Severe Acute Respiratory Syndrome Coronavirus 2 Seropositivity among Healthcare Personnel in Hospitals and Nursing Homes, Rhode Island, USA, July–August 2020

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Healthcare personnel are recognized to be at higher risk for infection with severe acute respiratory syndrome coronavirus 2. We conducted a serologic survey in 15 hospitals and 56 nursing homes across Rhode Island, USA, during July 17–August 28, 2020. Overall seropositivity among 9,863 healthcare personnel was 4.6% (95% CI 4.2%–5.0%) but varied 4-fold between hospital personnel (3.1%, 95% CI 2.7%–3.5%) and nursing home personnel (13.1%, 95% CI 11.5%–14.9%). Within nursing homes, prevalence was highest among personnel working in coronavirus disease units (24.1%; 95% CI 20.6%–27.8%). Adjusted analysis showed that in hospitals, nurses and receptionists/medical assistants had a higher likelihood of seropositivity than physicians. In nursing homes, nursing assistants and social workers/case managers had higher likelihoods of seropositivity than occupational/physical/speech therapists. Nursing home personnel in all occupations had elevated seropositivity compared with hospital counterparts. Additional mitigation strategies are needed to protect nursing home personnel from infection, regardless of occupation.

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Healthcare personnel face higher risk of infection during the coronavirus disease (COVID-19) pandemic because of their essential role in identifying and treating persons affected (*1*,*2*). Although essential workers in many occupations have higher risk of infection because of face-to-face interaction with the public, personnel in hospitals and nursing homes have more frequent and prolonged contact with persons known to be infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).

Hospitals and nursing homes are potential hotspots of infection transmission. Hospital personnel conduct activities ranging from infection screening to administering advanced life support measures and may be exposed to patients with high viral loads (*3*). Infection risk can be exacerbated by shortages in personal protective equipment (PPE) and other resources, including staff (*4*,*5*). Nursing homes have been referred to as "ground zero" (*6*) of the pandemic because resident deaths have contributed disproportionately to overall COVID-19 mortality (*2*,*7*). Several factors may increase intrafacility transmission, including residents with risk factors for severe COVID-19 disease and prolonged viral shedding (e.g., advanced age, underlying conditions), a large proportion of asymptomatic infections, and new resource constraints alongside long-standing challenges (*8*–*11*). Assessing SARS-CoV-2 seropositivity among hospital and nursing home personnel may reveal risk factors that can be addressed through additional interventions. Community transmission has been identified as a primary determinant of transmission in both nursing homes and hospitals (*12*,*13*), but the relative impact in each of these settings has not been simultaneously compared.

The Rhode Island Department of Health (RIDOH) and the US Centers for Disease Control and Prevention (CDC) collaborated on a serologic survey of personnel in hospitals, nursing homes, and first responder agencies (e.g., fire, law enforcement) across Rhode Island. As of July 17, 2020, when the survey was initiated, there were >17,700 persons positive for COVID-19 in Rhode Island, of whom 2,675 were nursing home residents and 1,210 nursing home staff, and just more than 1,000 deaths, most among nursing home residents (*14*). Because of the disproportionate impact on nursing homes, we made an added effort to include as many nursing home facilities as possible in the survey. This analysis compares SARS-CoV-2 seroprevalence among nursing homes and hospital personnel and assesses characteristics and factors related to seropositivity.

Methods

The serologic survey was conducted throughout Rhode Island during July 17–August 28, 2020. RIDOH performed outreach to all agencies to encourage participation. The protocol was reviewed by CDC human subjects research officials, who determined that the activity was public health surveillance as defined in 45 CFR 46 (*15*). Participation was voluntary, results were not shared with employers, and CDC did not have access to personally identifying information.

RIDOH provided participating agencies with study information and a link to the secure web-based survey to distribute to employees (Appendix Table 1, https://wwwnc.cdc.gov/EID/article/27/3/20-4508-App1.pdf). Upon completing the screening and questionnaire on a personal device, participants received information about blood collection events at their workplace or nearby facility. Each participant provided 10–15 mL of blood using standard venipuncture techniques. Centrifuged serum samples were transferred to a central laboratory for SARS-CoV-2 antibody testing using the ORTHO Clinical Diagnostics VITROS Immunodiagnostic Products Anti-SARS-CoV-2 IgG Test (https://www.orthoclinicaldiagnostics.com). The emergency use authorization data submitted to the US Food and Drug Administration indicated that this test measures IgG directed at the S1 domain of the spike protein with a sensitivity of 90% and a specificity of 100% (*16*). Results were reported to participants as negative (signal-to-cutoff ratio <1.0), positive (≥1.0), or lack of valid result.

A total of 11,987 participants ≥18 years of age consented to phlebotomy and reported no new symptoms of cough, shortness of breath, fever, change in sense of taste/smell, or positive test for SARS-CoV-2 by reverse transcription PCR (RT-PCR) in the 2 weeks before survey participation. Seven were excluded for lack of valid serologic test result because of lipemia or insufficient sample volume and 1,860 did not work in either a hospital (inpatient units and/or ambulatory clinics) or nursing home. Of the remaining 10,120 participants, 9,863 had occupations in direct patient care and support (Appendix Table 2) and were included in this analysis.

We calculated seropositivity (percent positive for SARS-CoV-2 antibodies) overall and for subgroups. We estimated exact Clopper-Pearson 95% CIs and assessed significant statistical differences by evaluating nonoverlapping 95% CI or χ^2 tests for categorical variables and Cochran-Armitage trend tests for ordinal variables (2-sided with $\alpha = 0.05$).

We classified participants who reported race/ethnicity as non-Hispanic Native Hawaiian or other Pacific Islander, non-Hispanic American Indian or Alaska Native, or other race as other race (n = 231, 2.3%) and those who declined to specify race/ethnicity as declined (n = 240, 2.4%). We stratified analyses by primary agency selected by participants: hospital or nursing home. Participants could then choose one or more specific workplaces from a precategorized list or free-text workplaces not listed. Hospital emergency department was inadvertently omitted from the response categories for specific workplace but was included in the analysis based on free-text responses. Some hospital and nursing home participants reported working in additional settings that were not the focus of the analysis (e.g., emergency medical services) or in the other agency type (e.g., 1% of hospital and 2% of nursing home personnel worked in both hospital and nursing home settings). These participants were retained in the analysis, but these other workplaces were reported infrequently and are not shown separately. A precategorized list and free-text option were also provided for occupation. Prespecified categories with low frequencies were combined (Appendix Table 2). Among nursing home occupations, 4 with low sample size were combined (other nursing home: engineer/maintenance staff, pharmacist, receptionist/medical assistant, and physician, n = 56). Analyzing workplace and occupation simultaneously resulted in small sample sizes. Only occupation/workplace groups with sample size >20 or with absolute 95% CI width >30% were shown to ensure estimate reliability (*17*). Each workplace was represented as a separate dichotomous variable to allow modeling of non–mutually exclusive categories.

Participants reported the frequency at which they performed aerosol-generating procedures; if they needed complete PPE, as defined by CDC recommendations by occupation and patient contact; if, since March 1, they ever used PPE shortage protocols (extended use, reuse, or both); if they lacked specific PPE components when in contact with a person with suspected/confirmed COVID-19 in the workplace; and if they received training in the previous year on PPE donning/doffing techniques. Participants also reported whether their work involved in-person interaction with the community, patients, or both and if they were exposed (spent >10 minutes within 6 feet) to any COVID-19 positive co-workers, household members, patients, or other persons.

We used generalized estimating equations to model likelihood of seropositivity, accounting for clustering by facility (15 hospitals and 56 nursing homes, using an independence correlation structure). PPE variables had a common category (never use PPE) and were thus collinear. Therefore, only PPE shortage protocol use was included in the model, given evidence that shortages may contribute to transmission (*12*). Similarly, questions assessing use of individual PPE components had a common category, not applicable. Of these, only use of an N95/powered air-purifying respirator (PAPR) was included in the model, because it had an unadjusted association with seroprevalence. For hospital occupations, physicians were the reference group for comparability to a previous study (*18*). There were not enough physicians in nursing homes to categorize separately, so occupational/physical/speech therapists were the reference group for nursing homes. No interaction terms were explored. We used SAS 9.4 software (SAS Institute, https://www.sas.com) for all analyses.

Results

Overall seropositivity for 9,863 participants was 4.6% (95% CI 4.2%–5.0%) but differed between hospital personnel (3.1%; 95% CI 2.7%–3.5%) and nursing home personnel (13.1%; 95% CI 11.5%–15.0%) (Table 1). Generally, we found higher facility-level seropositivity in nursing homes than in hospitals, as well as lower or 0% seropositivity in facilities in rural western Rhode Island (Figure 1). Demographic characteristics were similar between hospital and nursing home personnel, but some seropositivity patterns differed. Seropositivity was highest among hospital personnel 18–24 years of age, but there were no age differences among nursing home personnel ($p = 0.64$ by χ^2 test). For both groups, there were no differences by sex ($p>0.05$), and Hispanic and non-Hispanic Black personnel had higher seropositivity compared with non-Hispanic White personnel (pairwise $p<0.001$ for both groups). Among nursing home personnel, those who lived in multiunit housing had higher seroprevalence than those in single-family housing ($p = 0.001$).

Table 1. SARS-CoV-2 seropositivity among hospital and nursing home personnel, by demographic characteristics, Rhode Island, USA, July–August 2020*

	Hospital			Nursing home		
Characteristic	No. (%)	Seropositive, no.	Seropositive, % (95% CI)	No. (%)	Seropositive, no.	Seropositive, % (95% CI)
Total	8,370 (100)	256	3.1 (2.7–3.5)	1,494 (100)	196	13.1 (11.5–15.0)
Age group, y						
18–24	275 (3.3)	21	7.6 (4.8–11.4)	68 (4.6)	7	10.3 (4.2–20.1)
25–34	1,987 (23.7)	71	3.6 (2.8–4.5)	254 (17.0)	37	14.6 (10.5–19.5)
35–44	1,874 (22.4)	56	3.0 (2.3–3.9)	328 (22.0)	45	13.7 (10.2–17.9)
45–59	2,890 (34.5)	81	2.8 (2.2–3.5)	569 (38.1)	78	13.7 (11.0–16.8)
60–64	896 (10.7)	22	2.5 (1.6–3.7)	170 (11.4)	20	11.8 (7.3–17.6)
≥65	448 (5.4)	5	1.1 (0.4–2.6)	105 (7.0)	9	8.6 (4.0–15.7)
Sex						
M	1,582 (18.9)	44	2.8 (2.0–3.7)	227 (15.2)	39	17.2 (12.5–22.7)
F	6,788 (81.1)	212	3.1 (2.7–3.6)	1,267 (84.8)	157	12.4 (10.6–14.3)
Race/ethnicity						
Non-Hispanic White	6,829 (81.6)	182	2.7 (2.3–3.1)	1,165 (78.0)	119	10.2 (8.5–12.1)
Non-Hispanic Black	284 (3.4)	20	7.0 (4.4–10.7)	87 (5.8)	24	27.6 (18.5–38.2)
Non-Hispanic Asian	316 (3.8)	10	3.2 (1.5–5.7)	28 (1.9)	6	21.4 (8.3–41.0)
Hispanic	554 (6.6)	31	5.6 (3.8–7.9)	130 (8.7)	28	21.5 (14.8–29.6)
Other†	191 (2.3)	11	5.8 (2.9–10.1)	40 (2.7)	8	20.0 (9.1–36.7)
Decline	196 (2.3)	2	1.0 (0.1–3.6)	44 (2.9)	11	25.0 (13.2–40.3)
Housing						
Single family	6,924 (82.7)	204	3.0 (2.6–3.4)	1,136 (76.0)	131	11.5 (9.7–13.5)
Multiunit	1,446 (17.3)	52	3.6 (2.7–4.7)	358 (24.0)	65	18.2 (14.3–22.6)

*SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.
†Other race/ethnicity includes non-Hispanic Native Hawaiian and other Pacific Islander, non-Hispanic American Indian and Alaska Native, and participants who indicated other non-Hispanic race.

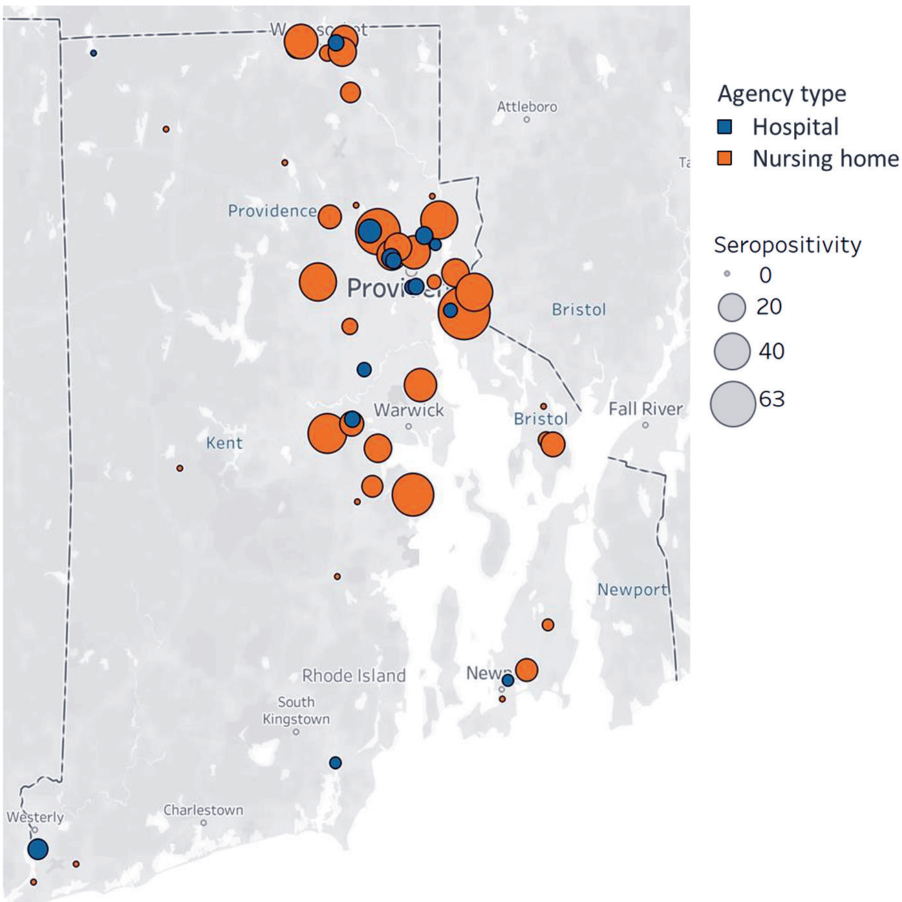

Figure 1. Seropositivity for severe acute respiratory syndrome coronavirus 2 among hospital and nursing home personnel, by facility, Rhode Island, USA, July–August 2020. Map based on average of longitude and average of latitude. Marker size is proportional to facility-level seroprevalence. Facilities with participant sample size <10 are not shown.

Among hospital personnel, nurse assistants had higher seropositivity (5.9%, 95% CI 3.8%–8.7%) than the overall hospital level of 3.1% (Table 2). Among nursing home personnel, nurse assistants had higher seropositivity (19.9%, 95% CI 15.5%–24.9%) than the overall nursing home level of 13.1%. Overall, 27.3% of participants reported working at >1 workplace. Among hospital personnel, seropositivity was higher among those working in hospital COVID-19 units (5.0%, 95% CI 4.0%–6.3%) than the overall hospital level. Among nursing home personnel, those working in nursing home COVID-19 units had higher seropositivity (24.1%, 95% CI 20.6%–27.8%) than the overall nursing home level. Figure 2 shows workplace and occupation together in non–mutually exclusive categories. Occupation/workplace groups with seroprevalence significantly elevated above the overall level of 4.6% included nurse assistants (31.4%, 95% CI 23.7%–39.9%), nurses (24.6%, 95% CI 18.7%–31.4%), and occupational therapists (13.4%, 95% CI 7.3%–21.8%) who worked in nursing home COVID-19 units; social workers/case managers (17.7%, 95% CI 6.8%–34.5%), nurse assistants (14.4%, 95% CI 10.0%–20.0%), and nurses (10.2%, 95% CI 7.1%–14.0%) who worked in nursing home non–COVID-19 units; and nurses (7.5%, 95% CI 5.5%–9.9%) who worked in hospital COVID-19 units. Across all occupational groups, seropositivity was higher for those who worked in nursing homes compared with those with the same occupation in hospitals.

Among hospital personnel, 27.2% of those exposed to a household member who tested positive for COVID-19 were seropositive versus 2.4% of those unexposed (Table 3). For nursing home personnel, 54.0% of those exposed to a household member with COVID-19 were seropositive versus 10.9% of those unexposed. For both hospital and nursing home personnel, exposure versus no exposure to a co-worker was associated with higher seropositivity, as was exposure to a patient (with or without PPE use) and exposure to some other person. Seropositivity was higher among personnel with community or patient interaction as part of work responsibilities compared with those without for both hospital (3.2% vs. 0.9%) and nursing home personnel (13.7% vs. 7.3%).

For both hospital and nursing home personnel, we found a significant linear trend of increasing

Table 2. SARS-CoV-2 seropositivity among hospital and nursing home personnel, by occupation and work location, Rhode Island, USA, July–August 2020*

	Hospital			Nursing home		
Category	No.	Seropositive, no.	Seropositive, % (95% CI)	No.	Seropositive, no.	Seropositive, % (95% CI)
Occupation						
Administrative/office staff/clerk	903	19	2.1 (1.3–3.3)	200	11	5.5 (2.8–9.6)
Diagnostic Imaging	369	11	3.0 (1.5–5.3)	0	NA	NA
Dietician/dietary services	135	3	2.2 (0.5–6.4)	114	10	8.8 (4.3–1.6)
Engineer/maintenance	108	2	1.9 (0.2–6.5)	26	6	23.1 (9.0–43.7)
Environmental services/cleaning	114	3	2.6 (0.6–7.5)	69	9	13.0 (6.1–23.3)
Laboratory technologist/technician	281	4	1.4 (0.4–3.6)	0	NA	NA
Nurse	2,733	114	4.2 (3.5–5.0)	413	63	15.3 (11.9–19.1)
Nurse assistant	392	23	5.9 (3.8–8.7)	296	59	19.9 (15.5–24.9)
Occupational/physical/speech therapist	283	8	2.8 (1.2–5.5)	163	16	9.8 (5.7–15.5)
Other healthcare	573	12	2.1 (1.1–3.6)	65	4	6.2 (1.7–15.0)
Pharmacist/pharmacist assistant	256	7	2.7 (1.1–5.6)	5	2	40.0 (5.3– 85.3)
Physician	1,001	22	2.2 (1.4–3.3)	10	0	0.0
Physician assistant	100	1	1.0 (0.0–5.5)	0	NA	NA
Receptionist/medical assistant	296	12	4.1 (2.1–7.0)	15	1	6.7 (0.2–32.0)
Social worker/case manager/counselor	432	7	1.6 (0.1–3.3)	46	10	21.7 (11.0–36.4)
Supervisor/manager	393	8	2.0 (0.9–4.0)	72	5	6.9 (2.3–15.5)
Workplace†						
Administrative office	1,132	21	1.9 (1.2–2.8)	218	12	5.5 (2.9–9.4)
Ambulatory healthcare/dental office	2,122	48	2.3 (1.7–3.0)	NA	NA	NA
Hospital COVID-19 unit	1,435	72	5.0 (4.0–6.3)	NA	NA	NA
Hospital general inpatient unit	3,752	138	3.7 (3.1–4.3)	NA	NA	NA
Hospital intensive care unit	1,250	37	3.0 (2.1–4.1)	NA	NA	NA
Hospital surgical unit	1,234	31	2.5 (1.7–3.6)	NA	NA	NA
Hospital emergency department	288	7	2.4 (1.0–4.9)	NA	NA	NA
Other hospital location	963	20	2.1 (1.3– 3.2)	NA	NA	NA
Nursing home COVID-19 unit	NA	NA	NA	565	136	24.1 (20.6–27.8)
Nursing home non–COVID-19 unit	NA	NA	NA	1,088	111	10.2 (8.5–12.2)

*Gray shading indicates nursing home occupation categories that had a sample size <30 and were combined into an other nursing home category, with a combined n = 56, percent seropositive 16.1% (7.6%–28.3%). COVID-19, coronavirus disease; NA, not applicable; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.
†Work location categories are not mutually exclusive: 27.3% of participants reported working in >1 workplace. Hospital and nursing home participants also reported working in other workplaces not shown in the table: corrections facilities (n = 16), Rhode Island Department of Health (n = 4), emergency medical services (n = 15), fire department (n = 6), law enforcement (n = 1), Rhode Island emergency management (n = 8), Rhode Island alternative hospital setup site (n = 14), Rhode Island remote COVID-19 testing site (n = 21), Rhode Island state warehouse (n = 1), or Rhode Island traffic and perimeter control (n = 1). Some worked in facilities in the other agency category; that is, 84 hospital personnel also worked in nursing home COVID-19 and non–COVID-19 units, and 34 nursing home personnel also worked in hospital COVID-19 units and general inpatient units.

seropositivity with greater procedure frequency of performing aerosol-generating procedures (Table 4). For both groups, seropositivity decreased with decreasing frequency of needing complete PPE. Among hospital personnel, those who reported no shortage of PPE had higher seropositivity than those who reused PPE ($p = 0.006$). Among nursing home personnel, there were no significant differences in seropositivity between those who reported no PPE shortages and those who reported extended use, reuse, or both. Among all personnel, there were no differences in seroprevalence between those who received PPE donning/doffing training versus those with no training ($p>0.05$ by χ^2 test). For each equipment type, there were no differences in seropositivity between those who reported having versus not having a specific PPE component, with one exception: hospital personnel who did not have an N95 respirator/PAPR were more likely to be seropositive than those who had this equipment (4.4% vs. 2.6%) (Figure 3).

In adjusted models (Figure 4; Appendix Table 3), both hospital personnel (Figure 4, panel A) and nursing home personnel (Figure 4, panel B) with exposure to a household member with COVID-19 had the highest odds of being seropositive. Otherwise, seropositivity patterns diverged by facility type. For hospital personnel, older age compared with 18–24 years of age was associated with lower seropositivity and non-Hispanic Black and Hispanic race/ethnicity were associated with higher seropositivity. Among nursing home personnel, there was no significant pattern of seropositivity by age or race/ethnicity. Personnel with work responsibilities including face-to-face interaction with members of the community or patients had a higher likelihood of seropositivity among hospital but not nursing home personnel. Among hospital personnel, nurses and receptionists or medical assistants had a higher likelihood of being seropositive compared with physicians. Among nursing home personnel, nurse assistants and social workers or case managers had higher likelihood compared with occupational, physical, and speech therapists. Finally, hospital personnel working in surgical units had lower likelihood of being seropositive. There were no associations by frequency of aerosol-generating procedures, use of PPE shortage protocols, or not having or using an N95 respirator/PAPR among either hospital or nursing home personnel.

Discussion

In this study, we compared SARS-CoV-2 seroprevalence among nursing home personnel to hospital per-

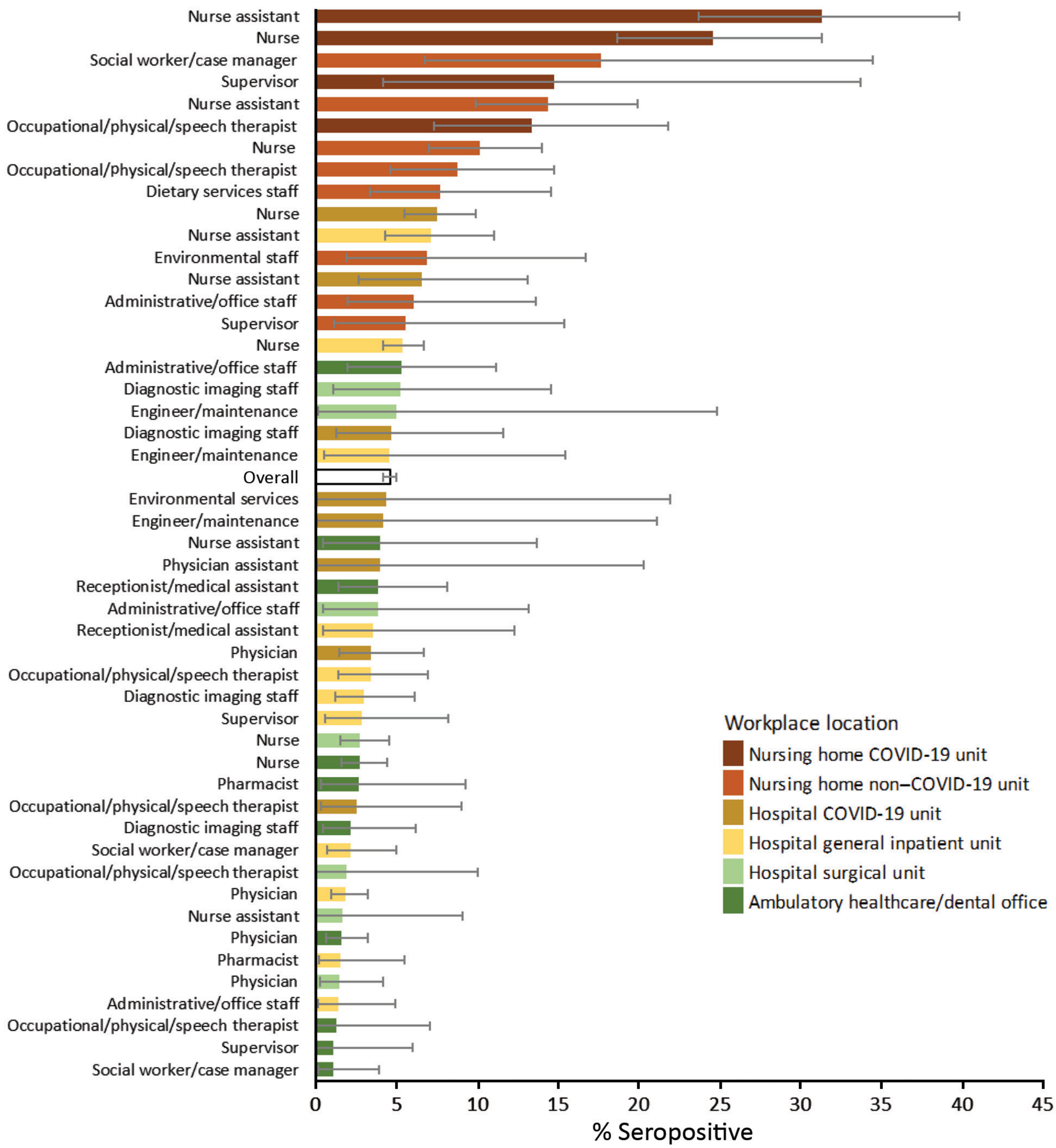

Figure 2. Seropositivity for severe acute respiratory syndrome coronavirus 2 among hospital and nursing home personnel, by selected workplace and occupation, Rhode Island, USA, July–August 2020. Error bars indicate 95% CIs. Workplace/occupation categories are not mutually exclusive: 27.3% of participants indicated >1 workplace. Occupations not included in the figure had 0% seroprevalence, sample size below n = 20, or absolute CI width >0.30 (unreliable estimate). Other healthcare category also not included. COVID-19, coronavirus disease.

Table 3. SARS-CoV-2 seropositivity among hospital and nursing home personnel, by exposure to persons testing positive for COVID-19 and in-person interaction in the workplace, Rhode Island, USA, July–August 2020*

	Hospital			Nursing home		
Question	No.	Seropositive, no.	Seropositive, % (95% CI)	No.	Seropositive, no.	Seropositive, % (95% CI)
Exposed to COVID-19–positive co-worker?						
Exposed	2,070	122	5.9 (4.9–7.0)	550	113	20.6 (17.2–24.2)
Not exposed/don't know	6,299	134	2.1 (1.8–2.5)	944	83	8.8 (7.1–10.8)
Exposed to COVID-19–positive household member?						
Exposed	213	58	27.2 (21.8–33.7)	76	41	54.0 (42.1–65.5)
Not exposed/don't know	8,156	198	2.4 (2.1–2.8)	1,418	155	10.9 (9.4–12.7)
Exposed to COVID-19–positive patient?						
Exposed while not wearing PPE	1,317	60	4.6 (3.5–5.8)	173	28	16.2 (11.0–22.5)
Exposed while wearing PPE	2,630	108	4.1 (3.4–4.9)	498	119	23.9 (20.2–27.9)
Not exposed/don't know	4,422	88	2.0 (1.6–2.5)	823	49	6.0 (4.4–7.8)
Exposed to other COVID-19–positive person?						
Exposed	827	67	8.1 (6.3–10.2)	163	54	33.1 (26.0–40.9)
Not exposed/don't know	7,542	189	2.5 (2.2–2.9)	1,331	142	10.7 (9.1–12.5)
In-person interaction with public/patients in the workplace?						
Work involves in-person interaction	7,795	251	3.2 (2.8–3.6)	1,370	187	13.7 (11.9–15.6)
No in-person interaction	574	5	0.9 (0.3–2.0)	124	9	7.3 (3.4–13.3)

*Exposure defined as being within 6 feet for at least 10 min. COVID-19, coronavirus disease; PPE, personal protective equipment; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

sonnel within 1 state. Nursing home personnel had a significantly higher seroprevalence (13.1%) than hospital personnel (3.1%), who had levels comparable to statewide seroprevalence of 2.8% based on commercial laboratory data as of August 2020 (*19*). High prevalence among nursing home personnel was observed across all occupations studied. A study analyzing Centers for Medicare and Medicaid Services facility-level data found that community COVID-19 prevalence was the strongest predictor of COVID-19 cases and deaths in nursing homes (*12*). In this study, the association between facility and community seroprevalence may hold, but with exaggerated SARS-CoV-2 transmission in nursing homes versus hospitals. SARS-CoV-2 seropositivity among nursing home COVID-19 unit personnel was nearly 5 times higher than among hospital-based COVID-19 unit personnel. Nursing home non–COVID-19 unit personnel had seropositivity nearly 3 times higher than hospital general inpatient unit personnel. As of November 17,

Table 4. SARS-CoV-2 seropositivity among hospital and nursing home personnel, by frequency of conducting aerosol-generating procedures frequency and use of PPE, Rhode Island, USA, July–August 2020*

	Hospital			Nursing home		
Characteristic	No.	Seropositive, no.	Seropositive, % (95% CI)	No.	Seropositive, no.	Seropositive, % (95% CI)
Aerosol-generating procedure frequency						
0 times per shift per week	4,121	108	2.6 (2.2–3.2)	858	93	10.8 (8.8–13.1)
1–5 times	1,679	62	3.7 (2.8–4.7)	114	25	21.9 (14.7–30.7)
6–10 times	380	22	5.8 (3.7–8.6)	36	7	19.4 (8.2–36.0)
11–25 times	277	11	4.0 (2.0–7.0)	23	4	17.4 (5.0–38.8)
>25 times	366	19	5.2 (3.2–8.0)	41	12	29.3 (16.1–45.5)
NA	1,546	34	2.2 (1.5–3.1)	422	55	13.0 (10.0–16.6)
PPE use						
Never use PPE	2,939	64	2.2 (1.7–2.8)	322	19	5.9 (3.6–9.1)
Used PPE and reported frequency of needing complete PPE						
Daily	1,809	66	3.7 (2.8–4.6)	632	125	19.8 (16.7–23.1)
Few times a week	1,860	75	4.0 (3.2–5.0)	332	42	12.7 (9.3–16.7)
Less than once a week	1,761	51	2.9 (2.2–3.8)	208	10	4.8 (2.3–8.7)
Use of PPE shortage protocol						
No shortage	511	25	4.9 (3.2–7.1)	238	28	11.8 (8.0–16.6)
Reuse	934	21	2.3 (1.4–3.4)	186	21	11.3 (7.1–16.7)
Extended use	1,341	42	3.1 (2.3–4.2)	253	45	17.8 (13.3–23.1)
Extended and reuse	2,644	104	3.9 (3.2–4.8)	495	83	16.8 (13.6–20.4)
Donning/doffing training in past year						
Yes	5,140	184	3.6 (3.1–4.1)	1,135	170	15.0 (13.0–17.2)
No	199	5	2.5 (0.8–5.8)	15	3	20.0 (4.3–48.1)
Don't know	91	3	3.3 (0.7–9.3)	22	4	18.2 (5.2–40.3)

*Significant linear trend of seropositivity with rising frequency of aerosol-generating procedures and decreasing frequency of needing complete PPE for hospital and nursing home settings (p<0.001 for all). NA, not applicable; PPE, personal protective equipment; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

2020, all 85 Rhode Island nursing homes had reported ≥1 COVID-19 cases; weekly counts of new cases were approximately equal for nursing home residents and staff, at ≈185 each as of November 25, 2020, according to RIDOH SARS-CoV-2 surveillance. Nursing homes have been deemed tinderboxes because of a constellation of factors that may perpetuate transmission, including resident populations with risk factors for severe COVID-19 and prolonged viral shedding, residents who may be asymptomatic or have nonspecific symptoms of infection (e.g., increased confusion), shared caretakers between patients, chronic staffing shortages that may be exacerbated by worker illness, and lack of testing and PPE (*10*,*12*,*20*–*22*). In addition, suboptimal infection control practices have been noted in direct observation studies of nursing home personnel (*23*).

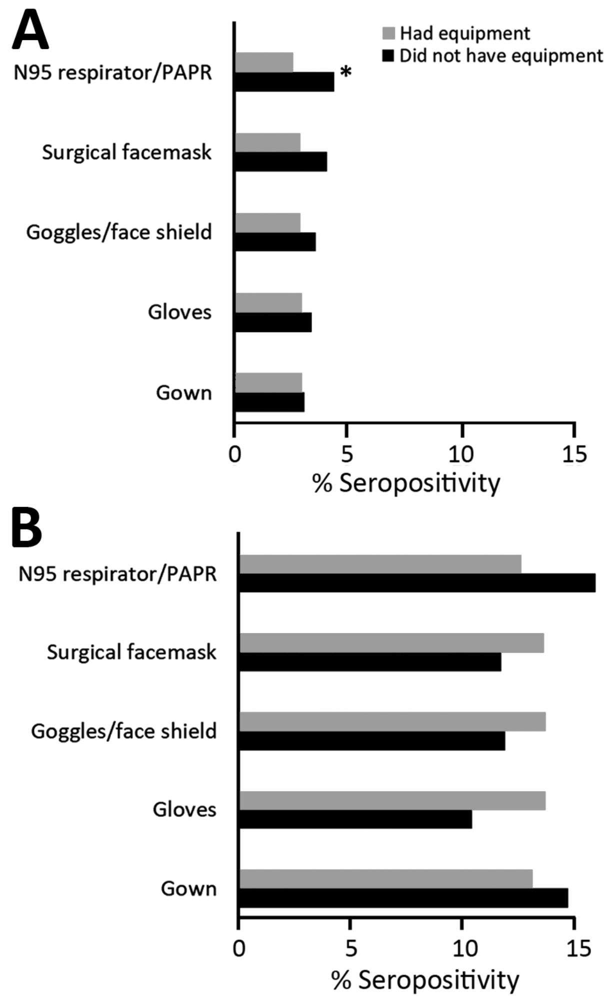

Figure 3. Seropositivity for severe acute respiratory syndrome coronavirus 2 among hospital and nursing home personnel, by having/not having specific PPE, Rhode Island, USA, July–August 2020. Excludes participants who reported no PPE use (19.6% of those in hospital settings, seropositivity 3.4%; 12.4% of those in nursing home settings, seropositivity 12.4%). Asterisk (*) indicates statistically significant difference ($p<0.05$ by χ^2 test). PPE, personal protective equipment.

We found patterns among hospital and nursing home personnel that suggest both community- and workplace-acquired infection. In both settings, contact with a COVID-19–positive household member was the strongest risk factor for seropositivity. Adjusted odds ratios for seropositivity by age group and race/ethnicity reflected community patterns (*24*–*26*) among hospital personnel but not among nursing home personnel. Other studies have found that seroprevalence was correlated with local cumulative COVID-19 incidence in general (*12*,*13*,*18*). Workplace transmission is suggested by higher likelihood of seropositivity among occupations with frequent and prolonged patient contact or working in common areas: nurses and receptionists/medical assistants in hospital settings and nurse assistants and social workers/case managers in nursing homes. Similar findings were noted in other studies (*2*,*18*,*27*). In hospitals, interaction with patients and community members was associated with higher seropositivity than was having no interaction as part of work responsibilities. Finally, in agreement with results from other hospital studies, our study found lower seropositivity among personnel in a controlled environment: hospital surgical units (*5*,*18*). However, in nursing homes, workplace factors appeared to dominate community factors given the elevated risk across occupation and seroprevalence >4 times greater than community levels (2.8%). Intrafacility transmission was found in a study of 2 skilled nursing facilities in which viral strains within each facility were genetically more similar than between the 2 facilities or the community; within 1 facility, there were 2 genetically distinct strains, which suggested community introduction into the facility followed by intrafacility transmission (*27*). That is, this group of studies suggest that community introduction into nursing homes may result in higher level of intrafacility transmission compared with hospital settings.

In at least 2 ways, the higher seroprevalence among nursing home COVID-19 unit personnel could have been partially driven by cohorting residents. First, even if the probability of transmission in facilities were equal, a higher percentage of infectious patients and residents in COVID-19 units would result in a greater number of transmitted infections. Second, if previously infected staff were assigned to COVID-19 units, seroprevalence among facility staff would be increased through staffing decisions rather than transmission. Without longitudinal or genotyping data, it is not possible to disentangle

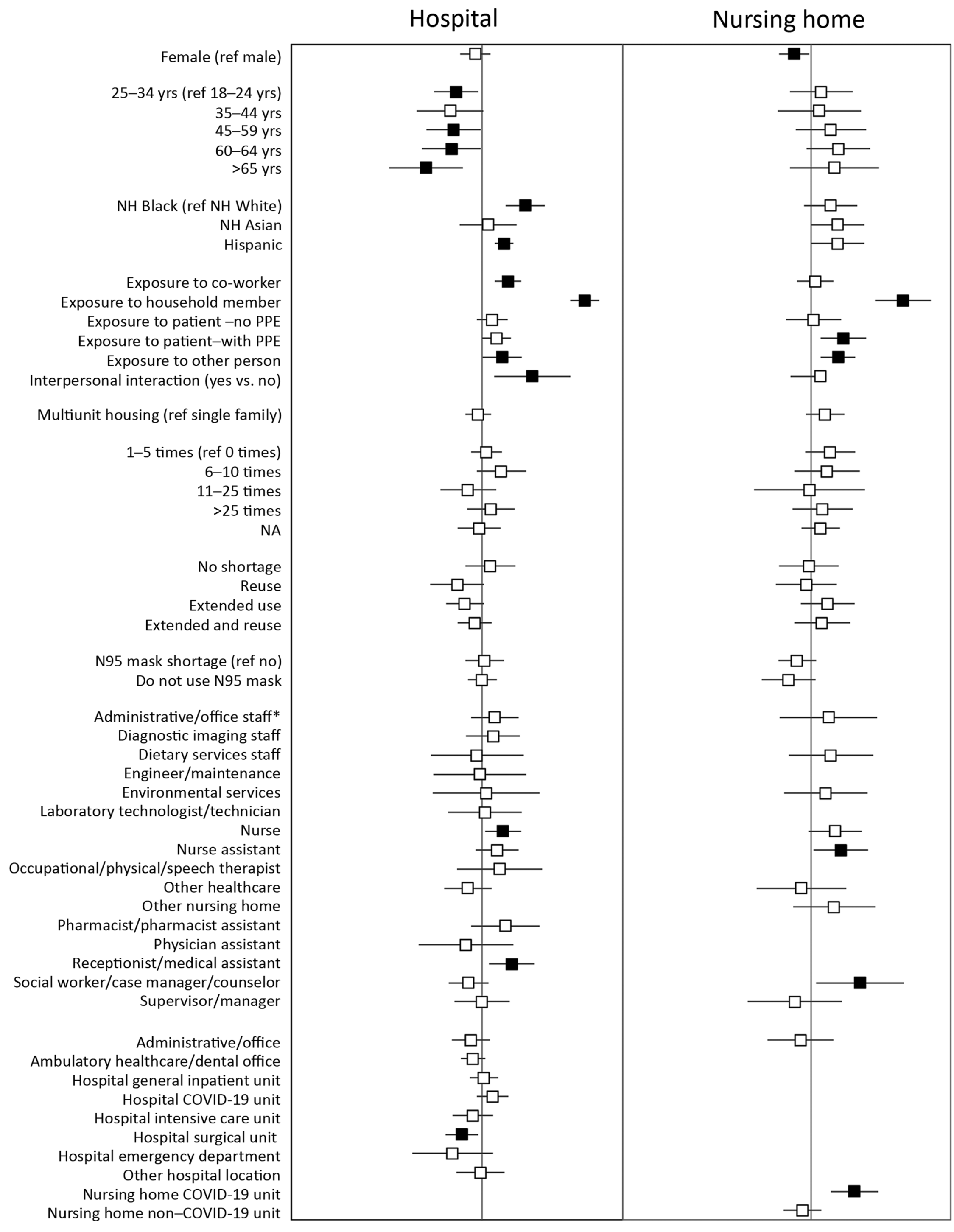

Figure 4. Adjusted odds ratios and 95% CIs for seropositivity, Rhode Island, USA, July–August 2020. The adjusted models were estimated using generalized estimating equations including all variables shown. Error bars indicate 95% CIs; black boxes denote adjusted odds ratios for which the 95% CI excludes 1.0. Workplace was represented by non–mutually exclusive dummy variables entered simultaneously into the model; the referent group for each workplace is not working in that specific workplace. Participants in workplaces with sample size <30 or with 0% seropositivity were included in the model but the workplace was not entered into the model. *For the hospital model, physicians were the referent occupation group. For the nursing home model, occupational/physical/speech therapists were the referent occupation group. Ref, referent; NH, non-Hispanic; PPE, personal protective equipment.

intrafacility transmission. Staff in Rhode Island were rarely transferred between facilities according to past infection status. Two facilities designated as COVID-19 facilities accepted infected residents, and the other 54 facilities cohorted patients within the facility or transferred residents to other facilities with COVID-19 units. No data were gathered on staff transfers within facilities between COVID-19 and non–COVID-19 units. Despite these gaps in fully understanding transmission, seroprevalence was still greatly elevated in nursing homes compared with hospitals among both COVID-19 and non–COVID-19 unit personnel.

Unadjusted analyses showed that those with daily requirements for complete PPE were more likely to be seropositive for both groups. However, there were no significant adjusted associations between seropositivity and frequency of requirement for complete PPE or PPE shortage protocol use. These findings suggest that PPE use was likely a marker for increased occupational risk (i.e., frequent close contact with infected patients or residents) and that personnel with the most frequent or intense patient contact may have received priority for PPE supplies or that PPE shortages did not have a major role in transmission in this study. More detailed studies are necessary to disentangle the complex factors surrounding PPE use.

Limitations include the cross-sectional study design. Patient or resident infection status was not ascertained. Infection timing relative to different exposures is unknown. For example, it is unknown whether participants who reported exposure to a COVID-19 positive household member were infected by that contact or introduced the infection into the household. Similarly, among seropositive participants who reported working in >1 workplace, it is not possible to ascertain their contribution, if any, to transmission between facilities. Furthermore, seroprevalence is a cumulative measure; antibody responses are reported to persist for ≥4 months (*28*). The extent to which seroprevalence was related to exposures early in the pandemic, when PPE shortages were more acute and infection control measures were still being developed, is unknown. Participation was voluntary among a convenience sample, so representativeness of the population is unknown. However, 56 of 85 nursing homes in Rhode Island were included and seropositivity among nursing home participants was related to resident and staff case counts in facilities, with higher seropositivity with rising quartile of case counts (Appendix Table 4). No information was collected about other possible exposures, such as travel and commuting (e.g., use of public transportation). In addition, there could be uncontrolled confounding, including factors related to other socioeconomic factors, such as less flexibility for household members to telework or otherwise reduce occupational exposures. Strengths included a large sample size that allowed stable estimates among subgroups.

This study highlights the increased risk among nursing home personnel for SARS-CoV-2 infection compared with hospital personnel. Although this study was not designed to pinpoint mechanisms underlying the higher seroprevalence among nursing home personnel, 2 patterns strongly suggest that additional workplace protections may mitigate risk in this setting: the elevated risk among all nursing home occupations compared with hospital counterparts and the weaker signals of community transmission among nursing home settings (i.e., no association between age group and race/ethnicity with seropositivity). Continued attention to adherence with current infection control recommendations (e.g., PPE use, handwashing) and ensuring adequate testing, equipment, training, and staffing are the foundations for bolstering the safety of nursing home personnel (*22*,*23*,*29*).

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Severe Acute Respiratory Syndrome Coronavirus 2 Seropositivity among Healthcare Personnel in Hospitals and Nursing Homes, Rhode Island, USA, July–August 2020

Appendix

Appendix Table 1. Questionnaire administered to respondent healthcare personnel, Rhode Island, USA, July–August 2020

Section	Question/item	Response categories
1.	Name	First Last
2.	Home address	Street City State Zip
3.1	Phone number (mobile)	Area code, phone number
3.2	Verify phone number (mobile)	Area code, phone number
4.1	Email address	(fill)
4.2	Verify email address	(fill)
5.	Date of birth	MM/DD/YYYY
6.	Sex at birth	Male Female
7.	Current gender	Man Woman Transgender man/trans man Transgender woman/trans woman Genderqueer/gender nonconforming neither exclusively male nor female Other (fill) Decline to answer
8.	Sexual orientation	Gay Straight Bisexual Something else/not sure Decline to answer
9.	Are you Hispanic or Latino/Latina?	Yes No Don't know Decline to answer
10.	What is your race? (select all that apply)	White Black/African American Asian American Indian or Alaska Native Native Hawaiian or other Pacific Islander Other Decline to answer
Added	Please select your age group	18–29 y 30–39 y 40–49 y 50–59 y 60–64 y 65–69 y 70–79 y

Section	Question/item	Response categories
11.1	Select your primary agency or work category:	Hospital/healthcare agency Fire agency Law enforcement/police agency EMS agency Nursing home Corrections (Go to 11.3) RI National Guard (Go to 11.3) RI Department of Health (Go to 11.3)
11.2	What is your primary work facility?	Hospitals (FULL LIST – 15 locations) Fire (FULL LIST – Will split in half if needed – 47 locations) Law Enforcement (FULL LIST – Will split in half if needed – 43 locations) EMS (Split list in half – 79 locations) Nursing homes (Split list in half – 85 locations)
11.3	Since March 1, did your work involve in-person interaction with members of the general community and/or patients?	Yes No
12.1	What were your main workplaces since March 1st? (Select all that apply)	Administrative office (any facility) Corrections—Intake Corrections—Minimum Security Corrections—Medium Security Corrections—Maximum Security Corrections—High Security Corrections—Probation and Parole Corrections—Women's Facility Department of Health—Cannon Building Department of Health—State Health Laboratory Department of Health—Medical Examiner's Office EMS- EMT/Paramedic Fire Department Law enforcement/Police Healthcare—Ambulatory/Dental/Outpatient Clinic Healthcare—Hospital general inpatient unit Healthcare—Hospital COVID-19 unit Healthcare—Hospital intensive care unit Healthcare—Hospital surgical unit Healthcare—Laboratory Nursing home—COVID-19 unit Nursing home—non–COVID-19 unit RI Emergency Management Agency RI alternate hospital setup site RI remote COVID-19 testing site RI state warehouses Traffic and perimeter control Other (any facility)
12.2	Which of the following best describes your occupation?	Administrative/business office staff/clerk Clinical technician (e.g., cardiac, renal, surgical) Clinical researcher/scientist Corrections officer/staff COVID-19 testing site staff Dentist/dental hygienist/dental assistant Diagnostic imagining staff Dietician/dietary services staff Dispatcher Emergency medical technician (EMT)/paramedic Engineer/maintenance/mechanic/repair staff Environmental services/cleaning staff Epidemiologist/infection control Firefighter/fire inspector/fire marshal Information/computer technologist Laboratory technologist/technician Law enforcement/police officer Medical examiner/mortuary technician/forensic staff Medical records/health information technician Military servicemember Nurse (e.g., CRNA, RN, LPN) Nurse assistant (e.g., CNA, CSA, aide, medication technician) Nurse midwife Nurse practitioner Occupational/physical/speech therapist

Section	Question/item	Response categories
		Patient aide/technician Pharmacist/pharmacist assistant Phlebotomist/medical technician Physician (e.g., MD, DO) Physician assistant Receptionist/medical assistant/patient registration Recreation specialist/therapist Respiratory therapist Security guard Social worker/case manager/counselor Surgical technician/technologist Supply chain/materials management (e.g., PPE) Supervisor/manager Other (fill)
14.	Since March 1, on average, how many times per shift did you participate in any aerosol-generating procedures for suspected or confirmed COVID-19 patient(s)? Examples: Open suctioning of airways Sputum induction Cardiopulmonary resuscitation Endotracheal intubation and extubation Noninvasive ventilation (e.g., BiPAP, CPAP) Bronchoscopy Manual ventilation	More than 25 times 11- 25 times 6–10 times 1–5 times 0 Not applicable
13.1	CDC recommends “complete” PPE when in contact with suspected or confirmed COVID-19: • Surgical face mask or respirator • Goggles or face shield • Gown • Gloves When aerosol generating or surgical procedures are performed, an N95 or higher-level respirator should be used instead of a surgical facemask. On average since March 1, in your workplace, how often were you in a situation where you needed complete PPE?	Never (Go to 15.1) Less than once a week A few times a week Every day
13.2	Since March 1, because of a PPE shortage, have you extended use of PPE (wearing the same PPE throughout an entire workday) or reused PPE at your workplace?	Yes, extended use of PPE Yes, reused PPE Yes, both extended use and reused No shortage
13.3	At any time since March 1, which PPE did you NOT have/use when you were in contact with a person with suspected or confirmed COVID-19 at your workplace? (Select all that apply)	Gown Gloves Goggles/face shield Surgical facemask N95 respirator/PAPR/other respirator NA
13.4	Have you been trained on how to properly put on and take off (don and doff) PPE in the past year?	Yes No Don’t know
15.1	Did you spend more than 10 min within 6 feet of a co-worker who tested positive for COVID-19?	Yes No Don’t know
15.2	Did you spend more than 10 min within 6 feet of a household member who tested positive for COVID-19?	Yes No Don’t know
15.3	Did you spend more than 10 min within 6 feet of a patient who tested positive for COVID-19?	Yes, with appropriate PPE at all times Yes, without appropriate PPE at least once No Don’t know

Section	Question/item	Response categories
15.4	Did you spend more than 10 min within 6 feet of any other person who tested positive for COVID-19?	Yes No Don't know
PREAMBLE: Next, we will be asking you about two different types of testing—testing for current COVID-19 infection or testing for past infection (antibody).		
16.1	Thinking about COVID-19, how many times were you tested for infection using a nasal, throat, or saliva sample?	[indicate 0 if none] (if 0 go to 17.1)
16.2	Have you ever had a positive nasal, throat, or saliva result for COVID-19?	Yes No (go to 17.1)
16.3	Approximately, what was the date of your **first positive test** using a nasal, throat, or saliva sample in 2020?	MM/DD Don't know
17.1	Now, thinking about testing for past infection, have you ever had a positive **antibody** test result using a blood sample?	Yes No (GO TO 18)
17.2	Approximately, when was the date of your **first positive antibody test** using a blood sample in 2020?	MM/DD Don't know
18.0	Since March 1, have you experienced any of the following symptoms? (select all that apply)	No symptoms Fever/chills Cough (new onset or worsening of chronic cough) Sore throat Shortness of breath or difficulty breathing Diarrhea Nausea or vomiting Fatigue/tiredness Nasal congestion or runny nose Muscle or body aches New loss in sense of smell or taste Headache (new onset or worsening headache) Other symptoms
19.	When did these symptoms start? (estimate as well as possible)	MM/DD Don't know
20.	Did you receive healthcare for these symptoms?	Yes No
21.	Were you hospitalized for COVID-19 illness?	Yes No
22.	Do you live in a single unit (e.g., house) or multiunit housing (e.g., an apartment)?	Single unit Multiunit
23.	Number of household members currently in the residence including yourself (resident, family, live-in staff, roommates, and long-term visitors)	Specify (scroll)
24.	What is your height?	Feet Inches
25.	What is your weight?	Weight in pounds
26.1	Do you have any of the following chronic medical conditions? (choose all that apply)	No conditions Asthma Cerebrovascular disease (affects blood vessels and blood supply to the brain) Chronic kidney disease Chronic liver disease COPD/emphysema/chronic bronchitis Diabetes HIV Hypertension or high blood pressure Immunocompromised condition (e.g., autoimmune disease, solid organ transplant, sickle cell disease) Immune weakening medication or therapy (e.g., cancer treatment) Serious heart conditions, such as heart failure, coronary artery disease, or cardiomyopathies Other chronic conditions
26.2	Do you currently smoke tobacco or vape nicotine or electronic cigarettes? (Select all that apply)	Yes, current smoker Yes, currently use electronic cigarettes No, former smoker

Section	Question/item	Response categories
		Never smoked
27.	Since March 1, have you been or are you currently pregnant?	Yes No Don’t know

Appendix Table 2. Sample eligibility criteria

Included health workplaces	Included health occupations
Administrative office	Administrative/business office staff/clerk
Ambulatory healthcare/dental office	Diagnostic imaging staff
Hospital general inpatient	Dietician/dietary services staff
Hospital COVID-19 unit	Engineer/maintenance/mechanic/repair staff
Hospital intensive care unit	Environmental services/cleaning staff
Hospital surgical unit	Laboratory technologist/technician
Hospital other location	Nurse (e.g., CRNA, RN, LPN)
Hospital emergency room	Nurse assistant (e.g., CNA, CSA, aide, medication technician)
Nursing home COVID-19 unit	Occupational/physical/speech therapist
Nursing home nonCOVID-19 unit	Other healthcare*
	Pharmacist/pharmacist assistant
	Physician (e.g., MD, DO)
	Physician assistant
	Receptionist/medical assistant/patient registration
	Social worker/case manager/counselor
	Supervisor/manager
Excluded health workplaces	**Excluded health occupations**
Corrections	Corrections officer
Department of Health	Emergency medical technician/paramedic
Emergency medical system	Fire fighter/inspector/marshal
Fire department	Law enforcement/police officer
Law enforcement	Military servicemember
Military base	Research/epidemiologist
Rhode Island emergency management	
Rhode Island alternative hospital set up	
Rhode Island remote COVID-19 testing site	
Rhode Island state warehouses	
Traffic and perimeter control	

*Includes clinical technician (e.g., cardiac, renal, surgical), dentist/dental hygienist/dental assistant, medical examiner/mortuary technician/forensic personnel, patient aide/technician, phlebotomist/medical technician, recreation specialist/therapist, respiratory therapist, surgical technician/technologist, and security guards and COVID-19 testing personnel in hospital and nursing home settings.

Appendix Table 3. Adjusted odds ratios and 95% confidence intervals for seropositivity, Rhode Island, USA, July–August 2020*

	Hospital personnel n = 9,836		Nursing home personnel n = 1,494	
Category	Adjusted odds ratio	95% CI	Adjusted odds ratio	95% CI
Sex				
Female (ref Male)	0.846	0.590–1.213	**0.657**	**0.458–0.941**
Age group				
18–24 y	ref		ref	
25–34 y	**0.533**	**0.310–0.916**	1.272	0.593–2.732
35–44 y	0.461	0.205–1.037	1.214	0.438–3.368
45–59 y	**0.498**	**0.258–0.961**	1.608	0.684–3.780
60–64 y	**0.476**	**0.232–0.974**	1.938	0.891–4.214
≥65 y	**0.258**	**0.106–0.628**	1.751	0.590–5.198
Race/ethnicity				
Non-Hispanic white	ref		ref	
Non-Hispanic Black	**2.827**	**1.767–4.521**	1.597	0.837–3.047
Non-Hispanic Asian	1.155	0.583–2.287	1.903	0.991–3.655
Hispanic	**1.697**	**1.350–2.131**	1.903	0.991–3.655
Other	1.937	0.890–4.215	1.520	0.636–3.632
Decline	0.376	0.115–1.229	**2.570**	**1.252–5.276**
Exposure to person testing positive for COVID-19				
Co-worker (ref not exposed)	**1.873**	**1.362–2.577**	1.103	0.706–1.723
Household member (ref not exposed)	**11.911**	**8.427–16.835**	**9.373**	**4.750–18.497**

Category	Hospital personnel n = 9,836		Nursing home personnel n = 1,494	
	Adjusted odds ratio	95% CI	Adjusted odds ratio	95% CI
Patient, no PPE (ref not exposed)	1.282	0.887–1.853	1.055	0.537–2.073
Patient, with PPE (ref not exposed)	1.408	0.991–2.001	**2.185**	**1.256–3.803**
Other person (ref not exposed)	**1.626**	**1.018–2.599**	**1.917**	**1.265–2.906**
Interpersonal interaction (vs none)	**3.375**	**1.345–8.470**	1.237	0.607–2.522
Housing				
Multiunit (ref single family)	0.911	0.671–1.236	1.399	0.878–2.230
Average frequency of aerosol generating procedures per shift per week				
0 times	ref		ref	
1–5 times	1.115	0.765–1.624	1.589	0.866–2.916
6–10 times	1.597	0.875–2.915	1.463	0.662–3.235
11–25 times	0.713	0.364–1.396	0.959	0.248–3.713
>25 times	1.239	0.699–2.199	1.312	0.629–2.739
Not applicable	0.931	0.554–1.565	1.259	0.789–2.008
PPE shortage protocol use				
No shortage	1.229	0.672–2.247	0.942	0.458–1.938
Reuse	0.546	0.284–1.052	0.886	0.421–1.867
Extended use	0.662	0.421–1.043	1.486	0.769–2.870
Extended and reuse	0.838	0.556–1.263	1.305	0.659–2.583
Never used PPE	ref		ref	
N95 respirator/PAPR shortage				
Yes	1.064	0.667–1.697	0.709	0.449–1.119
No shortage	ref		ref	
Not applicable	1.004	0.711–1.418	0.574	0.298–1.104
Occupation†				
Administrative/office staff/clerk	1.355	0.765–2.398	1.518	0.465–4.959
Diagnostic imaging staff	1.304	0.680–2.500	NA	NA
Dietician/dietary services staff	0.884	0.287–2.717	1.623	0.579–4.552
Engineer/maintenance staff	0.942	0.308–2.886	NA	NA
Environmental services/cleaning staff	1.104	0.304–4.014	1.420	0.512–3.937
Laboratory technologist/technician	1.066	0.439–2.593	NA	NA
Nurse (e.g., CRNA, RN, LPN)	**1.660**	**1.073–2.568**	1.782	0.929–3.419
Nurse assistant (e.g., CNA, CSA, Aide)	1.440	0.854–2.427	**2.055**	**1.057–3.998**
Occupational/physical/speech therapist	1.531	0.547–4.284	ref	
Other healthcare	0.708	0.401–1.249	0.785	0.264–2.329
Other nursing home‡	NA	NA	1.741	0.637–4.759
Pharmacist/pharmacist assistant	1.754	0.762–4.036	NA	NA
Physician (e.g., MD, DO)	ref		NA	NA
Physician assistant	0.678	0.217–2.118	NA	NA
Receptionist/medical assistant	**2.038**	**1.179–3.522**	NA	NA
Social worker/case manager	0.719	0.445–1.162	**3.284**	**1.119–9.638**
Supervisor/manager	0.996	0.513–1.935	0.669	0.213–2.108
Workplace (ref did not work in this setting)§				
Administrative office	0.765	0.485–1.208	0.771	0.345–1.724
Ambulatory healthcare/dental office	0.804	0.595–1.086	–	–
Hospital general inpatient unit	1.039	0.739–1.462	1.758	0.379–8.154
Hospital COVID-19 unit	1.286	0.884–1.870	0.198	0.035–1.121
Hospital intensive care unit	0.799	0.491–1.299	NA	NA
Hospital surgical unit	**0.612**	**0.410–0.912**	NA	NA
Other hospital location	0.965	0.541–1.723	NA	NA
Hospital emergency room	0.487	0.184–1.292	NA	NA
Nursing home COVID-19 unit	**3.946**	**1.392–11.186**	**2.860**	**1.606–5.095**
Nursing home non–COVID-19 unit	0.989	0.362–2.701	0.808	0.508–1.284

*The adjusted models were estimated using generalized estimating equations including all variables shown. Bolded adjusted odds ratios and 95% confidence intervals are those for which the 95% confidence interval excludes the value of 1.0. NA, not applicable; NH, non-Hispanic; PAPR, powered air purifying respirator; PPE = personal protective equipment.

†For hospital model, physicians were the referent occupation group. For nursing home model, occupational/physical/speech therapists were the referent occupation group.

‡Includes 4 categories with low sample size: engineer/maintenance staff, pharmacist, receptionist/medical assistant, and physician.

§Workplace was represented by non-mutually exclusive dummy variables entered simultaneously into the model. Participants in workplaces with sample size <30 or with 0% seropositivity were included in the model but the workplace was not entered into the model. Some participants worked in facilities in the other agency category. That is, 84 hospital personnel also worked in nursing home COVID-19 and non-COVID-19 units, and 239 nursing home personnel also worked in hospital administrative offices, COVID-19 units and general inpatient units. Results for these categories are shown in this table, but not in the main manuscript.

Appendix Table 4. SARS-CoV-2 seropositivity by resident cases, staff cases, and outbreak status among participants who worked primarily in nursing home settings, Rhode Island, USA, July–August 2020*

Category	n	Seropositive, n	Seropositive, %
Total	1,462	191	13.1
Cases per 100 residents			
0 to <2.3	400	5	1.3
2.3 to <16.3	369	19	5.2
16.3 to <55.9	323	58	18.0
55.9 to 83.7	370	109	29.5
Cases per 100 staff			
0 to <2.1	380	5	1.3
2.1 to <11.5	346	16	4.6
11.5 to <19.9	359	44	12.3
19.9 to 43.2.7	126	126	33.4
Outbreak status			
No	1146	128	10.1
Yes	125	63	33.5

*Note: 32 participants (2.1%) worked in facilities for which case and outbreak status data were not available.
Outbreak defined as ≥2 contacts within a facility having active COVID-19 or ≥2 persons with COVID-19 linked outside a case investigation.
Resident and staff case count obtained from Rhode Island Department of Health COVID-19 Data Tracker: Congregate Care: https://ri-department-of-health-covid-19-response-testin-1d583-rihealth.hub.arcgis.com