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.

JAMDA 23 (2022) 942–946

JAMDA

journal homepage: www.jamda.com

Brief Report

Quantifying Risk for SARS-CoV-2 Infection Among Nursing Home Workers for the 2020-2021 Winter Surge of the COVID-19 Pandemic in Georgia, USA

William C. Dube MPH [a], Joseph T. Kellogg MPH [a], Carly Adams MPH [b], Matthew H. Collins MD, PhD [c], Benjamin A. Lopman PhD [b,d], Theodore M. Johnson II MD [e,f], Avnika B. Amin MSPH [b], Joshua S. Weitz PhD [g,h,i], Scott K. Fridkin MD [a,b,*]

[a] Division of Infectious Diseases, Department of Medicine, Emory University School of Medicine, Atlanta, GA, USA
[b] Department of Epidemiology, Emory University Rollins School of Public Health, Atlanta, GA, USA
[c] The Hope Clinic of the Emory Vaccine Center, Division of Infectious Diseases, Emory University School of Medicine, Atlanta, GA, USA
[d] Department of Environmental Health, Emory University Rollins School of Public Health, Atlanta, GA, USA
[e] Division of General Internal Medicine, Department of Medicine, Emory University School of Medicine, Atlanta, GA, USA
[f] Department of Family and Preventive Medicine, Emory University School of Medicine, Atlanta, GA, USA
[g] School of Biological Sciences, Georgia Institute of Technology, Atlanta, GA, USA
[h] School of Physics, Georgia Institute of Technology, Atlanta, GA, USA
[i] Institut de Biologie, École Normale Supérieure, Paris, France

Keywords:
Occupational safety
COVID-19
SARS-CoV-2
nursing home
vaccination
risk factors

A B S T R A C T

Objectives: Estimate incidence of and risks for SARS-CoV-2 infection among nursing home staff in the state of Georgia during the 2020-2021 Winter COVID-19 Surge in the United States.
Design: Serial survey and serologic testing at 2 time points with 3-month interval exposure assessment.
Setting and Participants: Fourteen nursing homes in the state of Georgia; 203 contracted or employed staff members from those 14 participating nursing homes who were seronegative at the first time point and provided a serology specimen at second time point, at which time they reported no COVID-19 vaccination or only very recent vaccination (≤4 weeks).
Methods: Interval infection was defined as seroconversion to antibody presence for both nucleocapsid protein and spike protein. We estimated adjusted odds ratios (aORs) and 95% CIs by job type, using multivariable logistic regression, accounting for community-based risks including interval community incidence and interval change in resident infections per bed.
Results: Among 203 eligible staff, 72 (35.5%) had evidence of interval infection. In multivariable analysis among unvaccinated staff, staff SARS-CoV-2 infection–induced seroconversion was significantly higher among nurses and certified nursing assistants accounting for race and interval infection incidence in both the community and facility (aOR 5.3, 95% CI 1.0-28.4). This risk persisted but was attenuated when using the full study cohort including those with very recent vaccination.
Conclusions and Implications: Midway through the first year of the pandemic, job type continues to be associated with increased risk for infection despite enhanced infection prevention efforts including routine screening of staff. These results suggest that mitigation strategies prior to vaccination did not

W.C.D. and J.T.K. are co-first authors.

This work was supported by the Centers for Disease Control and Prevention (CDC; award number 6U01CK000555-02-01), the National Science Foundation [grants 2032082 (J.S.W.) and 2032084 (B.A.L.)], the Agency for Healthcare Research and Quality [R01 HS025987 (B.A.L.)], and the Health Resources and Services Administration [U1QHP33070 (T.M.J.)]. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the CDC. Some of the data for this project were supplied by the Georgia Department of Public Health, and the contents of this report do not necessarily represent the official views of, nor an endorsement by, the Georgia Department of Public Health.

Conflicts of Interest: B.A.L. reports grants and personal fees from Takeda Pharmaceuticals, personal fees from World Health Organization, outside the subject of the submitted work. All other authors declare no conflicts of interest.

* Address correspondence to Scott K. Fridkin, MD, Emory University School of Medicine, Division of Infectious Diseases, 1518 Clifton Road NE, Atlanta, GA 30329, USA.
E-mail address: sfridki@emory.edu (S.K. Fridkin).

https://doi.org/10.1016/j.jamda.2022.02.014

eliminate occupational risk for infection and emphasize critical need to maximize vaccine utilization to eliminate excess risk among front-line providers.

Nursing homes in the United States experienced great challenges in protecting their residents and staff throughout the COVID pandemic. Because routine reporting started in fall 2020, 1.2 million infections among residents and staff nationwide, and >20,000 resident infections and 3000 deaths reported by May 2021 in Georgia alone.[1–3] Nursing homes have high risk of SARS Co-V-2 transmission related somewhat to staffing challenges.[4] Early in the pandemic, several efforts quantified the risk of infection among nursing home staff at roughly 2 times that observed among peers in the community.[5–10] We published data in fall 2020 suggesting extensive direct-patient interactions (ie, certified nursing assistants) were >3 times as likely to have evidence of recent infection compared with non–patient-facing staff.[9,10]

To limit introduction and transmission of SARS-CoV-2 in nursing homes, the Centers for Medicare & Medicaid Services[11] required restricted resident visitation and universal masking early (spring 2020), and later ramped up regular testing of staff (fall/winter 2020) prior to staff vaccination programs, which started in Georgia around February 2021.[11–14] Testing frequency was often on a weekly or twice-weekly basis and remained in place throughout the spring; increased testing frequency had been hypothesized to greatly reduce transmission in these settings.[14–16] Despite these efforts, clusters of resident and staff infections did occur, mostly coinciding with surges of community-based COVID-19 infections during the winter months (December 2020 through March 2021), with some evidence pointing to inadequate staffing.[17] It is unclear to what degree infection prevention mitigation strategies put in place at the start of the winter surge reduced risk to nursing home staff before the availability of vaccines. We used the same network of nursing homes studied early in the pandemic to estimate risk for infection and identify risk factors for infection from December 2020 through April 2021.

Methods

Design and Ethical Approval

We recruited voluntary participants from 14 nursing homes that had previously participated in the COVID-19 Prevention in Nursing Homes (COPING) serologic survey study.[10] All facilities followed CMS-required testing policies and CDC infection prevention recommendations.[11,13] Participants were recruited from August 26 to November 19, 2020, for first serologic assessment and from February 11 to May 7, 2021, for the second assessment. This study was evaluated and approved by the appropriate university institutional review board (no. 00000900). All participants provided informed consent.

Study Population and Primary Data Collection

Recruitment, enrollment, survey methods, and specimen collection used at the first time point were previously published and used at second time point with the following notable differences.[10] Potential exposures assessed were limited to the prior 12 weeks, including contacts with confirmed or suspected SARS-CoV-2 infections (both inside and outside of work environment), vaccine receipt, and occupational activities. Participants used lancets to self-collect dried blood spot samples for SARS-CoV-2 serology testing[18] (Molecular Testing Laboratories). A qualitative enzyme-linked immunosorbent assay (EUROIMMUN) was used to test all samples for the presence of anti-SARS-CoV-2 spike protein immunoglobulin G (sensitivity, 90.0%; specificity, 100%), whereas samples from the second time point testing positive for the spike protein were reflexively tested for antibodies against SARS-CoV-2 nucleocapsid protein (Bio-Rad SARS-CoV-2 Total Ab, sensitivity, 98.0%; specificity, 99.3%).[19] At least 1 member of trained study staff was supervising participants during specimen collection, ensuring adherence to the manufacturer's guidelines.

Definition of Infection and Participant Susceptibility

Evidence of infection at second time points (ie, interval infection) was defined as samples from the second time point testing positive to both spike and nucleocapsid antibody while evidence of vaccine-induced antibody was defined as the sample testing positive for spike but negative for nucleocapsid. Participants with samples from the first time point (ie, prior to vaccine availability) testing positive for antibody to spike protein were considered previously infected and ineligible for analysis of interval infection. Study participants were classified as persistently test negative (no infection- and no vaccine-induced antibody), incident infection (evidence of interval infection), or vaccinated (evidence of vaccine-induced antibody). Only a subset of participants reporting vaccine receipt (irrespective of serology results) were eligible for inclusion in the main analysis: staff who reported their most recent vaccine dose ≤4 weeks of the second time point. These recently vaccinated participants were eligible for the initial study group and considered susceptible to infection during most of the exposure window, precisely at least 8 weeks of the 12-week exposure period before the second time point. Workers did not record if most recent vaccination was first or second dose; therefore, we arbitrarily used 4 weeks as a cutoff to categorize those vaccinated within 4 weeks of second time point as susceptible for the initial analysis; some of these workers may have just received their second dose, whereas others may have just received their first dose. Although this introduced bias into the analysis, our sensitivity analysis excluded all vaccinated staff.

External Data Sources

Community-based exposure was approximated using COVID-19 case data from the Georgia Department of Public Health. The participant-specific interval community case rate was defined as the difference between the cumulative case count at 2 weeks prior to second specimen collection date and 2 weeks before first specimen collection date, for the participant's residential ZIP Code Tabulation Area (ZCTA) adjusting for population counts (Table 1). ZCTA-specific population estimates were obtained from the 2019 American Community Survey.[18] Although nursing home resident infections may be the result of staff infection rates, we did consider resident infection rates as a possible exposure: we used data on confirmed nursing home resident COVID-19 cases reported to CMS and defined the facility-specific interval resident-infection rate as the difference in the documented cumulative number of infected residents between the 2 time points, divided by the average number of occupied beds over these weeks.[20]

Table 1
Nursing Home Average Resident Census and Resident Infections Between Time Points, Staff Infections, and Vaccinations at Second Time Point, by Facility

Certified Bed Count	Residents, n			Change in % Residents Infected	Participants at Time Point 2, n				% Vaccinated*	% Infected
	Interval Mean Census	Cumulative Infections Time Point 1	Cumulative Infections Time Point 2		Participants	Persistently Seronegative	Vaccine-Induced Seroconversion	Infection-Induced Seroconversion		
76	56	1	1	0.00	0	0	0	0	NA	NA
165	105	38	52	13.30	10	2	1	7	60.00	70.00
120	107	73	78	4.70	3	0	1	2	66.70	66.70
128	98	31	48	17.40	3	0	1	2	66.70	66.70
117	58	28	35	12.10	2	0	1	1	100.00	50.00
138	114	5	77	63.20	34	5	13	16	70.60	47.10
250	146	10	87	52.70	30	10	7	13	43.30	43.30
130	85	13	60	55.30	23	6	8	9	65.20	39.10
119	85	89	96	8.20	3	2	0	1	33.30	33.30
250	150	1	34	22.00	18	7	6	5	55.60	27.80
150	116	32	100	58.60	35	8	18	9	74.30	25.70
137	117	94	100	5.10	13	3	7	3	69.20	23.10
100	69	25	67	60.90	17	10	4	3	29.40	17.70
152	94	100	106	6.40	12	4	7	1	66.70	8.30
All	1400	540	941	28.6	203	57	74	72	36.5	35.5

Time points refer to initial survey/serologic testing occurring between August 29, 2020, and November 19, 2020 (time point 1), or February 11, 2021, through May 7, 2021 (time point 2). Facility 9 had no eligible participants at time point 2, as all participants submitting samples at both time point 2 and 1 were already seropositive at time point 1.
*Vaccination status was determined through self-report on survey at time point 2 as having received at least a single dose.

Statistical Analysis

Participants' data were first aggregated at the facility level to summarize facility-specific metrics of participation, interval community case rate, facility infection rate, and seroconversion status. Staff characteristics were compared between persistently seronegative, vaccine-induced seroconverted, and infection-induced seroconverted participants. Race and ethnicity were self-reported and combined for analysis, if a person identified as Hispanic, that took precedence over assigning race value. Because prior analysis early in the pandemic identified job category as the major risk factor for infection-induced seropositivity,[10] we considered job category as the main independent variable to assess and a priori identified race, age, sex, interval community-case rate, and facility-infection rate as potential confounders. Additional occupational factors or known contacts with COVID-19 infections were evaluated in an exploratory manner.

Staff responses were mapped to 6 job categories with similar frequency and proximity of expected contact with residents: (1) health care administration, pharmacy, and other nonresident care; (2) resident activities, environmental services, and food services; (3) social work and physical, occupational, respiratory, and speech therapy; (4) certified nursing assistants; (5) nurses (including registered nurses and licensed-practical nurses); and (6) physicians and advanced practice providers.

We used mixed model logistic regression to estimate unadjusted odds ratios (ORs), adjusted ORs (aORs), and 95% CIs for infection-induced seroconversion, including all a priori identified variables. We explored interactions between job role and facility-infection rate. We determined age, sex, job role, interval community rates, and facility infection rates were established risk factors to be retained in the model. Other variables were retained if P value $< .25$ or changed OR of exposure variable $>10\%$ when in model. Facility was included as a random effect to account for variability between sites. Primary analysis included the entire eligible study cohort, and a sensitivity analysis was performed using similar methods among only the subset of participants that reported never being vaccinated.

Results

Of 2053 eligible nursing home staff, 772 (37.6%) participated in initial time point serosurvey, of which 367 (48%) participated in second time point serosurvey; 274 were seronegative at the initial time point and considered in this analysis. Seventy-one (26%) reported vaccination >4 weeks before time point 2, leaving 203 staff included in the risk factor analysis classified as follows: persistently seronegative (57; 28.1%), infection-induced seroconversion (72; 35.5%), or vaccine-induced seroconversion (74; 36.5%) (Table 1).

Across all facilities, infection-induced seroconversion was 35% (72/203); however, the facility-specific rate ranged from 8% to 70%, partially because of small numbers of participants (≤10) from 4 facilities (Table 1). At the second time point, there were a cumulative 941 resident cases, and the size of COVID-19 outbreaks among residents, that is, the interval facility-infection rate (the interval difference in percentage of residents infected between time points) was 29% (median 15.3%, range 0%-61%). Facilities also varied in bed capacity and number of residents residing in the facility during the interval period (interval census). None of these facility factors appeared to correlate with percentage of staff seroconversion at the facility level (Table 1). The interval community-case rate among staff was a median of 5.4 documented infections per 100 persons within the staff's ZCTA population; this rate varied from 3.9 to 8.1 between facilities and varied widely within most facilities (Supplementary Figure 1).

Staff with infection-induced seroconversion resided in areas with similar interval community case rates and worked in facilities with

Table 2
Characteristics and Survey Responses Among 203 Eligible Participants, by Infection Status

Characteristic	Infected (n = 72)	Not Infected (n = 131)	Total (N = 203)
Sex			
Female	58 (81)	111 (85)	169 (83)
Male	14 (19)	20 (15)	34 (17)
Age category, y			
<40	19 (26)	40 (31)	59 (29)
40-49	21 (29)	32 (24)	53 (26)
50-59	23 (32)	39 (30)	62 (31)
≥60	9 (12)	20 (15)	29 (14)
Race			
White (non-Hispanic)	10 (14)	36 (27)	46 (23)
Black (non-Hispanic)	50 (69)	72 (55)	122 (60)
Hispanic	1 (1)	6 (5)	7 (3)
Prefer not to answer	8 (11)	15 (11)	23 (11)
Missing	3 (4.2)	2 (1.5)	5 (2.5)
Job category*			
Act/Env/Food/Admin	28 (39)	67 (51)	95 (47)
MD/APP/PT/OT/RT/SP/SW	12 (17)	21 (16)	33 (16)
Nurse/CNA	32 (44)	43 (33)	75 (37)
Work at other facility in prior 3 mo			
Yes	5 (7)	4 (3)	9 (4)
No	66 (92)	124 (95)	190 (94)
Prefer not to answer	1 (1)	3 (2)	4 (2)
Known community COVID-19 contact in prior 3 mo			
Yes	10 (14)	11 (8)	21 (10)
No	61 (85)	116 (89)	177 (87)
Unknown	1 (1)	4 (3)	5 (2)
Known COVID-19 contact in workplace in prior 3 mo			
At least 1 contact	32 (44)	52 (40)	84 (41)
No or unsure	40 (56)	79 (60)	119 (59)
Able to always practice universal masking at work			
≥80% of the time	66 (92)	117 (89)	183 (90)
<80% of the time	6 (8)	14 (11)	20 (10)
Able to always practice social distancing at work			
Yes	60 (83)	116 (89)	176 (87)
No or unsure	12 (17)	15 (11)	27 (13)
Interval difference in % residents infected			
≥50%	50 (69)	89 (68)	139 (68)
<50%	22 (31)	42 (32)	64 (32)
Interval community incidence in participant zip code			
≤4.83	23 (32)	43 (33)	66 (33)
4.84-6.47	23 (32)	43 (33)	66 (33)
>6.47	25 (35)	43 (33)	68 (33)
Missing	1 (1.4)	2 (1.5)	3 (1.5)

Values are n (%).
Infected participates were those testing negative to antibody at first time point and testing positive to both spike and nucleocapsid antibody at second time point. Only a subset of vaccinated participants reporting vaccine receipt (irrespective of serology results) were eligible for inclusion in the main analysis: staff reporting most recent vaccine dose <5 weeks of the second time point.
*Job category includes activities (Act), environmental services (Env), dietary or food preparation (Food), administrative (Admin), physician (MD), advanced practice provider (APP), physical therapy (PT), occupational therapy (OT), respiratory therapy (RT), speech therapy (SP), social work (SW), registered nurses (Nurse), or clinical nurse assistant (CAN).

similar interval resident infection rates as noninfected staff (Table 2). However, staff with infection-induced seroconversion had different distributions of race and job categories than noninfected staff but very similar ages, duration of working at the testing facility, known COVID-19 close contacts, and self-reported infection control practices (Table 2).

In multivariable analyses for full study group, Black race, interval case rates (both facility and community), having known COVID-19 contacts, and patient-facing job categories had elevated odds of infection (Table 3). In the sensitivity analysis limited to only the 80 unvaccinated study participants, job category became statistically significant; nurses or certified nursing assistants were associated with a significantly higher odds of interval infection compared to non-patient-facing staff (aOR 5.65, 95% CI 1.39-22.97) (Table 3). Self-reporting as Black remained an important predictor of infection in this smaller study group, although with a less precise estimate (aOR 2.07, 95% CI 0.40-10.81).

Discussion

During the roughly 5-month winter surge of the COVID-19 pandemic, December 2020 through April 2021, prior to widespread vaccine uptake among Georgia nursing home staff, these staff had a roughly 1 in 3 chance of becoming infected with SARS-CoV-2. Like early in the pandemic, job types that require substantial close contact with residents (eg, certified nursing assistant) to perform high-contact care were at higher risk for infection compared to non-patient-facing staff. This suggests that during this interval, where weekly or biweekly testing of asymptomatic staff was in place, infection risk persisted related to occupational factors. Our approach was unique to previous

Table 3
Adjusted ORs for SARS-CoV-2 Seroconversion Among Nursing Home Staff

Characteristic	Adjusted OR (95% CI)	
	Study Group* (n = 203)	Unvaccinated Only (n = 80)
Sex		
Female	Referent	Referent
Male	1.67 (0.67, 4.18)	0.32 (0.03, 3.68)
Race		
White	Referent	Referent
Black or African American	**3.03 (1.19, 7.73)**	2.07 (0.40, 10.81)
Hispanic	1.03 (0.10, 10.47)	9.51 (0.23, 391.83)
Prefer not to answer	1.75 (0.50, 6.18)	0.81 (0.10, 6.61)
Age category, y		
<40	Referent	Referent
40-49	1.37 (0.56, 3.32)	0.36 (0.07, 1.80)
50-59	1.25 (0.53, 2.95)	0.89 (0.18, 4.41)
≥60	0.82 (0.28, 2.44)	0.60 (0.07, 5.28)
Job category†		
No patient care	Referent	Referent
MD/APP or PT/OT/RT/SP/SW	1.69 (0.59, 4.83)	2.28 (0.40, 13.02)
Nurse/CNA	1.89 (0.93, 3.86)	**5.65 (1.39, 22.97)**
Social distance at work		
No	Referent	Referent
Yes	0.66 (0.27, 1.66)	0.54 (0.13, 2.25)
Interval difference in % residents infected		
<50%	Referent	Referent
≥50%	1.10 (0.45, 2.67)	2.88 (0.66, 12.47)
Interval community incidence per 100 in participant zip code		
>4.83	Referent	Referent
4.84-6.47	0.96 (0.41, 2.25)	5.33 (1.00, 28.43)
>6.47	1.60 (0.64, 4.03)	1.54 (0.29, 8.23)
Contact with confirmed or suspected COVID-19 outside of work		
No	Referent	Referent
Yes	2.18 (0.78, 6.12)	2.20 (0.36, 13.32)

Study group includes all eligible participants (staff testing negative at time point 1) and reported either no vaccine receipt or reported vaccine receipt (irrespective of serology results) < 4 weeks of time point 2. Infected participants were those testing negative to antibody at time point 1 and testing positive to both spike and nucleocapsid antibody at time point 2. Results significant at the 95% confidence level are shown in bold.
*Unvaccinated participants differed slightly from vaccinated (Supplementary Table 1).
†Job category includes activities (Act), environmental services (Env), dietary or food preparation (Food), administrative (Admin), physician (MD), advanced practice provider (APP), physical therapy (PT), occupational therapy (OT), respiratory therapy (RT), speech therapy (SP), social work (SW), nurses (LPN or RN), or certified nursing assistant (CNA).

single cross-sectional surveys because we used 2 time points. Notably, we were unable to demonstrate an association between resident-infection burden during the exposure period and staff risk, or that associations between staff risk and occupational factors were modified by resident-infection burden.

We note several limitations in this study. First, unmeasured occupational factors, such as compliance with infection control practices or compliance with testing and work exclusion policies, may have confounded the association between job role and SARS-CoV-2 infection risk. Second, it is possible that facility factors, such as ventilation or structure of the fixed care environment, led to differences between facilities. However, we could not examine facility-specific risk because of small sample sizes in some facilities. Next, importantly, our use of self-reported data on exposures introduces possible recall error into our risk factor assessment. We may have excluded reinfections, because we excluded all participants who were seropositive in the first round, and nonoccupational factors such as masking and social distancing at home were not queried. There is the potential for substantial selection bias evaluating only staff consenting to the study, as well as limiting the subset analysis to only those unvaccinated. Finally, although we initially recruited roughly 800 staff at the second time point, because of prior infection and rotating staff, our sample size for the main analysis was likely too small to quantify meaningful risk for some factors. Finally, it is important to note that the magnitude of the community-case rates reported here likely underestimate the true magnitude of disease because of established reporting bias, so comparisons to serology-defined infection rates among staff should not be made directly.[21,22]

Despite these limitations, we describe an important observation in these data related to vaccine receipt. Many of our study participants were vaccinated prior to the second time point. We tried to maximize the size of the cohort by initially including any eligible participant who was unvaccinated for most of the exposure period in the study. When using this liberal inclusion criteria, the association between job type and infection risk was attenuated, with an elevated aOR of 1.89 (95% CI 0.93-3.86) for nursing staff, whereas in the most conservative analysis excluding all self-reported vaccinated staff, that aOR increased to almost 5.65 (95% CI 1.39-22.97). This attenuation of the magnitude of the estimated risk with the very recently vaccinated staff suggests that the impact of vaccine on reducing job type–dependent risks for interval infection were swift and large. Other recent cross-sectional studies highlight the deadly impact of low staff vaccination coupled with high SARS-CoV-2 transmission in the nursing staff communities has on resident infections; overcoming barriers to fully vaccinate staff is of utmost importance.[23–25]

Conclusions and Implications

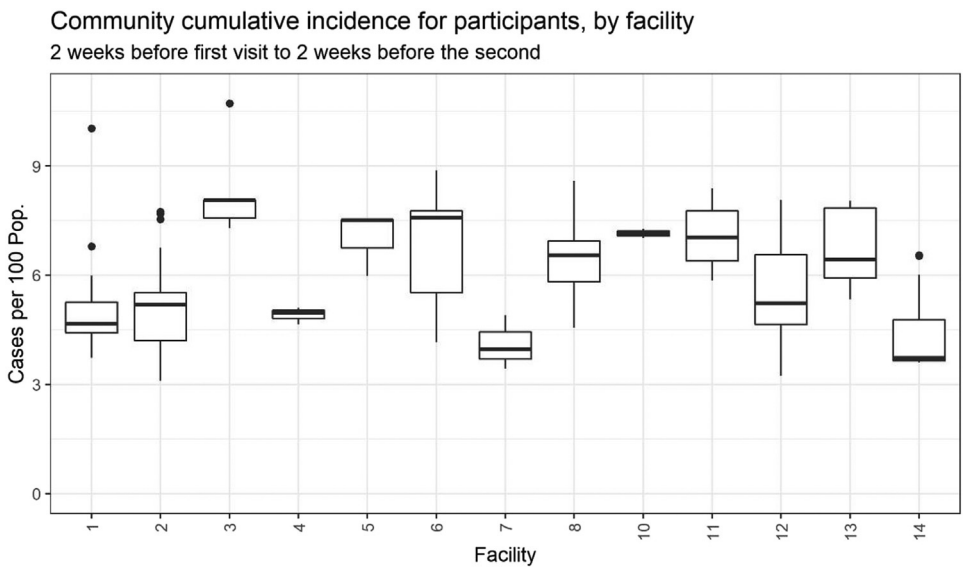
Elevated risk of SARS-CoV-2 infection among nursing staff suggests that the work activities of certified nursing assistants, and to a lesser extent nurses, has persisted despite extensive mitigation efforts focused on universal serial testing practices put into place at all nursing homes because of CMS regulations. However, these data highlight those risks attributed to job-type and patient-care activities can be eliminated with vaccine receipt.

Acknowledgments

We would like to thank the nursing home staff who participated while handling long hours, extra duties, and increased physical risk and mental stress during the ongoing COVID-19 pandemic and the Georgia Department of Public Health for supplying data for this project. We would also like to thank the serosurvey team (Nadia Khan, Kara Goldstone, Sean Huang, Michael Kozuch, Madison Cahill, Malay Mody, and Emily Dryzmalla) for assisting in the survey data collection and dried blood spot sample collection.

References

1. McMichael TM. COVID-19 in a long-term care facility—King County, Washington, February 27–March 9, 2020. MMWR Morb Mortal Wkly Rep 2020;69:339–342.
2. COVID-19 nursing home data. October 3, 2021. https://data.cms.gov/covid-19/covid-19-nursing-home-data. Accessed October 18, 2021.
3. 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.
4. Lansbury LE, Brown CS, Nguyen-Van-Tam JS. Influenza in long-term care facilities. Influenza Other Respir Viruses 2017;11:356–366.
5. Bagchi S. 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.
6. Akinbami LJ, Chan PA, Vuong N, et al. Severe acute respiratory syndrome coronavirus 2 seropositivity among healthcare personnel in hospitals and nursing homes, Rhode Island, USA, July-August 2020. Emerg Infect Dis 2021;27:823–834.
7. Steensels D, Oris E, Coninx L, et al. Hospital-wide SARS-CoV-2 antibody screening in 3056 staff in a tertiary center in Belgium. JAMA 2020;324:195–197.
8. Rudberg AS, Havervall S, Månberg A, et al. SARS-CoV-2 exposure, symptoms and seroprevalence in healthcare workers in Sweden. Nat Commun 2020;11:5064.
9. Amin AB, Kellogg JT, Adams C, et al. Risk factors for SARS-CoV-2 seropositivity among nursing home staff. Antimicrob Stewards Healthc Epidemiol 2021;1:e35.
10. Centers for Medicare & Medicaid Services. Interim Final Rule (IFC), CMS-3401-IFC, Additional policy and regulatory revisions in response to the COVID-19 public health emergency related to long-term care (LTC) facility testing requirements. https://www.cms.gov/medicareprovider-enrollment-and-certificationsurveycertificationgeninfopolicy-and-memos-states-and/interim-final-rule-ifc-cms-3401-ifc-additional-policy-and-regulatory-revisions-response-covid-19-0. Accessed March 29, 2022.
11. Guidance for Infection Control and Prevention of Coronavirus Disease 2019 (COVID-19) in Nursing Homes (REVISED). March 13, 2020. https://www.cms.gov/files/document/qso-20-14-nh-revised.pdf. Accessed March 29, 2022.
12. Centers for Disease Control and Prevention. Interim infection prevention and control recommendations to prevent SARS-CoV-2 spread in nursing homes. https://www.cdc.gov/coronavirus/2019-ncov/hcp/long-term-care.html. Accessed March 29, 2022.
13. Dykgraaf SH, Matenge S, Desborough J, et al. Protecting nursing homes and long-term care facilities from COVID-19: a rapid review of international evidence. J Am Med Dir Assoc 2021;22:1969–1988.
14. Holmdahl I, Kahn R, Hay JA, et al. Estimation of transmission of COVID-19 in simulated nursing homes with frequent testing and immunity-based staffing. JAMA Netw Open 2021;4:e2110071.
15. Dumyati G, Gaur S, Nace DA, Jump RLP. Does universal testing for COVID-19 work for everyone? J Am Med Dir Assoc 2020;21:1525–1532.
16. Simoni-Wastila L, Wallem A, Fleming S, et al. Staffing and protective equipment access mitigated COVID-19 penetration and spread in US nursing homes during the third surge. J Am Med Dir Assoc 2021;22:2504–2510.
17. Meyers E, Heytens S, Formukong A, et al. Comparison of dried blood spots and venous blood for the detection of SARS-CoV-2 antibodies in a population of nursing home residents. Microbiol Spectr 2021;9:e0017821.
18. American Community Survey 2019. United States Census Bureau. https://data.census.gov/cedsci/table?q=b01003&t=Populations%20and%20People&g=0400000US13,13.860000&tid=ACSDT5Y2019.B01003&hidePreview=true19. Accessed March 29, 2022.
19. Food and Drug Administration. EUA authorized serology test performance. https://www.fda.gov/medical-devices/coronavirus-disease-2019-covid-19-emergency-use-authorizations-medical-devices/eua-authorized-serology-test-performance. Accessed March 29, 2022.
20. Centers for Medicare & Medicaid Services. Division of Nursing Homes/Quality, Safety, and Oversight Group/Center for Clinical Standards and Quality. COVID-19 nursing home dataset. https://data.cms.gov/Special-Programs-Initiatives-COVID-19-Nursing-Home/COVID-19-Nursing-Home-Dataset/s2uc-8wxp. Accessed March 29, 2022.
21. Moghadas SM, Sah P, Shoukat A, et al. Population immunity against COVID-19 in the United States. Ann Intern Med 2021;174:1586–1591.
22. Centers for Disease Control and Prevention. Estimated COVID-19 burden. https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/burden.html. Accessed March 29, 2022.
23. McGarry BE, Barnett ML, Grabowski DC, Gandhi AD. Nursing home staff vaccination and Covid-19 outcomes. N Engl J Med 2022;386:397–398.
24. McGarry BE, Gandhi AD, Grabowski DC, Barnett ML. Larger nursing home staff size linked to higher number of COVID-19 cases in 2020. Health Aff (Millwood) 2021;40:1261–1269.
25. McGarry BE, Shen K, Barnett ML, Grabowski DC, Gandhi AD. Association of nursing home characteristics with staff and resident COVID-19 vaccination coverage. JAMA Intern Med 2021;181:1670–1672.



Supplementary Fig. 1. Zip code–specific interval cumulative incidence of COVID-19 among 203 nursing home staff, by nursing home. Median (solid line), interquartile values (box), 5th and 95th percentile values (whisker) and extreme values (circle).

Supplementary Table 1
Comparison of Self-Reported Vaccinated Staff and Unvaccinated Staff Among the Cohort of 203 Eligible Nursing Home Staff Studied

	Unvaccinated (n = 80)	Vaccinated (n = 123)	Total (N = 203)
Sex			
Female	69 (86)	100 (81)	169 (83)
Male	11 (14)	23 (19)	34 (17)
Age category, y			
<40	32 (40)	27 (22)	59 (29)
40-49	18 (22)	35 (28)	53 (26)
50-59	22 (28)	40 (33)	62 (31)
≥60	8 (10)	21 (17)	29 (14)
Race			
White	19 (24)	27 (22)	46 (23)
Black or African American	44 (55)	78 (63)	122 (60)
Hispanic	2 (2)	5 (4)	7 (3)
Prefer not to answer	13 (16)	10 (8)	23 (11)
Missing	2 (2.5%)	3 (2.4%)	5 (2.5%)
Job category*			
Act/Env/Food/Admin	28 (39)	67 (51)	95 (47)
Physician/PT/OT/RT/SP/SW	12 (17)	21 (16)	33 (16)
Nurse	16 (22)	26 (20)	42 (21)
CNA	16 (22)	17 (13)	33 (16)
Community contact			
Yes	9 (11)	12 (10)	21 (10)
No	69 (86)	108 (88)	177 (87)
Unknown	2 (2)	3 (2)	5 (2)
Work contact			
At least 1 contact	42 (52)	42 (34)	84 (41)
No or unsure	38 (48)	81 (66)	119 (59)
Universal masking			
≥80% of the time	71 (89)	112 (91)	183 (90)
<80% of the time	9 (11)	11 (9)	20 (10)
Social distancing			
Yes	66 (82)	110 (89)	176 (87)
No or unsure	14 (18)	13 (11)	27 (13)
Interval difference in % residents infected			
<50%	24 (30)	40 (33)	64 (32)
≥50%	56 (70)	83 (67)	139 (68)
Interval community incidence per 100 in participant zip code			
≤4.83	23 (29)	43 (35)	66 (33)
4.84-6.47	28 (35)	38 (31)	66 (33)
>6.47	27 (34)	41 (33)	68 (33)
Missing	2 (2.5)	1 (0.8)	3 (1.5)

Values are n (%).

*Job category includes activities (Act), environmental services (Env), dietary or food preparation (Food), administrative (Admin), physician (MD), physical therapy (PT), occupational therapy (OT), respiratory therapy (RT), speech therapy (SP), social work (SW), nurse (LPN or RN), or certified nursing assistant (CNA).