



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



JAMDA

journal homepage: www.jamda.com

Original Study

SARS-CoV-2 and Wisconsin Nursing Homes: Temporal Dynamics During the COVID-19 Pandemic



Cameron G. Gmehlin BA^a, Frida Rivera MD, PhD^a, Jorge A. Ramos-Castaneda PhD^b,
Liliana E. Pezzin PhD^{c,d}, Diane Ehn MS^e, Edmund H. Duthie MD^f,
L. Silvia Muñoz-Price MD, PhD^{a,*}

^a Division of Infectious Diseases, Department of Medicine, Medical College of Wisconsin, Milwaukee, WI, USA

^b Research Group Innovación y Cuidado, Faculty of Nursing, Universidad Antonio Nariño, Neiva, Colombia

^c Collaborative for Healthcare Delivery Science, Medical College of Wisconsin, Milwaukee, WI, USA

^d Institute for Health and Equity, Medical College of Wisconsin, Milwaukee, WI, USA

^e Froedtert Health, Milwaukee, WI, USA

^f Division of Geriatrics and Palliative Medicine, Department of Medicine, Medical College of Wisconsin, Milwaukee, WI, USA

A B S T R A C T

Keywords:
COVID-19
SARS-CoV-2
nursing homes
quality
5-star rating

Objectives: Evidence suggests that quality, location, and staffing levels may be associated with COVID-19 incidence in nursing homes. However, it is unknown if these relationships remain constant over time. We describe incidence rates of COVID-19 across Wisconsin nursing homes while examining factors associated with their trajectory during 5 months of the pandemic.

Design: Retrospective cohort study.

Setting/Participants: Wisconsin nursing homes.

Methods: Publicly available data from June 1, 2020, to October 31, 2020, were obtained. These included facility size, staffing, 5-star Medicare rating score, and components. Nursing home characteristics were compared using Pearson chi-square and Kruskal-Wallis tests. Multiple linear regressions were used to evaluate the effect of rurality on COVID-19.

Results: There were a total of 2459 COVID-19 cases across 246 Wisconsin nursing homes. Number of beds ($P < .001$), average count of residents per day ($P < .001$), and governmental ownership ($P = .014$) were associated with a higher number of COVID-19 cases. Temporal analysis showed that the highest incidence rates of COVID-19 were observed in October 2020 (30.33 cases per 10,000 nursing home occupied-bed days, respectively). Urban nursing homes experienced higher incidence rates until September 2020; then incidence rates among rural nursing homes surged. In the first half of the study period, nursing homes with lower-quality scores (1-3 stars) had higher COVID-19 incidence rates. However, since August 2020, incidence was highest among nursing homes with higher-quality scores (4 or 5 stars). Multivariate analysis indicated that over time rural location was associated with increased incidence of COVID-19 ($\beta = 0.05, P = .03$).

Conclusions and Implications: Higher COVID-19 incidence rates were first observed in large, urban nursing homes with low-quality rating. By October 2020, the disease had spread to rural and smaller nursing homes and those with higher-quality ratings, suggesting that community transmission of SARS-CoV-2 may have propelled its spread.

© 2021 AMDA – The Society for Post-Acute and Long-Term Care Medicine.

This article was supported by a grant from the Advancing a Healthier Wisconsin Foundation (AHW; FP00018465/BU00033280). AHW had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

The authors declare no conflicts of interest.

* Address correspondence to L. Silvia Muñoz-Price, MD, PhD, Division of Infectious Diseases, Department of Medicine, Medical College of Wisconsin, ID Division—HUB A8167, 8701 Watertown Plank Road, Milwaukee, WI 53226, USA.

E-mail address: smunozprice@mcw.edu (L.S. Muñoz-Price).

<https://doi.org/10.1016/j.jamda.2021.08.021>

1525-8610/© 2021 AMDA – The Society for Post-Acute and Long-Term Care Medicine.

The novel coronavirus (SARS-CoV-2), causative agent of the coronavirus disease 2019 (COVID-19), has spread quickly across the globe, becoming a major public health emergency. As of May 2021, more than 32 million COVID-19 cases and 584,975 related deaths have been reported in the United States.¹ Nursing homes have been particularly affected by the pandemic, which is probably due to their congregate nature and the older age and higher prevalence of comorbidities among their residents. Nursing home residents have experienced more than 650,000 confirmed COVID-19 cases and 132,305 related

Table 1
Characteristics of the Nursing Homes Included in the Study by Number of COVID-19 Cases

	No COVID-19 Cases (n = 115; 32.7%)	≥1 COVID-19 Cases (n = 237; 67.3%)	P Value
Number of beds, median (IQR)	60 (50-84)	80 (50-116)	<.001
Number of occupied-bed days, median (IQR)	7192.5 (5410.5-9879)	904.5 (6550.5-12711.5)	<.001
Average residents per day, median (IQR)	45.13 (36.18-63.18)	57.98 (41.46-84.82)	<.001
Insurance			
Medicare %, median (IQR)	9.56 (7.14-17.4)	10.48 (6.35-16)	.70
Medicaid %, median (IQR)	56.66 (42.25-68.36)	56.7 (44.26-67.92)	.69
Ownership			
Government	8 (7)	39 (16.5)	.014
Nonprofit	39 (33.9)	63 (26.6)	.16
For profit	68 (59.1)	135 (57)	.70
Location			
Urban	53 (46.1)	134 (56.5)	*
Rural	62 (53.9)	103 (43.5)	.07
Area Deprivation Index			
Q1: <5	31 (27)	70 (29.8)	.62
Q2: 5-6	26 (23.4)	57 (24.3)	.77
Q3: 7-8	37 (33.3)	66 (28.1)	.403
Q4: >8	17 (15.3)	42 (17.9)	.49
Social vulnerability index			
Q1: <0.4187	34 (29.6)	54 (22.9)	.18
Q2: 0.4187-0.6126	25 (21.7)	63 (26.7)	.32
Q3: 0.6127-0.7714	30 (26.1)	58 (24.6)	.76
Q4: >0.7714	26 (22.6)	61 (25.8)	.51
Five-star rating			
Overall, median (IQR)	4 (2.4-8)	3.8 (2.4-4.75)	.93
4 or 5 stars	72 (62.6)	151 (64)	†
1-3 stars	43 (37.4)	85 (36)	.80
Quality score, median (IQR)	4.4 (3.4-4.9)	4.2 (3.4-4.9)	.75
Health inspection score, median (IQR)	3 (2-4)	3 (2-4)	.646
Staffing score, median (IQR)	4 (3-4.6)	4 (3-4.65)	.92
Registered nurse staffing score, median (IQR)	4.16 (3.38-4.9)	4.1 (3.21-4.9)	.60
Adjusted registered nurse hours/pt./d, median (IQR)	1.05 (0.8-1.25)	0.97 (0.72-1.28)	.35
Adjusted total staff hours/pt./d, median (IQR)	3.85 (3.33-4.34)	3.88 (3.4-4.42)	.53
Staff COVID-19 cases, median (IQR)	1 (0.4-2.2)	1.2 (0.4-2.2)	.73

COVID-19, coronavirus disease 2019; Q, quartile; pt, patient.

*Urban location was used as the reference category.

†4-5 stars was used as the reference category.

deaths, constituting one-fourth of the total deaths in the United States.^{1,2} During nursing home outbreaks, COVID-19 attack rates varied widely, ranging from 19% to 77%.³⁻¹⁴ COVID-19 outbreaks continue to occur in nursing homes despite the use of various infection control measures, including social distancing, cancellation of group activities, elimination of visitation, and daily symptom screening.^{3-5,15-19} Some studies have found that quality ratings, nursing home location, resident demographics, and staffing levels may be associated with higher incidence of COVID-19; however, these studies did not examine if these relationships remained constant over time or were impacted by local or state COVID-19 incidence rates.²⁰⁻²⁷ As part of their ongoing response to the COVID-19 pandemic, the Centers for Medicare & Medicaid Services (CMS) has published weekly COVID-19 reports about morbidity and mortality across US nursing homes.² Using this unique data set, we aimed to characterize the associations between nursing home–level characteristics and nursing home–level COVID-19 incidence rates. Specifically, we examined these associations cross-sectionally and longitudinally throughout the first year of the COVID-19 pandemic in Wisconsin.

Methods

Study Data and Participants

We identified all skilled nursing facilities in the State of Wisconsin using the LeadingAge, Wisconsin Healthcare Association, and Wisconsin Department of Health Services nursing home directories.²⁸⁻³⁰ COVID-19 confirmed cases and associated deaths in Wisconsin nursing homes were obtained from the CMS COVID-19 database.² The

database was then linked to monthly Nursing Home Compare (NHC) data, published by CMS, to append facility characteristics.³¹ Location information was obtained from the US Department of Agriculture's (USDA) database, whereas resident characteristics were obtained from Brown School of Public Health's database, Long Term Care Facility focus (LTCFocus).^{32,33} Two measures of relative socioeconomic status—the area deprivation index (ADI) and the social vulnerability index (SVI)—were collected from the Neighborhood Atlas and the Centers for Disease Control and Prevention (CDC), respectively, and merged into the analytical file.^{34,35} Finally, COVID-19 testing and results data were obtained from the Wisconsin Department of Health Services.³⁶

The CMS 5-star quality rating is an aggregate of 3 nursing home domains: health inspections, quality measures, and staffing rating. The health inspection rating is a composite score based on points assigned to deficiencies identified in each provider's 3 most recent state health inspections. The quality measure rating is a composite score based on performance in 15 quality measures. The staffing rating is based on total nurse staffing hours per resident per day. In addition to their 5-star quality ratings, we also obtained information on nursing homes' characteristics, including ownership status, total beds, average daily census, adjusted registered nurse hours per patient per day, and adjusted total staff hours per patient per day.

Location, designated as either urban or rural, was determined for each nursing home using the Rural-Urban Continuum Codes (RUCC) 2010 primary codes and the Washington, Wyoming, Alaska, Montana, and Idaho (WWAMI) Rural Health Research Center's categorization C.^{32,37} Resident insurance information was obtained from the LTCFocus database, which was most recently updated in 2019.³³ ADI was

Table 2
Characteristics by Nursing Home Location

	Rural Nursing Homes (n = 165)			Urban Nursing Homes (n = 187)		
	0 Cases (n = 59)	≥1 Cases (n = 106)	P Value	0 Cases (n = 45)	≥1 Cases (n = 142)	P Value
Number of beds, median (IQR)	65 (50-87)	90 (50-122)	.002	50 (50-80)	68 (50-100)	.011
Number of occupied-bed days, median (IQR)	7725 (5643-9955.5)	10015 (6922.5-14719.50)	.001	7099.50 (5175-8709)	7993.50 (5827.50-11668.50)	.012
Average residents per day, median (IQR)	48.16 (38.27)	65.35 (46.81-89.5)	.001	44.14 (33.65-52.999)	49.23 (37.16-74.82)	.010
Medicare %, median (IQR)	11.70 (8.18-18.24)	11.24 (7.41-18.18)	.88	8.76 (6.29-16.56)	9.23 (4.88-13.79)	.22
Medicaid %, median (IQR)	52.99 (34.44-63.36)	51.61 (37.84-64.62)	.82	61.05 (49.50-68.45)	61.70 (53.66-72)	.09
Ownership, n (%)						
Nonprofit	2 (3.8)	15 (11.2)	.40	6 (9.7)	24 (23.3)	.14
Government	20 (37.7)	42 (31.3)	.11	19 (30.6)	21 (20.4)	.03
For profit	31 (58.5)	77 (57.5)	.90	37 (59.7)	58 (56.3)	.67
Area Disadvantage Index, n (%)						
Q1: <5	25 (51)	54 (40.6)	.28	6 (9.7)	16 (15.7)	.39
Q2: 5- 6	8 (16.3)	29 (21.8)	.80	18 (29)	28 (27.5)	.31
Q3: 7-8	12 (24.5)	32 (24.1)	.34	25 (40.3)	34 (33.3)	.86
Q4: >8	4 (8.2)	18 (13.5)	.73	13 (21)	24 (23.5)	.26
Social Vulnerability Index, n (%)						
Q1: <0.4187	24 (45.3)	45 (33.8)	.15	10 (16.1)	9 (8.7)	.15
Q2: 0.4187-0.6126	14 (26.4)	36 (27.1)	.21	11 (17.7)	27 (26.2)	.93
Q3: 0.6127-0.7714	4 (7.5)	19 (14.3)	.60	26 (41.9)	39 (37.9)	.21
Q4: >0.7714	11 (20.8)	33 (24.8)	.67	15 (24.2)	28 (27.2)	.56
Five-star rating						
Overall, median (IQR)	3.5 (2-4.6)	3.8 (2-4.9)	.30	4 (2.4-4.8)	3.7 (2.9-4.6)	.39
4 or 5 stars	29 (54.7)	80 (60.2)	—*	43 (69.4)	71 (68.9)	—*
1-3 stars	24 (45.3)	53 (39.8)	.50	19 (30.6)	32 (31.1)	.96
Quality measure score, median (IQR)	4.3 (3.3-4.9)	4.3 (3.6-4.9)	.57	4.4 (3.4-4.9)	4.1 (3.1-4.8)	.21
Health inspection score, median (IQR)	2.2 (1.3-3.7)	2.3 (1.8-4)	.51	3 (2-4)	3 (2.1-4)	.98
Staffing score, median (IQR)	4 (3-4.4)	4 (3.1-4.89)	.24	3.95 (3.1-4.7)	3.7 (3-4.2)	.20
Registered nurse staffing score, median (IQR)	4.1 (3-5)	4.1 (3-5)	.20	4.35 (3.6-4.9)	4 (3.2-4.9)	.08
Adjusted hours registered nurses/pt./d, median (IQR)	.99 (.76-1.26)	1 (.72-1.3)	.99	1.06 (0.84-1.20)	0.93 (0.75-1.21)	.12
Adjusted hours total/pt./d, median (IQR)	3.8 (3.3-4.8)	4 (3.4-4.5)	.49	3.76 (3.34-4.25)	3.67 (3.35-4.15)	.86
Staff COVID-19 cases, median (IQR)	1 (0.6-2.6)	1.1 (0.6-2.4)	.78	1 (0.4-2)	1.2 (0.4-2.2)	.41

*4 or 5 stars was used as the reference category.

assigned to nursing homes based on their 9-digit zip codes as found in the Wisconsin nursing home directory.^{28,34,38} SVI census tract summary rankings were used in our analysis, linked to specific nursing homes via geocoding.^{35,39} Finally, county-level data regarding COVID-19 testing was used to calculate percentage positive values for Wisconsin from June 1, 2020, to October 31, 2020.^{36,40}

Statistical Analysis

Nursing homes were divided into those with no reported cases and those with 1 or more cases. Categorical variables were reported as frequencies and percentages, whereas continuous variables were described as mean (standard deviation) or median [interquartile range (IQR)] as per their distribution (Kolmogorov-Smirnov test). We then analyzed nursing home characteristics based on COVID-19 cases (0 vs ≥1) using Pearson chi-square tests for categorical variables and Mann-Whitney *U* test for continuous variables. Nursing home COVID-19

Table 3
Multivariate Linear Regression Using Number of COVID-19 Cases as the Dependent Variable

Variable	β	P Value
Month	0.14	<.01
Location	−0.11	.15
Star rating	−0.018	.18
ADI	0.013	.06
Beds	0.0012	<.01
Month by location	0.053	.028

incidence rates were calculated by dividing the number of COVID-19 cases by monthly occupied-bed days, and then multiplying the result by 10,000. County-level percentage positive values were calculated by dividing positive tests performed by total tests and multiplying the result by 100. Variables of interest and those with a *P* value of <.3 were considered for the multivariate analysis. A multiple linear regression model was performed to address the association between COVID-19 cases and rurality while controlling for possible confounders. The dependent variable was the number of cases in nursing homes from June 1 to October 31, 2020, which was then transformed into the natural logarithm of the number of cases + 1 to reduce the effect of outliers. Data were analyzed using RStudio, version 1.3 (R Foundation for Statistical Computing, Vienna, Austria), and SPSS, version 24.0 (IBM Corp, Armonk, NY).

Ethical Aspects

This study was approved by the appropriate Institutional Review Board with a waiver of informed consent.

Results

All 363 nursing homes in the state of Wisconsin were included in the study. Of those, 352 reported data to CMS between June 1, 2020, and October 31, 2020. Two hundred forty-six (67.3%) nursing homes had 1 or more COVID-19 case, with a total of 2459 cases occurring during the study period. Among nursing homes with at least 1 COVID-19 case, the median number of confirmed cases was 4 (IQR 2-14).

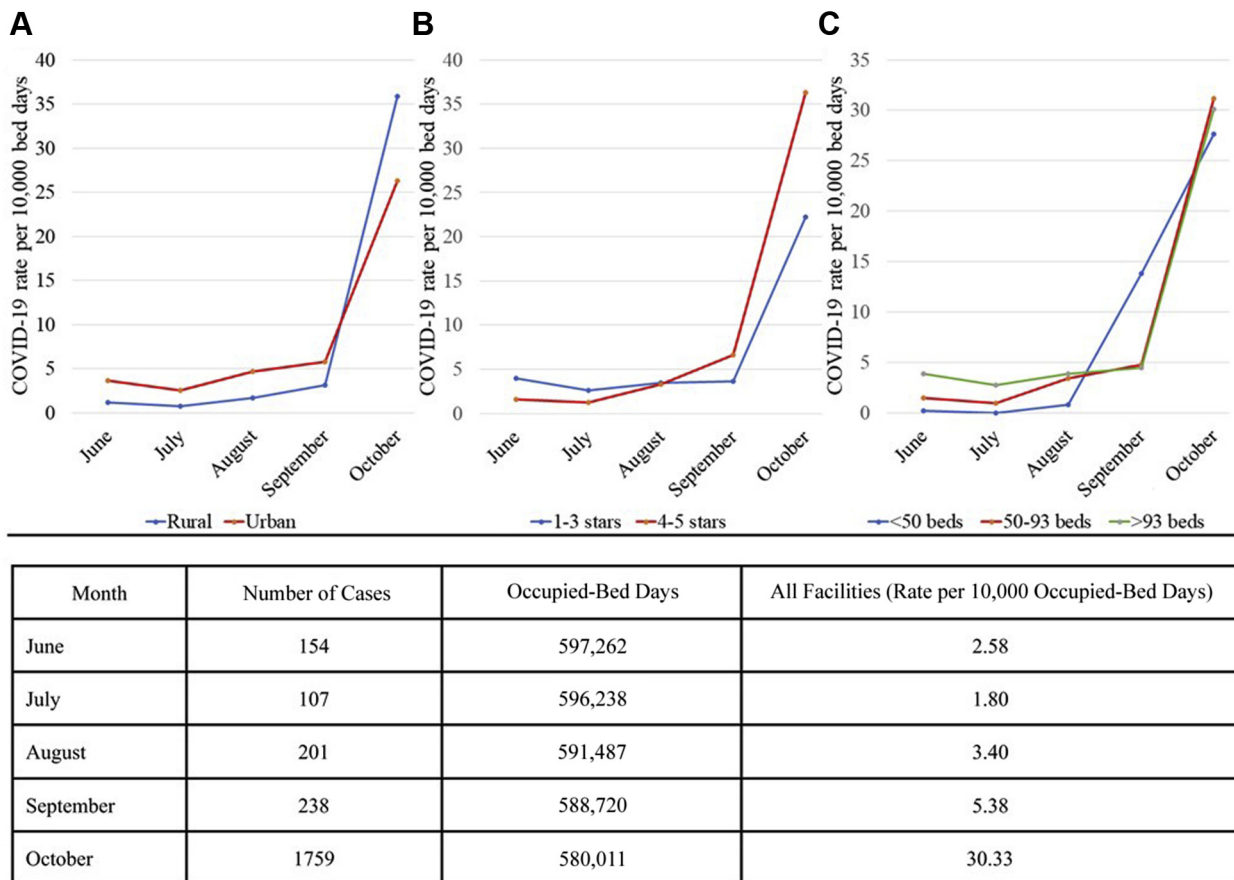


Fig. 1. Temporal analysis of various nursing home characteristics vs COVID-19 incidence. Top panel: variables analyzed include (A) location (urban vs rural), (B) overall quality rating, and (C) number of beds. Bottom panel: Calculated COVID-19 incidence in Wisconsin nursing homes during the study period. Graphs created using Excel 2016 (Microsoft Corp) and Inkscape 2020 (Inkscape Project).

The characteristics of nursing homes, stratified by COVID-19 cases (0 vs ≥ 1), are shown in Table 1. Higher incidence of COVID-19 cases was associated with urban location ($P = .065$), higher number of beds ($P < .001$), average count of residents per day ($P < .001$), government ownership ($P = .014$), nonprofit ownership ($P = .155$), and low SVI score (Q1, $P = .175$). Of note, neither the 5-star rating or its individual components were associated with having ≥ 1 COVID-19 cases.

Given our focus on the trajectory of COVID-19 across rural and urban nursing homes, we further stratified the analyses by location (rural vs urban; Table 2). Consistent with their smaller size [median number of beds = 60 (IQR 50-90) vs 81 (IQR 50-112); $P < .001$] and lower occupancy rates [median count of residents per day = 46.4 (IQR 34.34-63.89) vs 59.24 (IQR 41.42-82.42); $P < .001$], rural nursing homes had a lower number of COVID-19 cases [median 2 (IQR 0-8) vs 3 (IQR 1-13); $P = .018$]. Rural homes tended to be located in more disadvantaged areas, as measured by ADI [median 7 (IQR 6-8) vs 5 (IQR 3-7); $P < .001$] and SVI [median 0.67 (IQR 0.52-0.77) vs 0.52 (IQR 0.32-0.77); $P < .001$]. Regarding ownership status, there was a larger share of governmental ownership in rural areas [33 (18.9%) vs 17 (8.8%); $P = .005$] and nonprofit ownership in urban areas [64 (33%) vs 41 (24.3%); $P = .067$]. Rural nursing homes also had a higher percentage of Medicaid residents than urban nursing homes [median 61 (IQR 51-71) vs 52 (IQR 37-64); $P < .001$].

With respect to quality ratings, the overall 5-star rating was higher among rural nursing homes [median 3.9 (IQR 2.9-4.7) vs 3.75 (IQR 2-4.8); $P = .232$], driven by a better health inspection rating [median 3 (IQR 2-4) vs 2.3 (IQR 1.4-4); $P = .021$]. However, other dimensions of the 5-star rating including quality [median 4.1 (IQR 3.2-4.8) vs 4.3

(IQR 3.5-4.9); $P = .110$] and staffing [median 3.7 (IQR 3-4.3) vs 4 (IQR 3-4.74); $P = .110$] were lower in rural nursing homes compared to urban ones.

Subcategorization of rural and urban nursing homes into those with no cases of COVID-19 and those with ≥ 1 case showed that an increased number of beds, higher average count of residents per day, governmental ownership, SVI, lower staffing score, and lower registered nurse staffing scores were significantly associated with having at least 1 COVID-19 case in both rural and urban settings (Table 2). In contrast to rural nursing homes, low quality rating, higher share of residents with Medicaid, nonprofit status, and high ADI were significantly associated with COVID-19 cases in urban nursing homes.

We also performed a multivariate linear regression (Table 3), examining the impact of location on incidence of COVID-19 (continuous variable) while controlling for the month of the pandemic, 5-star rating, ADI, number of beds, and month by location (our interaction variable). Over time, the number of cases across nursing homes increased ($\beta = 0.14$, $P < .01$). Number of beds in a nursing home was also associated with an increased number of cases; however, at a reduced level ($\beta = 0.001$, $P < .01$). Finally, a statistically significant interaction was identified between the progression of the pandemic from June to October 2020 and increasing COVID-19 cases in rural locations ($\beta = 0.05$, $P = .03$).

Temporal Dynamics of COVID-19 Cases in Wisconsin Nursing Homes

Table 3 presents the incidence of COVID-19 cases in Wisconsin nursing homes during the study period. The highest COVID-19

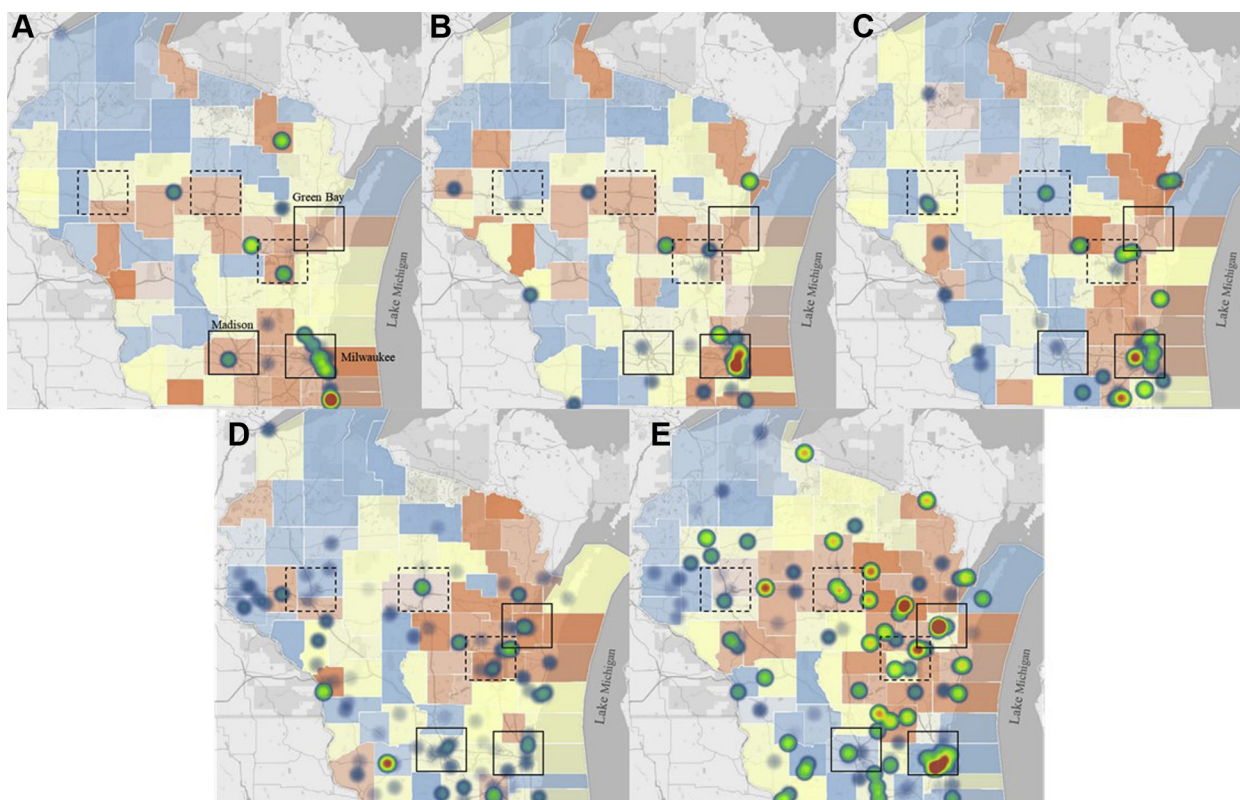


Fig. 2. Map of COVID-19 incidence vs county level positivity in Wisconsin nursing homes from June to October 2020. Nursing home COVID-19 incidence is indicated using heatmaps within circles (lowest to highest using the colors green, yellow, and red). County-level spread was stratified into tertiles (shaded based on category values) and is indicated by background county colors blue, yellow, and red (lowest to highest). Panels A through E show incidence of COVID-19 from June to October 2020, respectively. Outlined regions represent the 6 most populous metropolitan areas in the state of Wisconsin as of 2019 (United States Census Bureau). Solid lines were used to indicated named cities. Map created using Excel 2016 3D Maps (Microsoft Corp) and Inkscape 2020 (Inkscape Project).

incidence rates were observed during October 2020 (30.33 cases per 10,000 occupied-bed days). Urban nursing homes (Figure 1A and B) and those with a lower 5-star rating (overall score between 1 and 3; Figure 2A and B) initially experienced a higher incidence of COVID-19 earlier in the pandemic; subsequently, this trend reversed with increased incidence rates among rural nursing homes and nursing homes with higher 5-star quality ratings (overall score = 4 or 5) (Figure 1C–F and Figure 2A and B, respectively). Larger nursing homes were greatly affected at the start of the pandemic, but differences in incidence of the disease by nursing home size disappeared by the end of the observation period (Figure 2C). COVID-19 positivity rates appeared to move in a similar fashion to the spread of COVID-19 from nursing homes in urban to rural areas (Figure 1A–F).

Discussion

This study examined the statewide incidence of COVID-19 among nursing homes in Wisconsin during 5 months of the pandemic, with a special focus on time trends by rural or urban location. Our findings indicate that COVID-19 cases were associated with urban location, larger nursing home size, governmental ownership and nonprofit ownership, lower 5-star quality rating, lower staffing rating, and lower nurse staffing rating. High ADI and increased share of residents with Medicaid were only found to be significantly associated with 1 or more COVID-19 cases in urban nursing homes. Subsequent temporal evaluation of incidence rates showed that at the beginning of the pandemic, nursing homes located in urban settings, those with a 5-star quality rating of 1–3, and those with high bed counts experienced at least 1 case of COVID-19. In contrast, by the end of our

observation period, rural nursing homes, nursing homes with a 5-star quality rating of 4 or 5, and smaller nursing homes had similar or higher likelihood of having at least 1 case of COVID-19. Multivariate analysis supported this finding, showing that over the course of our study, rural location became increasingly associated with increased incidence of COVID-19. These findings are novel as they indicate that the relationships between nursing home characteristics and COVID-19 incidence fluctuated over time.

Our overall results are generally consistent with those of earlier studies.^{21–23,41–43} Although we did not note an association between increased COVID-19 incidence and overall 5-star quality rating, this finding was inconsistently reported across other studies.^{21–24,41,42} Another difference between our findings and previous investigations was the association between the percentage of Medicaid residents and COVID-19 cases; some studies showed that a higher percentage of Medicaid residents was associated with an increase in COVID-19 cases, a relationship that we only observed among urban nursing homes.^{21,23,24,44} Governmental nursing home ownership and to a lesser extent nonprofit status were found to be significantly associated with increased COVID-19 incidence during analysis, again a finding that has been inconsistently documented in prior studies.^{22–24,26,41} In contrast to the COVID-19 experience among the general population in the state, our analysis based on 2 proxies for social disadvantage—ADI and SVI—was mixed, showing a significant relationship between incidence rates and 1 quartile of SVI in rural and urban homes whereas high ADI was associated with increased COVID-19 cases in urban areas.⁴⁵ One plausible explanation for these inconsistent findings may relate to nursing home staff, many of whom may reside in different zip codes than the ones where the nursing homes are located.

Perhaps most striking was the temporal change observed for the association between 5-star rating and incidence rates of COVID-19 within individual nursing homes. In contrast to results from California where the relationships between nursing home quality and COVID-19 cases were reported to hold constant over the pandemic, our data show a reversal in trend over the 5-month study period.²² Further, our multivariate analysis showed that as the pandemic progressed, rural location became increasingly associated with higher incidence of COVID-19 cases in nursing homes. A recent report published by the Wisconsin Department of Public Health provides context to this observation, suggesting that a large spike in confirmed SARS-CoV-2 infections in college and university settings in the month of September was followed by a dramatic rise in COVID-19 incidence in long-term care facilities.⁴⁶ Bagchi et al⁴⁷ and White et al⁴² report similar findings, arguing that increased levels of community transmission were responsible for outbreaks of COVID-19 in nursing homes. Mapping of COVID-19 county positivity rates alongside nursing home incidence seems to support these conclusions. Although nursing homes have restricted visitation to prevent introduction of COVID-19, staff continued to circulate between the community and nursing homes.^{3,5,6,10,15,16} First suggested by White et al,⁴² this movement might explain the connection observed between community incidence and nursing home outbreaks.

This study has several limitations. First, we did not examine facility testing capabilities or patients' demographic and clinical characteristics, which could have influenced COVID-19 rates. We were also unable to account for physical characteristics of individual nursing homes such as room occupancy, building age, and ventilation. Because we used data provided by CMS, bias might have been introduced into our data set. Although CMS reporting is federally mandated and checked for accuracy, nursing homes during the initial period of data collection were not familiar with the survey forms used by the CDC and CMS and could have incorrectly entered data; therefore, we removed data prior to June 1, 2020. Next, our measures of socioeconomic disadvantage (ADI and SVI) are ecological variables that may not adequately reflect the situation of residents in a long-term care facility. Furthermore, although these measures consider varied economic, environmental, and social factors that impact communities, there is some overlap between categories.⁴⁸ Because we only analyzed data from Wisconsin nursing homes, our conclusions may not be generalizable to other areas. Lastly, we were unable to incorporate community transmission of COVID-19 into our univariate or multivariate analysis because of difficulty obtaining COVID-19 prevalence (longitudinally) at the zip code level.

Conclusions and Implications

Our findings suggest that although nursing home characteristics can predispose a particular nursing home to greater levels of COVID-19 risk, the location of a particular nursing home (rural vs urban) also impacts this risk. Further, the impact of rurality changed over time as the pandemic progressed, probably suggesting a role of community transmission.^{42,43} Further investigations should be focused on examination of the factors that link community transmission, the home zip codes of the nursing home workers, and COVID-19 cases within nursing homes.

References

- Centers for Disease Control and Prevention. Coronavirus disease 2019 (COVID-19) cases in the U.S. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/covid-data/covidview/index.html>. Accessed January 1, 2021.
- Centers for Medicare & Medicaid Services. COVID-19 nursing home data. Available at: <https://data.cms.gov/stories/s/COVID-19-Nursing-Home-Data/bk-wz-xpvg/>. Accessed January 1, 2021.
- Arons MM, Hatfield KM, Reddy SC, et al. Presymptomatic SARS-CoV-2 infections and transmission in a skilled nursing facility. *N Engl J Med* 2020;382:2081–2090.
- Blain H, Rolland Y, Tuailon E, et al. Efficacy of a test-retest strategy in residents and health care personnel of a nursing home facing a COVID-19 outbreak. *J Am Med Dir Assoc* 2020;21:933–936.
- Dora AV, Winnett A, Jatt LP, et al. Universal and serial laboratory testing for SARS-CoV-2 at a long-term care skilled nursing facility for Veterans - Los Angeles, California, 2020. *MMWR Morb Mortal Wkly Rep* 2020;69:651–655.
- Escobar DJ, Lanzi M, Saberi P, et al. Mitigation of a COVID-19 outbreak in a nursing home through serial testing of residents and staff. *Clin Infect Dis* 2021;72:e394–e396.
- Feaster M, Goh YY. High proportion of asymptomatic SARS-CoV-2 infections in 9 long-term care facilities, Pasadena, California, USA, April 2020. *J Emerg Infect Dis* 2020;26:10.
- Graham NSN, Junghans C, Downes R, et al. SARS-CoV-2 infection, clinical features and outcome of COVID-19 in United Kingdom nursing homes. *J Infect* 2020;81(3):411–419.
- McMichael TM, Currie DW, Clark S, et al. Epidemiology of Covid-19 in a long-term care facility in King County, Washington. *N Engl J Med* 2020;382:2005–2011.
- Patel MC, Chaisson LH, Borgetti S, et al. Asymptomatic SARS-CoV-2 infection and COVID-19 mortality during an outbreak investigation in a skilled nursing facility. *Clin Infect Dis* 2020;71:2920–2926.
- Sanchez GV, Biedron C, Fink LR, et al. Initial and repeated point prevalence surveys to inform SARS-CoV-2 infection prevention in 26 skilled nursing facilities - Detroit, Michigan, March-May 2020. *MMWR Morb Mortal Wkly Rep* 2020;69:882–886.
- Mehta HB, Li S, Goodwin JS. Risk factors associated with SARS-CoV-2 infections, hospitalization, and mortality among US nursing home residents. *JAMA Netw Open* 2021;4:e216315.
- Shi SM, Bakaev I, Chen H, et al. Risk factors, presentation, and course of coronavirus disease 2019 in a large, academic long-term care facility. *J Am Med Dir Assoc* 2020;21:1378–1383.e1.
- Weil AA, Newman KL, Ong TD, et al. Cross-sectional prevalence of SARS-CoV-2 among skilled nursing facility employees and residents across facilities in Seattle. *J Gen Intern Med* 2020;35:3302–3307.
- Borras-Bermejo B, Martínez-Gómez X, San Miguel MG, et al. Asymptomatic SARS-CoV-2 infection in nursing homes, Barcelona, Spain, April 2020. *J Emerg Infect Dis* 2020;26:2281–2283.
- Blackman C, Farber S, Feifer RA, et al. An illustration of SARS-CoV-2 dissemination within a skilled nursing facility using heat maps. *J Am Geriatr Soc* 2020;68:2174–2178.
- Roxby AC, Greninger AL, Hatfield KM, et al. Outbreak investigation of COVID-19 among residents and staff of an independent and assisted living community for older adults in Seattle, Washington. *JAMA Intern Med* 2020;180:1101–1105.
- Tobolowsky FA, Bardossy AC, Currie DW, et al. Signs, symptoms, and comorbidities associated with onset and prognosis of COVID-19 in a nursing home. *J Am Med Dir Assoc* 2021;22:498–503.
- Barnett ML, Hu L, Martin T, Grabowski DC. Mortality, admissions, and patient census at SNFs in 3 US cities during the COVID-19 pandemic. *JAMA* 2020;324:507–509.
- Figueroa JF, Wadhwa RK, Papanicolas I, et al. Association of nursing home ratings on health inspections, quality of care, and nurse staffing with COVID-19 cases. *JAMA* 2020;324:1103–1105.
- Li Y, Temkin-Greener H, Shan G, Cai X. COVID-19 infections and deaths among Connecticut nursing home residents: Facility correlates. *J Am Geriatr Soc* 2020;68:1899–1906.
- He M, Li Y, Fang F. Is there a link between nursing home reported quality and COVID-19 cases? Evidence from California Skilled Nursing Facilities. *J Am Med Dir Assoc* 2020;21:905–908.
- Abrams HR, Loomer L, Gandhi A, Grabowski DC. Characteristics of U.S. nursing homes with COVID-19 cases. *J Am Geriatr Soc* 2020;68:1653–1656.
- Chatterjee P, Kelly S, Qi M, Werner RM. Characteristics and quality of US nursing homes reporting cases of coronavirus disease 2019 (COVID-19). *JAMA Netw Open* 2020;3:e2016930.
- Bui DP, See I, Hesse EM, et al. Association between CMS quality ratings and COVID-19 outbreaks in nursing homes - West Virginia, March 17-June 11, 2020. *MMWR Morb Mortal Wkly Rep* 2020;69:1300–1304.
- Gorges RJ, Konetzka RT. Staffing levels and COVID-19 cases and outbreaks in U.S. nursing homes. *J Am Geriatr Soc* 2020;68:2462–2466.
- Chen AT, Yun H, Ryskina KL, Jung HY. Nursing home characteristics associated with resident COVID-19 morbidity in communities with high infection rates. *JAMA Netw Open* 2021;4:e211555.
- Wisconsin Department of Health Services. Directory of licensed Wisconsin nursing homes - Alphabetical by county. Available at: <https://www.dhs.wisconsin.gov/guide/nhdir.pdf>. Accessed June 1, 2020.
- LeadingAge Wisconsin. Provider members. Available at: <https://leadingagewi.org/about-us/member-network/not-for-profit-provider-members/owningparent-corporations-and-provider-members>. Accessed June 1, 2020.
- Wisconsin Health Care Association. Find a care facility. Available at: <https://www.whcawical.org/facility-finder/>. Accessed June 1, 2020.
- Centers for Medicare & Medicaid Services. Star ratings. Available at: <https://www.medicare.gov/care-compare/?providerType=NursingHome&redirect=true>. Accessed January 20, 2021.

32. US Department of Agriculture Economic Research Service. Rural-urban community area codes. Available at: <https://www.ers.usda.gov/data-products/rural-urban-commuting-area-codes/>. Accessed January 1, 2021.
33. Brown School of Public Health. LTCFocus Facility Database. <http://lctfocus.org/>. Accessed January 11, 2021.
34. University of Wisconsin Madison. The Neighborhood Atlas. Available at: <https://www.neighborhoodatlas.medicine.wisc.edu/>. Accessed January 20, 2021.
35. US Centers for Disease Control and Prevention. CDC Social Vulnerability Index 2018 Database, Wisconsin. Available at: https://www.atsdr.cdc.gov/placeandhealth/svi/data_documentation_download.html. Accessed January 11, 2021.
36. Wisconsin Department of Health Services. COVID-19 historical data by county. Available at: <https://data.dhsgis.wi.gov/datasets/covid-19-historical-data-by-county/data?orderBy=DATE&orderByAsc=false>. Accessed May 1, 2021.
37. Washington, Wyoming, Alaska, Montana, and Idaho Rural Health Research Center. Rural-urban commuting area codes - Using RUCA data. Available at: <https://depts.washington.edu/uwruca/ruca-uses.php>. Accessed January 11, 2021.
38. Kind AJH, Buckingham WR. Making neighborhood-disadvantage metrics accessible - The Neighborhood Atlas. *N Engl J Med* 2018;378:2456–2458.
39. Federal Financial Institutions Examination Council. FFIEC geocoding/mapping system. Available at: <https://geomap.ffiec.gov/FFIECGeocMap/GeocodeMap1.aspx>. Accessed January 11, 2021.
40. Johns Hopkins Bloomberg School of Public Health. COVID-19 testing: Understanding the “percent positive.” Available at: <https://www.jhsph.edu/covid-19/articles/covid-19-testing-understanding-the-percent-positive.html>. Accessed May 1, 2021.
41. Harrington C, Ross L, Chapman S, et al. Nurse staffing and coronavirus infections in California nursing homes. *Policy Polit Nurs Pract* 2021;21:174–186.
42. White EM, Kosar CM, Feifer RA, et al. Variation in SARS-CoV-2 prevalence in US skilled nursing facilities. *J Am Geriatr Soc* 2020;68:2167–2173.
43. Kosar CM, Rahman M. Early acceleration of COVID-19 in areas with larger nursing homes and certificate of need laws. *J Gen Intern Med* 2021;36:990–997.
44. Unruh MA, Yun H, Zhang Y, et al. Nursing home characteristics associated with COVID-19 deaths in Connecticut, New Jersey, and New York. *J Am Med Dir Assoc* 2020;21:1001–1003.
45. Muñoz-Price LS, Nattinger AB, Rivera F, et al. Racial disparities in incidence and outcomes among patients with COVID-19. *JAMA Netw Open* 2020;3:e2021892.
46. Pray IW, Kocharian A, Mason J, et al. Trends in outbreak-associated cases of COVID-19-Wisconsin, March-November 2020. *MMWR Morb Mortal Wkly Rep* 2021;70:114–117.
47. Bagchi S, Mak J, Li Q, et al. Rates of COVID-19 among residents and staff members in nursing homes - United States, May 25-November 22, 2020. *MMWR Morb Mortal Wkly Rep* 2021;70:52–55.
48. Brookings Institute. How we define “need” for place-based policy reveals where poverty and race intersect. Available at: <https://www.brookings.edu/research/how-we-define-need-for-place-based-policy-reveals-where-poverty-and-race-intersect/>. Accessed May 19, 2021.