

**Associations Between Operational Characteristics and COVID-19 Outbreaks in Skilled  
Nursing Facilities –Allegheny County, PA, 2020**

by

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# **Associations Between Operational Characteristics and COVID-19 Outbreaks in Skilled Nursing Facilities –Allegheny County, PA, 2020**

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University of Pittsburgh, 2022

## **Abstract**

The coronavirus disease 2019 (COVID-19) pandemic impacted many but disproportionately affected nursing home residents, older adults and those with underlying medical conditions – who are often vulnerable to COVID-19 and its adverse outcomes. Previous studies have focused on associations between nursing home characteristics and COVID-19 at the state or multi-state level. The objective of this study is to analyze associations between pre-COVID-19 skilled nursing facility characteristics and 2020 COVID-19 outbreaks in Allegheny County by number of outbreaks by facility, cases per 100,000 person hours, and outbreak duration (days). Studying COVID-19 nursing home outbreaks is crucial to help mitigate future outbreaks in terms of frequency, duration, and severity. Identifying significant factors can direct mitigation recommendations and policy decisions to better protect our older residents.

Data analysis, statistical testing—mainly Fisher’s Exact, Wilcoxon Rank Sum, and Kruskal-Wallis, and quantile regression modeling was performed on the Allegheny County COVID-19 skilled nursing facility 2020 outbreak data from the Pennsylvania National Electronic Disease Surveillance System (PA-NEDSS). Several Centers for Medicare and Medicaid Service (CMS) datasets containing nursing home characteristics were also analyzed.

Fifty-nine Allegheny County skilled nursing facilities and 133 COVID-19 outbreaks met eligibility criteria for analysis –an active facility at the start of 2020, not a hospital-based facility, and outbreaks with at least one COVID-19 case. Overall, any amount of clinical staffing shortages

was associated ( $P < 0.05$ ) with outbreak duration (days) in the bivariate and multivariate regression analyses. Survey rating was associated with cases per 100,000 person-hours ( $P < 0.05$ ) in the bivariate and regression analyses. Presence of any nursing/physician deficiencies was significantly associated ( $P < 0.01$ ) with the number of COVID-19 outbreaks in a facility in the bivariate analysis.

The results of this analysis have demonstrated that specific skilled nursing facility characteristics may provide insight to the magnitude and length of facilities' COVID-19 outbreaks. Continuous research, surveillance, and changes in skilled nursing facilities are needed to monitor and mitigate the spread and effects of COVID-19. This study is of public health relevance because it helps inform future research and decision making necessary to control transmission of the SARS-CoV-2 virus in nursing homes.

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## **1.0 Introduction**

### **1.1 Background**

A new infectious disease called coronavirus disease 2019 (COVID-19) was declared a global pandemic on March 11, 2020 by the World Health Organization (WHO).<sup>1</sup> A year after being declared a pandemic, there were over 3 million confirmed COVID-19 cases and over 62,000 deaths, (March 15, 2021) with numbers still continuing to rise world-wide.<sup>2</sup>

COVID-19 is caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The primary transmission method of SARS-CoV-2 is through respiratory droplets expelled from an infected person's mouth or nose.<sup>3</sup> This transmission can be through direct contact with droplets or indirect contact with the droplets on surfaces in the environment.<sup>4</sup> Presentation of COVID-19 can range from asymptomatic to fatal. Most people experience mild to moderate respiratory illness and can recover from COVID-19 without requiring hospitalization or specialized treatment, but some SARS-CoV-2 patients become severely ill and require medical attention and treatment. Severely ill patients with COVID-19 may develop significant complications such as acute respiratory distress syndrome (ARDS) requiring prolonged ventilatory support, cardiac injury, cardiac rhythm disorders, shock and death.<sup>4</sup>

Everyone is at risk for SARS-CoV-2 infection. However, older adults and those with underlying medical conditions are more likely to develop severe symptoms and have a higher risk of mortality.<sup>5,6</sup> In the US, over 80% of COVID-19 deaths occurred in those 65 years of age or older by the end of 2020. The COVID-19 mortality rate among people over age 65 was almost 208 times higher than the rate among those aged 18-29.<sup>7,8</sup> The most frequently listed comorbidities with

COVID-19 on death certificates were hypertension (20.6%, 79,227 deaths), diabetes (16.3%, 62,611 deaths) and Alzheimer disease and other Dementias (15.1%, 58,202 deaths), conditions more prevalent in older populations.<sup>9</sup>

Nursing homes, unsurprisingly, have been disproportionately impacted by the COVID-19 pandemic due to the large population of older adults and those with underlying medical conditions.<sup>10,11</sup> In the week ending on December 27, 2020, the 7-day confirmed COVID-19 case rate was 27.2 per 100,000 residents for nursing homes as compared to 3.9 per 100,000 individuals in the US.<sup>2,12</sup>

To help mitigate the spread of COVID-19 among nursing homes, the Centers for Medicare & Medicaid Services (CMS) and the Centers for Disease Control and Prevention (CDC) released a comprehensive document on April 2, 2020, with guidance on infection control practices, personal protective equipment (PPE), symptom screening, and staffing.<sup>13</sup> Other recommended strategies to reduce the risk of COVID-19 infection in nursing homes included discontinuing use of common dining areas, canceling all group activities, restricting visitors, and eliminating use of volunteers and other nonessential personnel.<sup>14</sup> In addition to the release of COVID-19 mitigation guidance, CMS also required nursing homes to report COVID-19 facility data to the CDC beginning on May 8, 2020, to assist with national surveillance of COVID-19 in nursing homes and support actions to protect the health and safety of nursing home residents.<sup>15</sup>

Recent analysis of COVID-19 cases and nursing homes in observational studies found that larger facility size, urban location, greater percentage of African American residents, non-chain status, and state (WA as the reference – CT, NJ, MA, and GA) were significantly associated with having a COVID-19 case.<sup>16</sup> However, traditional quality measures such as five-star ratings and prior infection control violations were not related to COVID-19 cases.<sup>17</sup> Medicaid dependency and

ownership were also not significantly related.<sup>18</sup> Among staffing characteristics, higher nurse aide hours and total nursing hours were associated with a lower probability of a larger outbreak and fewer deaths. On the other hand, higher registered nurse hours were associated with a higher probability of experiencing any COVID-19 cases.<sup>19</sup> The occurrence of COVID-19 cases in nursing homes is inevitable but more research is needed to better assess the relationship between COVID-19 outbreaks and skilled nursing home characteristics.

## **1.2 Gaps in Knowledge**

The relationship between the number of COVID-19 cases and nursing home characteristics has been well studied on state and multi-state levels. However, further investigation is needed to discern relationships between skilled nursing facility characteristics and COVID-19 outbreaks within these facilities. There are also few analyses that evaluate the association between COVID-19 outbreaks and skilled nursing facility characteristics at a county level.

## **1.3 Public Health Significance**

Better understanding of COVID-19 outbreaks among skilled nursing facilities is crucial to help mitigate future outbreaks in terms of frequency, duration, and severity. Identifying significant factors and trends can help to direct mitigation recommendations and drive policy decisions to better protect our older and vulnerable residents.

## **2.0 Objectives**

The proposed aim of this analysis was to explore the relationship between pre-COVID-19 skilled nursing facility characteristics and COVID-19 outbreaks that occurred in 2020, in terms of number of outbreaks by facility, cases per 100,000 person hours, and outbreak duration (days) within Allegheny County.

### **3.0 Methods**

#### **3.1 Allegheny County COVID-19 Skilled Nursing Facility Outbreaks**

The COVID-19 outbreak data for 2020, as reported in the Pennsylvania National Electronic Disease Surveillance System (PA-NEDSS), were used to examine and identify relationships between Allegheny County skilled nursing facility outbreaks and facility characteristics. The 2020 outbreak data for skilled nursing facilities include COVID-19 outbreaks (N = 148 outbreaks) initiated in 2020 (up to December 31<sup>st</sup> 2020) at skilled nursing facilities located in Allegheny County (N = 61 facilities). The time period was selected to precede the effects of the Pfizer-BioNTech COVID-19 vaccine, approved on December 11, 2020 for Emergency Use Authorization by the Food and Drug Administration (FDA).<sup>20</sup> Facilities reported names and dates of birth of COVID-19 confirmed and probable cases of residents and staff to ACHD. These names were used to assign cases to appropriate COVID-19 outbreaks in PA-NEDSS. Laboratory reports of COVID-19 tests and patient information are entered into PA-NEDSS by labs and facilities daily. Long term care facility outbreaks are defined by the Council of State and Territorial Epidemiologists (CSTE) as having at least one confirmed or probable case who is a resident or staff member and was within the facility within 48 hours of symptom onset. Confirmed cases are supported by confirmatory laboratory evidence: detection of SAR-CoV-2 ribonucleic acid through a clinical or autopsy specimen using a molecular amplification test. Probable cases are supported by a positive antigen test, clinical criteria and epidemiologic linkage with no confirmatory laboratory evidence, or death certificate documentation with no confirmatory laboratory evidence. Outbreaks concerning Allegheny County long term care facilities are considered closed once 28 days have passed without

the report of a new COVID-19 case at the facility. The data analyzed include information on the long-term care facility outbreaks and associated cases in PA-NEDSS, including the total number of linked cases to a specific outbreak, along with symptom onset dates of first and last outbreak case, and test reporting dates of first and last outbreak case.

## **3.2 Centers for Medicare and Medicaid Services (CMS) Datasets**

### **3.2.1 COVID-19 Nursing Home Data**

The Nursing Home COVID-19 public file includes data reported by nursing homes to the CDC's National Healthcare Safety Network (NHSN) Long Term Care Facility (LTCF) COVID-19 Module: Surveillance Reporting Pathway.<sup>21</sup> The dataset contains weekly reporting from certified skilled nursing facilities: COVID-19 cases among residents and staff, COVID-19 deaths, staff shortages and personal protective equipment (PPE) shortages. The first reported data are for the week ending on 5/24/2020 but facilities may have opted to report cumulative data retrospectively back to January 1, 2020. The 2020 COVID-19 nursing home data for Allegheny County facilities were used for this analysis.

### **3.2.2 Provider Information**

The CMS Provider Information dataset contains general information on currently active skilled nursing homes, including number of certified beds, quality measure scores, staffing and other information used in the CMS Five-Star Rating System.<sup>22</sup> The rating system covers three

dimensions of nursing home quality: health inspection results, staffing data, and quality measure data, as well as a composite of these three dimensions into an overall rating.<sup>23</sup> Health Inspection Survey ratings are based on outcomes from the state health inspections. Staffing ratings are determined by measures based on nursing home staffing levels. Quality measures ratings account for resident-level quality measures, CMS quality measure performances, and the Minimum Data Set (MDS). The MDS summarizes information for residents currently in nursing homes by calendar quarter.<sup>24</sup> The December 2019 CMS Provider Information dataset was used for this analysis. The dataset was filtered by county to only include Allegheny County facilities (n = 61).

### **3.2.3 Payroll Based Journal for Daily Nurse and Non-Nurse Staffing**

The Payroll Based Journal (PBJ) Nurse Staffing and Non-Nurse Staffing quarterly datasets provide information, including rehabilitation services, submitted by nursing homes to CMS through the PBJ system. The data include the hours staff are paid to work each day for each active facility. The nurse staffing dataset includes categories such as Director of Nursing, Administrative Registered Nurses, Registered Nursing, Administrative Licensed Practice Nurses, Licensed Practice Nurses, Certified Nurse Aides, Certified Medication Aides, and Nurse Aides in Training. The non-nurse staffing dataset includes categories such as Respiratory Therapist, Occupational Therapist, and Social Worker. The datasets also include a facility's daily resident census calculated using the MDS submission.<sup>25</sup> The Q4 2019 PBJ nurse staffing dataset and the Q1 to Q4 2020 PBJ nurse and non-nurse staffing datasets for Allegheny County facilities were accessed and used for analysis.

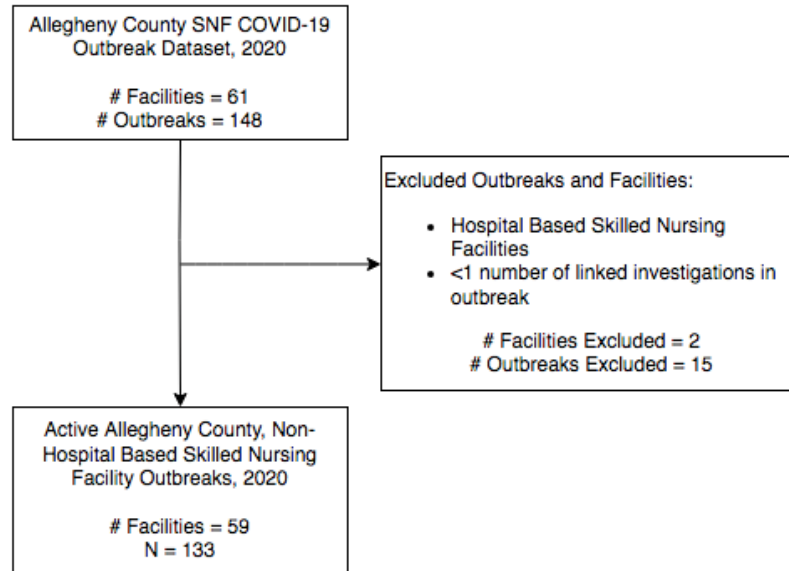
### **3.2.4 Health Deficiencies**

The CMS Health Deficiencies data include nursing home health citations in the last three years, including the name of the facility that received the citation, the associated inspection date, the citation tag number and description, the scope and severity, the current status of the citation and the correction date.<sup>26</sup> Deficiency categories include infection control deficiencies, quality of life and care deficiencies, nursing and physician services deficiencies, and other deficiencies. The scope of the deficiency is determined by how extensive it is in terms of it being an isolated event, a pattern, or a widespread issue. The severity of a deficiency is determined by the degree of harm to residents, ranging from no actual harm but with potential for minimal harm to immediate jeopardy to resident health or safety. The combination of scope and severity determines the health inspection score, which is a lettered score.<sup>27</sup> Health inspection scores of J, K, L, H, I and F constitute substandard quality of care under certain conditions. Health deficiencies from the latest 2019 scheduled state health inspection for each Allegheny County facility were used and any complaint-based deficiencies were excluded.

### **3.3 COVID-19 Outbreak Inclusion and Exclusion Criteria**

The 2020 Allegheny County COVID-19 outbreak data included information on 148 skilled nursing facility outbreaks. Outbreaks that occurred in hospital based skilled nursing facilities and outbreaks with 0 linked investigations were excluded (N = 15) (Figure 1). Of the 61 active skilled nursing facilities in Allegheny County, 2 hospital-based facilities were excluded.





**Figure 1. COVID-19 Skilled Nursing Facility Outbreak Exclusion and Inclusion Flowchart, Allegheny County**

### 3.4 Outcome Variables

Outbreak outcomes examined were number of outbreaks for each active nursing home facility, the length of an outbreak in days, and the number of cases per 100,000 person (resident and staff) hours. The length of an outbreak (days) was calculated using the earliest and latest symptom onset date of associated outbreak cases. If symptom onset dates were unavailable, earliest and latest report dates were used (N = 10). To adjust for instances when earliest and latest onset or test report dates were the same dates, resulting in a length of outbreak being 0 days, an addition of 1 was performed on the outcome variable for all observations. The number of cases per 100,000 person-hours was calculated using the number of linked COVID-19 cases in each outbreak and the total staffing and resident person hours from the 2020 PBJ dataset (January 1, 2020 to December 31, 2020 data) and COVID-19 Nursing Home dataset (April 19, 2020 to December 31, 2020 data—

with some facilities that had opted to report cumulative data retrospectively back to January 1, 2020).

### 3.5 Facility Characteristics and Factors

Nursing facility characteristics and factors examined included operational characteristics, staffing hours, quality measures, and operational shortages from several CMS datasets.

**Table 1. Detailed Skilled Nursing Facility 2019-2020 Characteristics and Factors**

<b>Facility Characteristics and Factors</b>	<b>Description</b>
<i>Facility Size</i>	Facilities were categorized based on the number of certified/licensed beds each contained. Small was defined by 0 to 119 beds, Medium by 120 to 269, and Large by 270 or more beds.
<i>Ownership Type</i>	Reported ownership information to the PA Department of Health was classified as profit or non-profit.
<i>Ratings</i>	Overall, Survey (Health Inspection), Quality, and Staffing ratings as defined by the CMS Five Star Ratings of 1-3 were categorized as "Low Rating" and those scored 4-5 were categorized as "High Rating".
<i>Deficiencies (Type)</i>	Any scheduled inspection infection control, nursing and physician, quality of life and care, and high severity deficiencies were included. High severity deficiencies were defined as having health inspection scores of J, K, L, H, I or F. Variables were defined as Yes/No by facility.
<i>Limited 1 Week Supply</i>	2020 weekly facility reported supply shortages of PPE for N95 masks, surgical masks, eye protection, gowns, gloves, and hand sanitizer were categorized as Yes/No by facility.
<i>Staffing Shortage</i>	2020 weekly facility reported staffing shortages of personnel for clinical, aide, nursing, or other types of staff were defined as Yes/No by facility.
<i>Average Number of Residents Per Day</i>	Average numbers of residents per day were calculated for each facility utilizing data from the Q4 2019 PBJ dataset.
<i>Number of Inspection Deficiencies</i>	Total number of inspection deficiencies by facility from the latest scheduled inspection conducted in 2019. Does not include complaint based deficiencies.
<i>Total Staff Hours Per Resident Day (HPRD)</i>	Staffing hours per resident day for register nurses (RN), licensed practical nurses (LPN), certified nursing assistants (CNA), nurse aides (NA) in training, direct care staffing (RN, LPN, CAN, and NA), professional staff (RN and LPN) were calculated for each facility from the Q4 2019 PBJ dataset.
<i>Professional to Non-Professional Staff</i>	The proportion of professional (RN and LPN) to non-professional (CNA) staffing was calculated for each facility.

### **3.6 Statistical Analysis**

Overall frequencies and descriptive statistics were examined for each outcome variable and each facility variable. Bivariate analysis for each outbreak outcome (number of outbreaks, length of outbreak, and cases per 100,000 person-hours) with each facility characteristic was completed using appropriate parametric and non-parametric statistical tests and multivariate analysis. Parametric tests used were Chi-Squared and 1-way ANOVA. Non-parametric tests used were Wilcoxon Rank Sum, Kruskal-Wallis, Fisher's Exact, and Spearman's correlation. Quantile regression was used for multivariate analysis. Statistically significant independent variables from the bivariate statistical tests were included in the regression models. Collinear variables were identified and the models were reduced to determine the most suitable one. Statistical analyses were performed in SAS 9.4.

## 4.0 Results

A majority of the 59 Allegheny county skilled nursing facilities were small and medium sized (37.3% and 59.3%, respectively), with less than 270 certified beds, and half (50.9%) were owned by non-profit organizations (Table 2). Prior to the COVID-19 pandemic, less than half of these facilities had high ratings (rating of 4 or 5) across the CMS Five Star Rating System categories. The proportions of facilities with high overall, survey, quality, and staffing ratings were 46.6%, 37.9%, 46.6%, and 36.2%, respectively. Of the three types of health inspection deficiencies examined, quality of life and care deficiencies were the most frequent type noted (62.7%) among the 59 facilities. On average, each facility had 6.0 deficiencies (SD = 4.9) from their latest 2019 scheduled health inspection. Among the 59 skilled nursing facilities, 83.1% of these facilities experienced two or more outbreaks and 37.3% of the facilities experienced three or more outbreaks. During the COVID-19 pandemic, many facilities experienced PPE and staffing shortages. Just over half of facilities experienced N95 mask shortages (52.5%) and gown shortages (50.9%) at least once during 2020. Almost half of facilities had aide (45.8%) and nursing (42.4%) personnel shortages at least once.

Of the 133 COVID-19 skilled nursing facility outbreaks that occurred in Allegheny County in 2020, most occurred in small and medium sized facilities (36.8% and 58.7%, respectively) (Table 2). Similarly, most outbreaks occurred in non-profit facilities (52.6%). Outbreak distribution also followed similar frequencies and means seen in facility characteristics for the CMS Five Star Rating System categories, type of deficiency, PPE shortages, staffing shortages, and number of deficiencies. On average, outbreaks had 60.9 cases per 100,000 person hours and lasted 59.8 days (SD = 66.05).

Having any nursing and physician deficiencies was significantly ( $P < 0.01$ ) associated with the number of COVID-19 outbreaks in a facility (Table 3). Other types of deficiencies, including facility size, PPE shortages, staffing shortages, and staffing hours were not significantly associated with the number of COVID-19 outbreaks in a facility.

The length of outbreak (days) was significantly associated with facility size, survey rating, and having any clinical staffing shortages ( $P < 0.05$ ) (Table 4). Average number of residents per day and number of health inspection deficiencies were also associated with length of outbreak (days) ( $P < 0.05$ ). Other ratings, deficiencies, PPE shortages, other staffing shortages, and staff hours were not significantly associated with outbreak length.

The distribution of number of cases per 100,000 person hours significantly differed by high and low survey rating ( $P < 0.05$ ) (Table 5). Facility characteristics, deficiencies, shortages, and other ratings were not significantly associated with number of cases.

In multivariate quantile regression analyses, clinical staff shortage was significantly associated with length of outbreak (days), adjusted for number of certified beds (Table 6). At the 0.75 quantile level, having no clinical staffing shortage was estimated to have 68.0 fewer outbreak days compared to a facility with any clinical staffing shortage ( $P < 0.05$ ). There were no significant associations with length of outbreak (days) and several other characteristics, including facility size, survey rating, clinical staff shortage, number of inspection deficiencies and average number of residents with adjustment for number of certified beds. The outcome variable, cases per 100,000 person hours, in the quantile regression model with survey rating and adjustment for number of certified beds resulted in survey rating being statistically significant ( $p < 0.05$ ) at the 0.25 quantile level (Table 7). Cutoff values for the corresponding outcome variables and quantile levels can be found in Appendix A (Appendix Table 1).

**Table 2. Characteristics of Allegheny County Skilled Nursing Facilities and COVID-19 Outbreaks**

Categorical Variables	Outbreak (N = 133) n (%)	Facility (N = 59) n (%)
Any Outbreak:		
<i>0-1 Outbreaks</i>	-	10 (16.9%)
<i>2 Outbreaks</i>	-	27 (45.8%)
<i>&gt;2 Outbreaks</i>	-	22 (37.3%)
Facility Size		
<i>Small (&lt;120 beds)</i>	49 (36.8%)	22 (37.3%)
<i>Medium (120-269 beds)</i>	78 (58.7%)	35 (59.3)
<i>Large (&gt;269 beds)</i>	6 (4.5%)	2 (3.4%)
Ownership		
<i>For Profit</i>	49 (36.9%)	24 (40.7%)
<i>Non Profit</i>	70 (52.6%)	30 (50.9%)
<i>Other</i>	14 (10.5%)	5 (8.4%)
Overall Rating*		
<i>High Rating</i>	63 (47.4%)	27 (46.5%)
<i>Low Rating</i>	70 (52.6%)	31 (53.5%)
Survey Rating*		
<i>High Rating</i>	55 (41.4%)	22 (37.9%)
<i>Low Rating</i>	78 (58.6%)	36 (62.1%)
Quality Rating*		
<i>High Rating</i>	61 (45.9%)	27 (46.6%)
<i>Low Rating</i>	72 (54.1%)	31 (53.4%)
Staffing Rating*		
<i>High Rating</i>	50 (37.6%)	21 (36.2%)
<i>Low Rating</i>	83 (62.4%)	37 (63.8%)
Any Infection Control Deficiencies	48 (36.1%)	21 (35.6%)
Any Nursing and Physician Deficiencies	29 (21.8%)	15 (25.4%)
Any Quality of Life Deficiencies	83 (62.4%)	37 (62.7%)
Any High Severity Deficiencies	4 (30.1%)	18 (30.5%)
Any Limited 1 Week Supply:		
<i>N95 Masks</i>	67 (50.4%)	31 (52.5%)
<i>Surgical Masks</i>	54 (40.6%)	23 (39.0%)
<i>Eye Protection</i>	57 (42.9%)	25 (42.4%)
<i>Gowns</i>	64 (48.1%)	30 (50.9%)
<i>Gloves</i>	30 (22.6%)	13 (22.0%)
<i>Hand Sanitizer</i>	31 (23.3%)	15 (25.4%)
Any Staff Shortage:		
<i>Clinical Staff</i>	21 (15.8%)	10 (17.0%)
<i>Aide Staff</i>	57 (42.9%)	27 (45.8%)
<i>Nursing Staff</i>	52 (39.1%)	25 (42.4%)
<i>Other Staff</i>	45 (33.8%)	21 (35.6%)
Continuous Variables	Mean (SD)	Mean (SD)
Cases Per 100,000 Person Hours	60.9 (136.17)	-
Length of Outbreak (Days)	59.8 (66.05)	-
Average number of Residents per Day	115.4 (56.60)	112.7 (56.13)
Number of Inspection Deficiencies	5.8 (4.64)	6.0 (4.88)
Total Staff (Hours Per Resident Day):		
<i>Total RN Hours</i>	0.7 (0.27)	0.6 (0.27)
<i>Total LPN Hours</i>	0.7 (0.22)	0.7 (0.22)
<i>Total CNA Hours</i>	2.1 (0.39)	2.0 (0.40)
<i>Total Nurse Aide in Training Hours</i>	0.1 (0.11)	0.1 (0.10)
<i>Total Direct Care Hours</i>	3.5 (0.62)	3.4 (0.58)
<i>Total Professional Hours</i>	1.4 (0.32)	1.3 (0.31)
Professional to Non-Professional Staff	0.4 (0.05)	0.4 (0.05)

\* One facility did not have CMS ratings

**Table 3. Association of Skilled Nursing Facility Characteristics with Number of COVID-19 Outbreaks, Allegheny County, PA, 2020**

Facility Characteristic	Any Outbreak			p-value
	0-1 Outbreaks (N = 10)	2 Outbreaks (N = 27)	>2 Outbreaks (N = 22)	
Facility Size				
<i>Small (&lt;120 beds)</i>	5 (22.7%)	10 (45.5%)	7 (31.8%)	0.517
<i>Medium (120-269 beds)</i>	5 (14.3%)	17 (48.6%)	13 (37.1%)	
<i>Large (&gt;269 beds)</i>	0 (0.0%)	0 (0.00%)	2 (100.00%)	
Ownership				
<i>For Profit</i>	5 (20.8%)	12 (50.0%)	7 (29.2%)	0.827
<i>Non Profit</i>	5 (16.6%)	14 (46.7%)	11 (36.7%)	
<i>Other</i>	0 (0.0%)	1 (20.0%)	4 (80.0%)	
Overall Rating				
<i>High Rating</i>	6 (22.2%)	9 (33.3%)	12 (44.5%)	0.270
<i>Low Rating</i>	4 (12.5%)	18 (56.3%)	10 (31.2%)	
Survey Rating				
<i>High Rating</i>	5 (22.7%)	6 (27.3%)	11 (50.0%)	0.565
<i>Low Rating</i>	5 (13.5%)	21 (56.8%)	11 (29.7%)	
Quality Rating				
<i>High Rating</i>	7 (25.9%)	9 (33.3%)	11 (40.7%)	0.160
<i>Low Rating</i>	3 (9.3%)	18 (56.3%)	11 (34.4%)	
Staffing Rating				
<i>High Rating</i>	3 (14.3%)	10 (47.6%)	8 (38.1%)	0.937
<i>Low Rating</i>	7 (18.4%)	17 (44.8%)	14 (36.8%)	
Any Infection Control Deficiencies	3 (14.3%)	10 (47.6%)	8 (38.1%)	1.000
<i>None</i>	7 (18.4%)	17 (44.7%)	14 (36.8%)	
Any Nursing and Physician Deficiencies	2 (13.3%)	12 (80.0%)	1 (6.7%)	<b>0.004</b>
<i>None</i>	8 (18.2%)	15 (34.1%)	21 (47.7%)	
Any Quality of Life Deficiencies	6 (16.2%)	19 (51.4%)	12 (32.4%)	0.555
<i>None</i>	4 (18.2%)	8 (36.4%)	10 (45.4%)	
Any High Severity Deficiencies	2 (11.1%)	11 (61.1%)	5 (27.8%)	0.365
<i>None</i>	8 (19.5%)	16 (39.0%)	17 (41.5%)	
Any Limited 1 Week Supply:				
<i>N95 Masks</i>	5 (15.1%)	16 (51.6%)	10 (32.3%)	0.620
<i>Surgical Masks</i>	3 (13.0%)	12 (52.2%)	8 (34.8%)	0.777
<i>Eye Protection</i>	3 (12.0%)	14 (56.0%)	8 (32.0%)	0.416
<i>Gowns</i>	6 (20.0%)	14 (46.7%)	10 (33.3%)	0.786
<i>Gloves</i>	2 (15.4%)	7 (53.8%)	4 (30.8%)	0.913
<i>Hand Sanitizer</i>	3 (20.0%)	9 (60.0%)	3 (20.0%)	0.267
Any Staff Shortage:				
<i>Clinical Staff</i>	2 (20.0%)	5 (50.0%)	3 (30.0%)	0.814
<i>Aide Staff</i>	6 (22.2%)	12 (44.5%)	9 (33.3%)	0.689
<i>Nursing Staff</i>	5 (20.0%)	12 (48.0%)	8 (32.0%)	0.737
<i>Other Staff</i>	4 (19.0%)	11 (52.4%)	6 (28.6%)	0.669
		Mean (SD)		p-value
Facility Characteristic	0-1 Outbreaks	2 Outbreaks	>2 Outbreaks	
Average number of Residents per Day	89.9 (42.76)	111.1 (56.82)	125.1 (59.24)	0.311
Number of Inspection Deficiencies	4.2 (3.22)	7.6 (6.15)	4.8 (2.83)	0.053
Total Staff HPRD:				
<i>Total RN Hours</i>	0.6 (0.28)	0.8 (0.31)	0.6 (0.22)	0.692
<i>Total LPN Hours</i>	0.7 (0.26)	0.7 (0.23)	0.7 (0.20)	0.426
<i>Total CNA Hours</i>	2.0 (0.37)	2.10 (0.49)	2.0 (0.28)	0.738
<i>Total Nurse Aide in Training Hours</i>	0.03 (0.06)	0.04 (0.07)	0.07 (0.13)	0.750
<i>Total Direct Care Hours</i>	3.3 (0.41)	3.5 (0.63)	3.4 (0.58)	0.535
<i>Total Professional Hours</i>	1.3 (0.38)	1.4 (0.29)	1.3 (0.30)	0.179
Professional to Non-Professional Staff	0.4 (0.09)	0.4 (0.06)	0.4 (0.03)	0.799

**Table 4. Association of Skilled Nursing Facility Characteristics Length of Outbreak (Days), Allegheny County, PA, 2020**

Facility Characteristic	Length of Outbreak (Days)	
	Mean (SD)	p-value
<b>Facility Size</b>		
<i>Small (&lt;120 beds)</i>	39.9 (49.32)	
<i>Medium (120-269 beds)</i>	69.8 (72.02)	<b>0.01</b>
<i>Large (&gt;269 beds)</i>	93.0 (72.08)	
<b>Ownership</b>		
<i>For Profit</i>	63.2 (80.88)	
<i>Non Profit</i>	51.5 (50.80)	0.761
<i>Other</i>	89.3 (71.47)	
<b>Overall Rating</b>		
<i>High Rating</i>	54.0 (60.47)	0.172
<i>Low Rating</i>	65.0 (70.73)	
<b>Survey Rating</b>		
<i>High Rating</i>	41.2 (47.10)	<b>0.004</b>
<i>Low Rating</i>	72.9 (74.17)	
<b>Quality Rating</b>		
<i>High Rating</i>	63.7 (77.48)	0.919
<i>Low Rating</i>	56.5 (54.90)	
<b>Staffing Rating</b>		
<i>High Rating</i>	67.8 (63.58)	0.242
<i>Low Rating</i>	55.0 (67.42)	
<b>Any Infection Control Deficiencies</b>		
<i>None</i>	57.6 (76.56)	0.645
<b>Any Nursing and Physician Deficiencies</b>		
<i>None</i>	58.2 (68.84)	0.274
<b>Any Quality of Life Deficiencies</b>		
<i>None</i>	47.5 (51.41)	0.099
<b>Any High Severity Deficiencies</b>		
<i>None</i>	54.9 (54.87)	0.535
<b>Any Limited 1 Week Supply:</b>		
<i>N95 Masks</i>	61.6 (62.02)	0.738
<i>Surgical Masks</i>	59.6 (60.12)	0.929
<i>Eye Protection</i>	60.3 (59.50)	0.747
<i>Gowns</i>	61.6 (60.50)	0.592
<i>Gloves</i>	67.6 (62.68)	0.308
<i>Hand Sanitizer</i>	80.3 (92.10)	0.134
<b>Any Staff Shortage:</b>		
<i>Clinical Staff</i>	99.5 (101.60)	<b>0.019</b>
<i>Aide Staff</i>	66.1 (74.44)	0.335
<i>Nursing Staff</i>	69.9 (78.09)	0.227
<i>Other Staff</i>	72.0 (78.82)	0.111
Facility Characteristic	Corr. Coeff.*	p-value
Average number of Residents per Day	0.30	<b>0.0002</b>
Number of Inspection Deficiencies	0.20	<b>0.019</b>
<b>Total Staff HPRD:</b>		
<i>Total RN Hours</i>	-0.10	0.262
<i>Total LPN Hours</i>	0.03	0.709
<i>Total CNA Hours</i>	-0.04	0.634
<i>Total Nurse Aide in Training Hours</i>	-0.01	0.896
<i>Total Direct Care Hours</i>	-0.07	0.460
<i>Total Professional Hours</i>	-0.02	0.826
Professional to Non-Professional Staff	-0.04	0.651

\* Spearman's Correlation



**Table 5. Association of Skilled Nursing Facility Characteristics with Number of COVID-19 Cases Per 100,000**

**Person Hours, Allegheny County, PA, 2020**

Facility Characteristic		Cases per 100,000 Person Hours	
		Mean (SD)	p-value
<b>Ownership</b>			
	<i>For Profit</i>	82.0 (179.44)	0.053
	<i>Non Profit</i>	56.0 (1110.49)	
<b>Overall Rating</b>			
	<i>High Rating</i>	64.1 (160.14)	0.554
	<i>Low Rating</i>	58.0 (111.40)	
<b>Survey Rating</b>			
	<i>High Rating</i>	71.8 (170.33)	<b>0.049</b>
	<i>Low Rating</i>	53.2 (106.29)	
<b>Quality Rating</b>			
	<i>High Rating</i>	39.4 (35.41)	0.991
	<i>Low Rating</i>	79.0 (180.78)	
<b>Any Infection Control Deficiencies</b>		61.2 (121.26)	0.846
	<i>None</i>	60.7 (144.60)	
<b>Any Nursing and Physician Deficiencies</b>		73.2 (150.81)	0.963
	<i>None</i>	57.4 (132.38)	
<b>Any Quality of Life Deficiencies</b>		45.2 (90.48)	0.151
	<i>None</i>	86.8 (187.49)	
<b>Any High Severity Deficiencies</b>		53.7 (62.34)	0.585
	<i>None</i>	63.9 (157.88)	
<b>Any Limited 1 Week Supply:</b>			
	<i>N95 Masks</i>	65.5 (160.80)	0.852
	<i>Surgical Masks</i>	49.4 (66.76)	0.652
	<i>Eye Protection</i>	52.4 (69.81)	0.569
	<i>Gowns</i>	47.9 (67.07)	0.462
	<i>Gloves</i>	46.0 (54.00)	0.942
	<i>Hand Sanitizer</i>	86.1 (222.44)	0.596
<b>Any Staff Shortage:</b>			
	<i>Clinical Staff</i>	32.9 (43.65)	0.098
	<i>Aide Staff</i>	41.3 (46.58)	0.520
	<i>Nursing Staff</i>	41.2 (51.81)	0.217
	<i>Other Staff</i>	45.3 (63.37)	0.483
		Corr. Coeff.*	p-value
<b>Facility Characteristic</b>			
<b>Number of Inspection Deficiencies</b>		-0.16	0.075

\* Spearman's Correlation

**Table 6. Quantile Regression of Length of Outbreak (Days), Adjusting for Number of Certified Beds,  
Allegheny County, PA, 2020**

Facility Characteristics	Length of Outbreak (Days)		
	0.25 Quantile	0.5 Quantile	0.75 Quantile
Intercept	41.0 (25.3)	89.0 (27.6)**	166.0 (27.2)**
High Survey Rating	-13 (7.8)	-14.0 (13.9)	-25.0 (25.3)
No Clinical Shortage	-27.0 (25.9)	-39.0 (29.0)	-68.0 (32.7)*

Parameter Estimate (SE)

\* p-value <0.05

\*\* p-value <0.01

**Table 7. Quantile Regression of Cases per 100,00 Person Hours, Adjusting for Number of Certified Beds,  
Allegheny County, PA, 2020**

Facility Characteristics	Cases per 100,000 Person Hours		
	0.25 Quantile	0.5 Quantile	0.75 Quantile
Intercept	8.6 (1.9)**	22.1 (3.7)**	37.4 (6.2)**
High Survey Rating	10.1 (4.4)*	5.3 (5.1)	4.9 (12.4)

Parameter Estimate (SE)

\* p-value <0.05

\*\* p-value <0.01

## 5.0 Discussion

The present study was designed to explore and analyze associations between skilled nursing facility characteristics and 2020 COVID-19 outbreaks in Allegheny County. Our findings suggest that COVID-19 nursing home length of outbreak (days) are associated with certain pre-COVID-19 facility characteristics and COVID-19 operational challenges. This study identified that average COVID-19 outbreak duration (days) increased with size of facility. Unsurprisingly, the average number of residents per day was positively associated with the mean outbreak duration (days), with longer outbreaks in facilities that had higher average number of residents per day. Previous studies have found a positive association between facility size and COVID-19 rates, probability of having a COVID-19 case, or probability of having a COVID-19 outbreak in skilled nursing facilities.<sup>16,18</sup>

A similar trend was seen with number of health inspection deficiencies, with more deficiencies associated with higher mean outbreak duration days. This association was reflected in the survey rating, with low rating (rating of 1-3) facilities having a longer mean length of outbreak (days) than high rating (rating 4 or 5) facilities. Studies have found that skilled nursing facilities with low CMS ratings are associated with a higher risk of health care-associated infections.<sup>28</sup> However, findings of an association between CMS star rating and COVID-19 in skilled nursing facilities have been mixed. Some studies have found evidence of an association while other studies have found no significant associations between CMS star rating and COVID-19 infections.<sup>16,29</sup>

Operationally, having any clinical staffing shortage during 2020 was related to longer outbreaks (mean days). Other studies that have analyzed the association between staffing shortage and COVID-19 in nursing homes have been statistically significant.<sup>19</sup> But no significant

association was seen in the pre-COVID-19 staffing hours in this analysis. Current literature found that during pandemic nurse aide hours were associated with facility COVID-19 outbreaks.<sup>19,29</sup>

We identified links between facility characteristics and additional outbreak outcomes. Having any nursing and physician deficiencies in the latest 2019 health inspection was associated with number of outbreaks in a facility. However, facilities that experienced 2 outbreaks had the highest proportion (80.0%) of having any nursing and physician deficiencies, followed by facilities with 0-1 outbreaks (13.3%) and facilities with >2 outbreaks (6.7%). High health survey rating had higher mean cases per 100,00 person hours while low health survey rating had lower mean cases per 100,00 person hours, 71.8 and 53.2 respectively. We found no relationship between number of inspection deficiencies and cases per 100,000 person hours.

In quantile regression models adjusted for number of certified beds, we found that clinical staff shortage, but not survey rating, was significantly associated with length of outbreak days. In this model, the intercept is the mean length of outbreak in days for each quantile for a facility with a low survey rating and has clinical staffing shortage with weighing for number of certified beds. The length of outbreak in days in a facility with no clinical staffing shortage was shorter than in a facility with a clinical staff shortage. This effect is greatest in the 0.75 quantile level with a difference of about 68 days. In other words, any facility that did not have clinical staffing shortage had 68 fewer days compared to facilities with clinical staffing shortage but only with facility outbreaks where the number of outbreak days were 85 days or greater. In the quantile regression models adjusted for number of certified beds, we found survey rating to be significantly associated with cases per 100,000 person hours. The intercept for this model is the mean cases per 100,000 person hours for each quantile level for a facility with a low survey rating with weighing for number of certified beds. A facility with a high survey rating has more cases per 100,000 person

hours than in a facility with a low survey rating. This effect was greatest in the 0.25 quantile level with a difference of about 10 cases per 100,000 person hours. This means that highly survey rated facilities had 10 more cases than in facilities with lower survey ratings but only with facility outbreaks that had 15 or fewer cases per 100,000 person hours.

A key strength of the present study was the comprehensive measurement of skilled nursing facility characteristics and COVID-19 operational challenges. The measurements for these characteristics come from standard state inspections, regular facility and resident assessments, and self-reported staffing hours submitted on a regular basis.<sup>30</sup> Another strength was completeness of COVID-19 outbreak information for Allegheny County skilled nursing facilities. ACHD regularly received COVID-19 case information directly from the skilled nursing facilities. Case information was supported by COVID-19 test reports in PA-NEDSS. This study was also a novel exploratory analysis between COVID-19 cases and outbreaks and skilled nursing homes on a county level, specifically Allegheny County. Many studies have primarily focused on statewide or multi-state analyses on this topic.

Despite the strengths of our study, there are important limitations to note. Being limited geographically to Allegheny County, this study had a small sample size, which produced low statistical power. As such, this study lacked sufficient ability to find precise associations between facility characteristics and outbreak outcomes. Conversely, many facility and operational characteristics were found to be not statistically significant and type II error may also be present. Another limitation is low generalizability to other Pennsylvania counties due to analysis within a single county. Associations found to be statistically significant to COVID-19 skilled nursing facility outbreak outcomes in Allegheny County may not be applicable to other counties, especially those more geologically distant or with different county-specific policies and regulations. Prior

literature reviews on COVID-19 in nursing homes have shown statistically significant associations by state, with certain states having significantly greater or lower odds of cases compared to a reference state.<sup>18</sup> Lastly, accuracy of the number of cases in early 2020 at skilled nursing facilities may have been affected by limited testing capabilities at the beginning of the pandemic. Compounded with small sample size, this may have affected the associations found in this study.

Based on the existing literature and results of this analysis, further studies should expand to regional analysis to see if similar COVID-19 and skilled nursing facility associations are found on a multi-county level. This would, at least, provide stronger statistical power due to the increase in sample size. Evidence from such studies may provide stronger and consistent evidence to drive facility and policy changes to help better protect nursing home staff and residents from COVID-19 infections and worse outcomes. There is an immediate need and opportunity to develop or improve upon infection control measures and standards that go beyond self-reporting and assessments for procedure completeness. Trainings, protocols, and policies based on quality improvement research and evidence is needed to help reduce the impact of COVID-19, and potentially future infections, on skilled nursing facilities. In other words, quality improvements on the systemic level are crucial to help reduce the spread of COVID-19 infections, associated challenges, and to prepare against future variants. Additionally, staffing shortage was related to skilled nursing facility COVID-19 outbreaks for initial and multivariate analyses. The staffing shortages, which may be due to large outbreaks, exacerbates the spread of COVID-19 in skilled nursing facilities. Currently, PA legislation seeks to increase direct care hours per resident day from the standard minimum of 2.7 to 4.1 hours.<sup>31</sup> Based on information from this study and current literature, increasing hours, especially clinical and nurse aide hours, may greatly help to reduce the

impact of COVID-19 in skilled nursing homes. However, the feasibility to implement this policy is a major challenge.

The results of this analysis have demonstrated that specific modifiable skilled nursing facility characteristics are associated with the magnitude and length of COVID-19 outbreaks. There is, therefore, an urgent need for continuous research, surveillance, and changes in skilled nursing facilities to monitor and mitigate the spread and effects of COVID-19. These study findings of have high public health significance as they provide direction for future research. Further, this study and future work in this area can be used to guide policy decisions necessary for protecting nursing home residents, one of the most vulnerable populations to the SARS-CoV-2 virus and its variants.

## Appendix A Supplementary Tables and Figures

**Appendix Table 1. Quantile/Percentile Cutoff Values for Continuous Outcome Variables**

Continuous Outcome Variable	25th Percentile	50th Percentile	75th Percentile
Length of Outbreak (Days)	5.0	41.0	85.0
Cases per 100,000 Person Hours	14.9	29.9	52.2



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