratory-confirmed COVID-19 cases among residents during outbreak wave	Continuous
Average Resident Census	Average number of residents at facility during outbreak wave	Continuous
CMS 5-Star Rating	Overall 5-Star Rating assigned by CMS based on assessments of health, quality management, and staffing such that a higher score indicates greater proficiency	Categorical (1, 2, 3, 4, 5)
Hours per Resident per Day		
Aides[a]	Reported average nursing aide staffing hours per resident per day at facility	Categorical
Licensed Practical Nurses (LPNs)[a]	Reported average licensed practical nurse (LPN) staffing hours per resident per day at facility	Categorical
Registered Nurses (RNs)[a]	Reported average registered nurse (RN) staffing hours per resident per day at facility	Categorical
Located in a Hospital	Indicates whether facility resides in hospital	Dichotomous
Metro-Urban Status	Metro and urban classification of the county in which a facility is located	Categorical (Metro-Urban, Nonmetro-Urban, Nonmetro-Rural)
Ownership	Nature of organization that operates the facility	Categorical (For-profit, Government, Non-profit)
Physical Therapist Access[a]	Any physical therapist staffing hours per resident per day	Dichotomous
Proportion of Unoccupied Beds[a]	Average proportion of empty beds per facility	Continuous ($0 \leq x \leq 1$)
Proportion of Weeks with Staff Shortage		
Aides[a]	Proportion of reports indicating shortage of aides: certified nursing assistants, nurse aides, medication aides, and medication technicians	Continuous ($0 \leq x \leq 1$)
Licensed Staff[a]	Proportion of reports indicating shortage of licensed staff: physicians, physician assistants, advance practice nurses	Continuous ($0 \leq x \leq 1$)
Other[a]	Proportion of reports indicating shortage of other staff or facility personnel, regardless of clinical responsibility or resident contact, not included in the other staff categories	Continuous ($0 \leq x \leq 1$)
Proportion of Weeks Testing		
All Asymptomatic Residents[a]	Proportion of reports indicating that asymptomatic residents facility-wide were tested following a case	Continuous ($0 \leq x \leq 1$)

All Asymptomatic Staff[a]	Proportion of reports indicating that asymptomatic staff facility-wide were tested following a case	Continuous ($0 \leq x \leq 1$)
Symptomatic Residents[a]	Proportion of reports indicating that residents were tested after developing new symptoms	Continuous ($0 \leq x \leq 1$)
Symptomatic Staff[a]	Proportion of reports indicating that staff were tested after developing new symptoms	Continuous ($0 \leq x \leq 1$)
Staff Cases[a]	Cumulative incident laboratory-confirmed COVID-19 cases among staff	Continuous
Supply Shortage		
Hand Sanitizer[a]	Indicates whether the facility ever reported not having enough hand sanitizer supply to last one week	Dichotomous
Masks[a]	Indicates whether the facility ever reported simultaneously not having enough N95 or surgical mask supply to last one week	Dichotomous
Total Beds	Total number of federally certified beds at facility	Continuous

Data were obtained from the CMS Nursing Home COVID-19 Public File and Provider Information datasets.[10,11]

[a] Variable is time-varying and value is specific to the corresponding wave.