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SARS-CoV-2 seroprevalence among healthcare personnel at a large health system in Atlanta

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ABSTRACT

Background: Estimates of the prevalence of SARS-CoV-2 antibodies and factors associated with infection among healthcare personnel (HCP) vary widely. We conducted a serosurvey of HCP at a large public healthcare system in the Atlanta area.

Materials and methods: All employees of Grady Health System were invited to participate in mid-2020; a volunteer sample of those completing testing was included. Asymptomatic HCP were offered testing for IgG antibody and for SARS-CoV-2 RNA using polymerase chain reaction (PCR). Symptomatic HCP were offered PCR testing. Antibody index values for IgG and cycle threshold values for PCR were evaluated for those with a positive result. An online survey was distributed at the time of testing.

Results: 624 of 1677 distributed surveys (37.2%) were completed by 608 unique HCP. The majority were female (76.4%) and provided clinical care (70.9%). The most common occupations were clinician (24.8%) and nurse (23.5%). 37 of 608 (6.1%) HCP had detectable IgG. Exposure to a confirmed case of COVID-19 outside of the hospital was associated with detectable IgG (12.8% vs 4.4%, $p = 0.02$), but exposure to a patient with COVID-19 was not.

Conclusions: Among HCP in a large healthcare system, 6.1% had detectable SARS-CoV-2 IgG. Seropositivity was associated with exposures outside of the healthcare setting.

Key indexing terms: COVID-19; SARS-CoV-2 antibodies; Community exposure; Healthcare workers. **[Am J Med Sci 2022;364(3):296–303.]**

INTRODUCTION

Since emerging in late 2019, the novel coronavirus SARS-CoV-2 has caused a global pandemic of coronavirus disease 2019 (COVID-19), with the United States now accounting for the highest number of reported cases and deaths.[1] Preventing nosocomial spread of COVID-19 is essential to protect healthcare personnel (HCP), who are at high risk of infection due to frequent exposure, and thousands of whom have died of COVID-19.[2,3] This requires a better understanding of COVID-19 transmission in healthcare facilities, particularly the role of asymptomatic transmission and exposures both in and out of the workplace. Despite the availability of highly effective SARS-CoV-2 vaccines, not all HCP have been or will be immunized, and post-vaccination illness can occur.[4–6] Infection control measures and testing will remain essential for preventing transmission among HCP and between HCP and patients.

Medical center testing programs have found that a minority of HCP with anti-SARS-CoV-2 antibodies reported symptoms consistent with COVID-19 illness or thought that they were previously infected with COVID-19, but asymptomatic carriage remains a concern.[7,8] These findings suggest that testing only symptomatic HCP may miss a sizeable proportion of SARS-CoV-2 cases among this population. Studies of SARS-CoV-2 antibody seroprevalence among HCP have produced a range of estimates and illustrated the importance of preventive measures. In a multi-site study, approximately

6% of HCP were seropositive, but 29% of these HCP had been asymptomatic, and 44% did not believe they previously had COVID-19.[9] Prevalence of SARS-CoV-2 antibodies was higher among those who did not report always wearing a facial covering. In a large health care system, implementation of a mask requirement in hospitals was associated with a decrease in SARS-CoV-2 PCR positivity from 14.7% to 11.5%, suggesting universal face coverings may reduce the spread of COVID-19 in the hospital setting.[10] Provided adequate preventive measures in healthcare facilities, exposure to SARS-CoV-2 outside of the healthcare workplace takes on greater importance. In hospital-wide antibody screening in Belgium, the odds of seropositivity were not increased by having direct involvement in clinical care nor working in COVID-19 wards, but were increased with contact with a suspected COVID-19 case within the household.[11] In another study, known exposure to COVID-19 outside of the hospital was associated with 14.8% seroprevalence compared to 3.7% among those with no exposure outside the hospital.[12]

We have previously reported results of a program testing symptomatic HCP at Grady Health System (GHS), a large public healthcare system in Atlanta.[13] In this subsequent study, all GHS employees were invited to participate in a testing program involving SARS-CoV-2 serology, PCR, and a questionnaire to describe the seroprevalence and factors associated with SARS-CoV-2 infection among HCP.

METHODS

The Grady Health System COVID-19 screening program used re-deployed hospital staff and was implemented through employee health services. The program was voluntary and was advertised through institutional emails to hospital employees and medical staff. All employees were eligible to be tested regardless of position or symptoms. Asymptomatic HCP were scheduled for both IgG and PCR testing for SARS-CoV-2, while symptomatic HCP were offered PCR. Testing was conducted Monday through Friday in an outdoor medical tent located near the emergency department. A rotating team of GHS-employed nurses and medical assistants conducted tests using blood draws and nasopharyngeal swabs. From May 11 to July 20, 2020, an online REDCap survey was distributed to HCP electronically prior to testing to collect demographic information, COVID-19 exposures, and SARS-CoV-2 testing history with questions based on the World Health Organization risk assessment tool (Supplementary data).[14,15] Exposure was defined as self-reported interaction with a personal contact or patient with confirmed COVID-19. SARS-CoV-2 IgG serology testing was conducted using the Abbott Architect instrument (Abbott Park, IL) using the Abbott SARS-CoV-2 IgG nucleocapsid assay and SARS-CoV-2 polymerase chain reaction (PCR) testing was conducted using the Abbott Laboratories *m*2000 RealTime system (Des Plaines, IL) in the Grady Memorial Hospital microbiology laboratory. Test results and back-to-work guidance were provided via a phone call within 48–72 h of testing by the GHS employee health services. Personal protective equipment (PPE) guidance was informed by emerging data on transmission. During the study period, a universal masking policy was implemented requiring surgical masks in GHS facilities at all times. N95 masks, eye protection with goggles or face shield, gown, and gloves were required for care of patients with confirmed COVID-19 or patients under investigation for COVID-19. There was no reported lack of PPE. Study approval was obtained from the Emory University Institutional Review Board and Grady Research Oversight Committee.

Statistical analysis

Analysis was completed with SAS (version 9.4, SAS Institute, Cary, NC). Characteristics of those with and without a positive SARS-CoV-2 IgG or PCR result were compared using the Chi-square test or Fisher's exact test, as appropriate, for categorical variables and Wilcoxon rank-sum test for continuous variables. A p-value < 0.05 was considered significant. Index values for IgG and cycle threshold (CT) values for PCR were analyzed for those with a positive result. Pearson correlation coefficients were calculated to evaluate for correlation between index values and CT values.

RESULTS

A total of 1677 HCP were invited to participate. 624 (37.2%) surveys were completed by 608 unique HCP (Figure 1). The median age of these HCP was 41 years (IQR 31-50), and the majority were female (76.4%), worked at Grady Memorial Hospital (77.8%), and provided clinical care to patients (70.9%) (Table 1). The most common occupations were nurse (23.5%) and clinician (24.8%), which included physicians, nurse

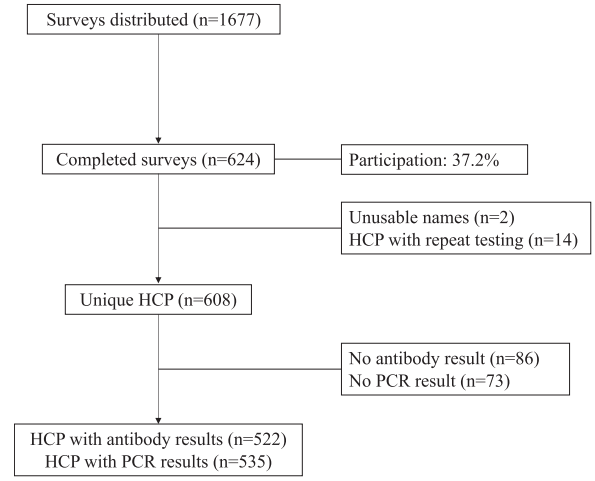

FIGURE 1. Survey completion and test results among healthcare personnel (HCP) screened for SARS-CoV-2.

practitioners, and physician assistants. Overall, 1412 HCP were tested for SARS-CoV-2 antibodies during the study period and 91 (6.4%, 95% CI 5.3−7.8%) had detectable IgG. Of the 608 unique HCP who completed surveys, 37 (6.1%, 95% CI 4.3−8.3%) had detectable SARS-CoV-2 IgG. Among the surveyed HCP, seropositivity was more common among males than females (11.2% and 4.5%, respectively, $p = 0.03$), but other demographic characteristics including body mass index, self-reported medical conditions, primary work location, and occupation did not significantly differ by serostatus. Among the 37 HCP with an initial positive antibody, 6 had subsequent antibody testing at a median of 46 days (IQR 34−57), and all remained IgG positive. Among the 571 with an initial negative antibody, 56 had subsequent antibody testing at a median of 49 days (IQR 35.5−57), and only 2 had seroconverted.

Reported exposures

Overall, HCP who reported exposure to a confirmed case of COVID-19 outside of the hospital (14.1%) were more likely to be seropositive compared to those without such exposure (12.8% and 4.4%, respectively, $p = 0.02$), while there was no difference in seropositivity between those who reported exposure to a patient with COVID-19 and those who did not. After excluding those who self-reported a prior known positive nasal or oral swab test for SARS-CoV-2, believing one previously had COVID-19 disease was more common among those who were seropositive ($p < 0.0001$) (Figure 2). However, of the 92 HCP in this subgroup who believed they had COVID-19, the majority (64, 69.6%) were seronegative. Of the 24 who were seropositive, 9 (37.5%) did not believe they had previously been infected.

Clinical care, PPE, and procedures

Of the 431 HCP who reported providing clinical care to patients, most (83.8%) spent >4 h per day doing so. The most common care areas were outpatient (31.6%), medical/surgical floors (22.5%), intensive care units (18.6%), and emergency department (13.7%), and there was no association between seropositivity and working in these areas. A small proportion (18.6%) were present during aerosol-generating procedures for a patient with confirmed or suspected COVID-19; the most common procedures were intubation (15.1%), airway suctioning (10.7%), and cardiopulmonary resuscitation (6.3%). Among those who reported face to face contact with a confirmed case, nearly all HCP (78.6%) reported always wearing PPE. There was no association between aerosol-generating procedures or self-reported PPE use and SARS-CoV-2 IgG.

SARS-CoV-2 PCR

A total of 535 HCP had SARS-CoV-2 PCR results, with 20 positive (3.7%, 95% CI 2.3−5.7%). There was no association between PCR positivity and demographic characteristics (Table 1). A positive PCR result was more likely in HCP who were present for aerosol-generating procedures in general (7.5 vs 1.4%, $p < 0.01$) and intubation in particular (7.7 vs 1.6%, $p = 0.01$) than those who were not. To examine self-reported symptoms, results were limited to HCP who responded to the survey within 7 days of a PCR result. Of the 10 HCP in this group with a positive PCR, 3 (30%) were symptomatic in the previous 14 days; PCR positivity was not more common among those with any symptoms or individual symptoms (Supplemental table). Notably, of the 435 HCP who were asymptomatic, 7 (1.6%) had SARS-CoV-2 detected by PCR.

Antibody index and PCR cycle threshold

For those HCP who were either SARS-CoV-2 IgG or PCR positive, antibody index and CT values were not correlated. There was no significant difference in index or CT values by belief one had previous COVID-19, exposure to family or friends with confirmed COVID-19, or presence for aerosol-generating procedures (Table 2). The median index value was higher for those who reported recent symptoms (6.75, IQR 4.75−6.92) compared to those who were asymptomatic (4.62, IQR 2.86−6.25), but this difference was not statistically significant. Among the 10 HCP with survey responses within 7 days of their positive PCR result, there was no difference in CT between symptomatic (median 40.2, IQR 20.6−41.0) and asymptomatic (median 34.3, IQR 31.1−34.5) individuals.

DISCUSSION

We screened 608 healthcare personnel at a large public healthcare system for SARS-CoV-2 IgG from May to July 2020 and found that 37 (6.1%) had detectable antibodies. HCP who believed they previously had COVID-19 and those who had exposure to a confirmed case among family or friends were more likely to be seropositive. The estimated seroprevalence is consistent with that reported in the literature, including a large study of 3248 HCP in 13 academic medical centers which found approximately 6% had SARS-CoV-2 antibodies, with seroprevalence by hospital ranging from 0.8% to 31.2%.[9,16,17] A serosurvey of another large healthcare system in the Atlanta area during a similar time period (April to June 2020) estimated a slightly lower crude (5.7%) and adjusted (3.8%) seroprevalence than our study, but similarly determined community risk factors were better associated with seropositivity than workplace exposures.[18] Notably, these estimates are higher than the estimated community seroprevalence in the two counties served by our healthcare system in the weeks prior to the study period (2.5%, 95% CI 1.4−4.5%).[19] Evaluating seropositivity among HCP remains important, as there is a significantly reduced risk of reinfection over

TABLE 1. Characteristics and test positivity of healthcare personnel screened for SARS-CoV-2 by IgG and PCR testing.

Characteristic	*N* = 608 (column %)	IgG positive *N* = 37	IgG negative *N* = 485	p[a]	PCR positive *N* = 20	PCR negative *N* = 515	p[a]
Age in years (median, IQR)	41.0 (32.0, 51.0)	40.0 (31.0, 50.0)	42.0 (33.0, 51.0)	0.19	34.0 (30.0, 43.5)	41.0 (33.0, 51.0)	0.08
Gender							
Female	464 (76.3)	21 (56.8)	380 (78.4)	0.03	12 (60.0)	398 (77.3)	0.30
Male	143 (23.5)	16 (43.2)	104 (21.4)		8 (40.0)	116 (22.5)	
Missing	1 (0.2)		1 (0.2)		-	1 (0.2)	
BMI kg/m^2 (median, IQR)	27.4 (24.0, 32.7)	27.4 (25.0, 30.9)	27.2 (23.8, 32.7)	0.65	30.9 (25.5, 35.5)	27.1 (23.7, 32.5)	0.05
Medical conditions							
None	333 (54.8)	24 (64.9)	260 (53.6)	0.38	11 (55.0)	276 (53.6)	0.90
Hypertension	137 (22.5)	7 (18.9)	114 (23.5)	0.55	6 (30.0)	117 (22.7)	0.43
Diabetes	45 (7.4)	4 (10.8)	36 (7.4)	0.62	1 (5.0)	40 (7.8)	1.0
Tobacco use	10 (1.6)	-	9 (1.9)	1.0	-	10 (1.9)	1.0
Primary work location							
Grady Memorial Hospital	472 (77.6)	25 (67.6)	381 (78.6)	0.30	17 (85.0)	401 (77.9)	0.59
Clinic or subacute nursing facility[b]	136 (22.4)	12 (32.4)	104 (21.4)		3 (15.0)	114 (22.1)	
Occupation							
Nurse	143 (23.5)	7 (18.9)	113 (23.3)	0.83	3 (15.0)	120 (23.3)	0.60
Clinician (Physician, NP, PA)	151 (24.8)	9 (24.3)	119 (24.5)		4 (20.0)	127 (24.7)	
Other[c]	314 (51.7)	21 (56.7)	253 (52.1)		13 (65.0)	268 (52.0)	
Provide clinical care	431 (70.9)	23 (62.2)	349 (72.0)	0.40	11 (55.0)	371 (72.0)	0.10
Prior COVID-19 nasal/oral swab result							
Positive	19 (3.1)	13 (35.1)	4 (0.8)	<0.001	9 (45.0)	9 (1.8)	<0.01
Negative	221 (36.4)	15 (40.6)	186 (38.3)		1 (5.0)	207 (40.2)	
Unknown	10 (1.6)	-	9 (1.9)		-	10 (1.9)	
Not reported	358 (58.9)	9 (24.3)	286 (59.0)		10 (50.0)	289 (56.1)	
Believe had COVID-19	*N* = 589	*N* = 24	*N* = 481		*N* = 11	*N* = 506	
(excluding those reporting prior positive)	92 (15.6)	13 (54.2)	64 (13.3)	<0.001	3 (27.3)	74 (14.6)	0.16
Yes	441 (74.9)	9 (37.5)	375 (78.0)		7 (63.6)	387 (76.5)	
No	56 (9.5)	2 (8.3)	42 (8.7)		1 (9.1)	45 (8.9)	
Missing							
Exposure to friend/family with COVID-19							
Yes	86 (14.1)	11 (29.7)	68 (14.0)	0.02	4 (20.0)	75 (14.6)	0.61
No	414 (68.1)	18 (48.7)	335 (69.1)		12 (60.0)	353 (68.5)	
Unknown	108 (17.8)	8 (21.6)	82 (16.9)		4 (20.0)	87 (16.9)	
Exposure to patient with confirmed COVID							
Yes	281 (46.2)	14 (37.9)	224 (46.2)	0.20	11 (55.0)	234 (45.4)	0.66
No	202 (33.2)	11 (29.7)	167 (34.4)		5 (25.0)	174 (33.8)	
Unknown	123 (20.2)	12 (32.4)	91 (18.8)		4 (20.0)	105 (20.4)	
Missing	2 (0.3)	-	2 (0.4)			2 (0.4)	
Exposure to confirmed case	*N* = 281	*N* = 14	*N* = 224		*N* = 11	*N* = 234	
PPE use with confirmed case							
Always	221 (78.6)	12 (85.7)	176 (78.6)	0.84	9 (81.8)	187 (79.9)	1.0
Not always	60 (21.4)	2 (14.3)	43 (19.2)		2 (18.2)	43 (18.4)	

(*continued on next page*)

TABLE 1. (*continued*)

Characteristic	*N* = 608 (column %)	IgG positive *N* = 37	IgG negative *N* = 485	p[a]	PCR positive *N* = 20	PCR negative *N* = 515	p[a]
PPE elements (all that apply)							
Gown	200 (71.2)	12 (85.7)	161 (71.9)	0.23	8 (72.7)	169 (72.2)	1.0
Gloves	234 (38.5)	13 (92.9)	186 (83.0)	0.59	9 (81.8)	196 (83.8)	0.70
Procedure mask	190 (31.3)	9 (64.3)	154 (68.8)	0.72	8 (72.7)	160 (68.4)	1.0
N95 mask	239 (39.3)	14 (100)	190 (84.8)	0.23	9 (81.8)	200 (85.5)	0.67
Face shield	153 (25.2)	7 (50.0)	126 (52.3)	0.47	5 (45.5)	130 (55.6)	0.55
Other mask	37 (6.1)	2 (14.3)	29 (13.0)	0.98	1 (9.1)	30 (12.8)	1.0
Clinical care providers	*N* = 431	*N* = 23	*N* = 349		*N* = 11	*N* = 371	
Main care area							
Inpatient[d]	235 (54.5)	8 (21.6)	188 (38.8)	0.15	7 (63.6)	197 (53.1)	0.63
Outpatient	136 (31.6)	11 (47.8)	112 (32.1)		2 (18.2)	121 (32.6)	
Emergency Department	59 (13.7)	4 (17.4)	48 (13.8)		2 (18.2)	52 (14.0)	
Missing	2 (0.4)	-	1 (0.3)		-		
Present for aerosol-generating procedures							
Yes	80 (18.6)	6 (26.1)	66 (18.9)	0.39	6 (54.6)	68 (18.3)	<0.01
Procedures (all that apply)							
Intubation	65 (15.1)	6 (26.1)	55 (15.8)	0.07	5 (45.5)	56 (15.1)	0.01
BiPAP or CPAP	20 (4.6)	2 (8.7)	13 (3.7)	0.13	2 (18.2)	15 (4.0)	0.08
Airway suctioning	46 (10.7)	3 (13.0)	37 (10.6)	0.93	2 (18.2)	38 (10.2)	0.32
Bronchoscopy	4 (0.9)	1 (4.4)	3 (0.9)	0.28	-	3 (0.8)	1.0
Tracheostomy	8 (1.9)	1 (4.4)	6 (1.7)	0.42	-	6 (1.6)	1.0
Cardiopulmonary resuscitation	27 (6.3)	3 (13.0)	22 (6.3)	0.26	1 (9.1)	23 (6.2)	0.52
Other	9 (2.1)	1 (4.4)	6 (1.7)	0.26	1 (9.1)	7 (1.9)	0.21

PCR = polymerase chain reaction. IQR = interquartile range. BiPAP = bi-level positive airway pressure. CPAP = continuous positive airway pressure.

[a] Chi-square, Wilcoxon rank-sum, or Fisher's exact test, as appropriate.

[b] Includes 9 locations (8 clinics and 1 subacute nursing facility).

[c] Other occupations: medical assistant, physical/occupational therapy, imaging tech, laboratory tech, respiratory therapist, clinical dietitian, emergency medical services provider, information technology, social work/case management, pharmacist/pharmacy tech, phlebotomist, guest services, environmental services, administration.

[d] Inpatient areas: medical/surgical wards, intensive care units, surgical services, and labor & delivery.

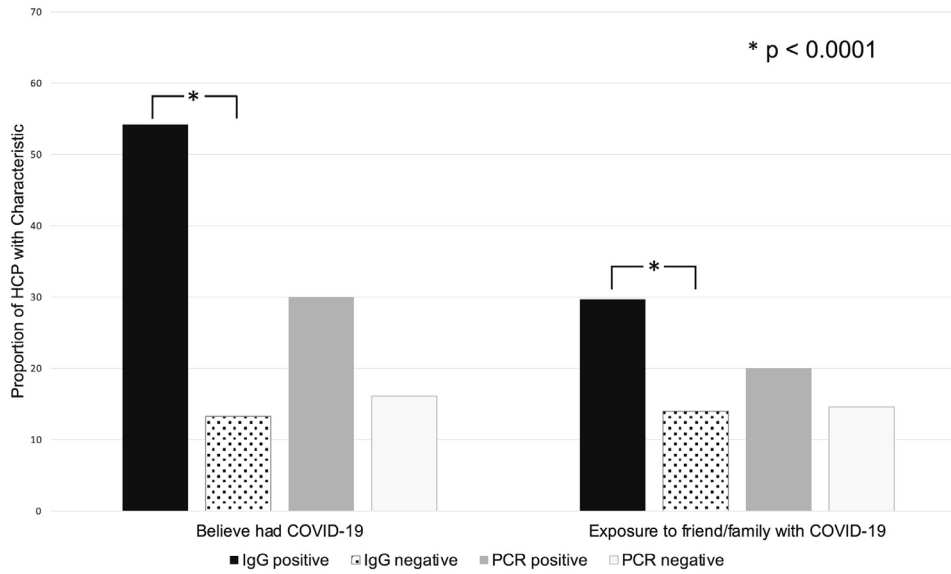

FIGURE 2. Healthcare personnel (HCP) known exposure to friend/family with COVID-19 and belief one had COVID-19 by IgG and PCR test positivity among HCP screened for SARS-CoV-2.

6 months in those with IgG antibodies, and vaccine implementation is ongoing.[20]

Our study population included those in both clinical care and non-patient-facing roles, but seropositivity was not associated with occupation, patient care, PPE use, or presence during aerosol generating procedures. These findings support recent data indicating hospital infection control measures have reduced the risk of SARS-CoV-2 infection for HCP within the healthcare environment but that exposure away from the workplace is an important ongoing risk factor.[10–12] Importantly, among HCP in our study without a known prior positive test who believed they had COVID-19, the majority (70%) were seronegative and of those who were seropositive, more than a third did not believe they had previously been infected. In this general screening program, 3.7% of HCP with PCR testing had SARS-CoV-2 detected, including 1.6% of those who were asymptomatic at the time of testing. While the association of PCR positivity with aerosol-generating procedures likely reflects the changing PPE recommendations early in the pandemic and underscores the need for adherence to infection control measures, the presence of asymptomatic infection

TABLE 2. IgG optical density and PCR cycle threshold among healthcare personnel screened for SARS-CoV-2.

Characteristic	IgG Index (median, IQR)	p	PCR cycle threshold (median, IQR)	p
Antibody positive (*N* = 37)	5.13 (3.79, 6.88)			
Symptomatic	6.75 (4.75, 6.92)	0.073		
Asymptomatic	4.62 (2.86, 6.25)			
PCR positive overall (*N* = 20)	1.81 (0.03, 5.17)	-	30.53 (20.11, 35.97)	-
PCR positive within 7 days of survey (*N* = 10)				
Symptomatic			40.21 (20.6, 41.02)	0.57
Asymptomatic			34.32 (31.08, 34.53)	
Believe had COVID-19 (excluding those with prior positive result)				
Yes	5.17 (4.32, 7.12)	0.18	27.17 (22.0, 34.43)	0.77
No	4.36 (1.84, 6.88)		31.08 (20.11, 40.26)	
Exposure to friend/family with COVID-19				
Yes	5.39 (3.04, 6.88)	0.57	34.53 (20.11, 41.02)	0.12
No	5.43 (4.61, 6.75)		31.08 (23.80, 35.97)	
Unknown	4.02 (2.67, 6.05)		18.79 (14.61, 23.40)	
Present for aerosol-generating procedures				
Yes	5.84 (2.86, 6.87)	0.94	23.60 (20.60, 40.21)	1.0
No	5.08 (4.62, 6.79)		34.43 (25.24, 35.25)	

PCR = polymerase chain reaction. IQR = interquartile range.

and the unreliability of self-diagnosis have implications for staff screening and monitoring programs.[21] Although three COVID-19 vaccines have received emergency use authorization from the Food and Drug Administration, healthcare systems will likely continue to require that HCP reduce their risk of exposure to SARS-CoV-2 and self-monitor for symptoms until more widespread distribution of vaccines and while variants of concern emerge, particularly as outbreaks in hospital settings have been associated with unmasked exposure among HCP.[22]

We found no correlation between antibody index and CT values for those HCP who were either IgG or PCR positive, and no association between these quantitative results and HCP characteristics or exposures. Notably, median CT values were similar between symptomatic and asymptomatic HCP with SARS-CoV-2 detected by PCR, which is consistent with previous findings of similar viral load in symptomatic and asymptomatic infection.[23] However, there were relatively few PCR-positives and results could be affected by prolonged PCR positivity. Others have shown that among HCP with COVID-19 illness, symptomatic individuals had higher antibody index than those who were asymptomatic.[24] Our data are similar, though the lack of a significant difference may be due to sample size or differences in symptom assessment at initial scheduling and survey distribution.

A strength of this study is inclusion of all personnel across the healthcare system, not just clinical care providers. Limitations include potential recall bias regarding exposures, the inability to adjust for changing PPE implementation, and the relatively low survey participation, which could bias the results if seropositivity or particular exposures are associated with survey nonresponse. For example, the higher proportion of male than female HCP with detectable IgG may reflect this, as the majority of the study population identified as female. Most HCP were tested only at a single time point, limiting detection of both seroconversion, where an individual without detectable antibody is found to have detectable antibodies on subsequent testing, and seroreversion, with loss of detectable antibodies.[25] However, there were only 2 episodes of seroconversion and no seroreversions.

Among HCP at a large urban healthcare system screened for SARS-CoV-2 early in the pandemic, 6.1% had detectable IgG, seropositivity was associated with exposures outside of the healthcare setting, and more than a third of seropositive HCP did not believe they had previously been infected. Even with the implementation of effective infection prevention measures within hospitals and clinics, maintaining focus on minimizing the risk of exposure both at work and home is critical to protect healthcare personnel and patients as the COVID-19 pandemic continues to impact communities and healthcare systems.

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AUTHORS' CONTRIBUTIONS

Daniel Graciaa: Conceptualization, Methodology, Formal Analysis, Funding Acquisition, Writing - Original Draft. Russell Kempker: Conceptualization, Methodology, Funding Acquisition, Writing - Review & Editing. Yun F. Wang: Investigation, Resources. Hanna Schurr, Snehaa Krishnan: Data Curation, Visualization. Kelley Carroll, Mary Hunter: Resources, Supervision, Project Administration. Linda Toomer, Stephanie Merritt, Denise King: Investigation, Resources. Paulina Rebolledo: Conceptualization, Methodology, Reesources, Funding Acquisition, Writing - Review & Editing. All authors reviewed and approved the final version of the manuscript.

DECLARATION OF COMPETING INTEREST

The authors report no conflicts of interest.

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SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.1016/j.amjms.2022.04.009.

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