Coronavirus Disease 2019 Exposure in Surgeons and Anesthesiologists at a New York City Specialty Hospital

A Cross-Sectional Study of Symptoms and SARS-CoV-2 Antibody Status

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Objective: We measured the seroprevalence of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) immunoglobulin G (IgG) antibodies among surgeons and anesthesiologists and associated antibody status with coronavirus disease 2019 (COVID-19) clinical illness. **Methods:** A cross-sectional study of SARS-CoV-2 IgG seroprevalence with a survey assessing demographics, SARS-CoV-2 exposure risk, and COVID-19 illness. The primary outcome was the period prevalence of SARS-CoV-2 IgG antibodies associated with COVID-19 illness. **Results:** One hundred forty three surgeons and anesthesiologists completed both serology and survey testing. We found no significant relationships between antibody status and clinical role (anesthesiologist, surgeon), mode of commuting to work, other practice settings, or place of residence. SARS-CoV-2 IgG seroprevalence was 9.8%. Positive IgG status was highly correlated with presence of symptoms of COVID-19 illness. **Conclusions:** These results suggest the relative safety of surgeons and anesthesiologists where personal protective equipment (PPE) is available and infection control protocols are implemented.

Keywords: antibodies, antibody testing, coronavirus, COVID-19, healthcare workers, pandemic, SARS-CoV-2

KEY POINTS

Question: What is the seroprevalence of IgG antibodies to SARS-CoV-2 among surgeons and anesthesiologists, and does this correlate with reported risk factors for exposure, and history of COVID-19 illness?
Findings: Seroprevalence was 9.8% and 86% of antibody-positive participants reported a COVID-19-like illness. Cases declined in parallel with rising institutional availability of personal protective equipment (PPE) and implementation of infection control protocols.
Meaning: In a global epicenter of COVID-19, SARS-CoV-2 seroprevalence was low among surgeons and anesthesiologists, and highly correlated with positive symptoms. These findings suggest the relative occupational safety afforded by PPE and safety protocols.

The first case of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) was reported in New York State on March 1, 2020[1] and New York City was declared a global epicenter 3 weeks later.[2] Despite stable trends in new cases of coronavirus disease 2019 (COVID-19), New York City remains one the most affected jurisdictions in the United States.[3]

Strategies to protect healthcare workers (HCWs) from occupational acquisition of SARS-CoV-2 have assumed progressive importance on the research agenda. Most emphasize appropriate personal protective equipment (PPE) and infection control protocols, although rigorous methods to assess the efficacy of these interventions is lacking.[4] Specialty-specific risks are variable, with anesthesiologists recognized to be at high risk for COVID-19 illness and death.[5,6] In contrast, risks for surgical subspecialties have not been characterized. Although most studies have explored the risk of patient-to-HCW transmission, there is also an imperative to protect patients from nosocomial infection. The extent of asymptomatic or oligosymptomatic spread of SARS-CoV-2 is controversial and has not been studied between HCWs and their patients.[7]

SARS-CoV-2 antibody testing is emerging as a tool to address these knowledge gaps. Serology has been used to estimate the effectiveness of PPE and infection control protocols, the potential for individual and herd immunity, and to characterize viral spread through a community.[8–10] There are minimal data to suggest specialty-specific seroprevalence of SARS-CoV-2 immunoglobulin G (IgG) antibodies and there are no studies which estimate prevalence in surgical/anesthetic care teams.[11,12] Correlations between community and occupational risk factors for SARS-CoV-2 acquisition, symptoms of COVID-19 illness, and antibody status among HCWs have likewise not been described.

Accordingly, we designed the current study to (1) to establish the period prevalence of immunoglobulin G (IgG) SARS-CoV-2 antibodies among surgeons and anesthesiologists, and (2) to correlate symptomatic COVID-19 illness and antibody status. We hypothesized a positive correlation between antibody status and clinical COVID-19 illness, and that there would be measurable differences between specialties related to occupational risk.

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Clinical Trial Registry: ClinicalTrials.gov (NCT04389294), PI: Ellen M Soffin.
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Clinical significance: The seroprevalence of IgG antibodies to SARS-CoV-2 in surgeons and anesthesiologists at a dedicated COVID-19 hospital was 9.8%. Cases declined in parallel with implementation of PPE and infection control protocols despite rising rates of community spread. These results support the relative occupational safety of frontline healthcare workers following protocol implementation.
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METHODS

This manuscript adheres to applicable STrengthening the Reporting of OBservational studies in Epidemiology reporting guidelines.

Study Design and Setting

A cross-sectional study of the seroprevalence of SARS-CoV-2 IgG antibodies among surgeons and anesthesiologists, with a survey assessing the presence of symptoms and risk factors associated with COVID-19 illness. The study was conducted at Hospital for Special Surgery, approved by the hospital's Institutional Review Board, and registered at ClinicalTrials.gov (NCT04389294). All participants provided written informed consent.

Hospital for Special Surgery is an orthopedic surgery specialty hospital in New York City. Prior to March 17, 2020 the hospital functioned as a comprehensive musculoskeletal care center. After March 17, 2020, the hospital was converted into a designated COVID-19 care facility and all elective surgical procedures were postponed.[13,14] Surgeons and anesthesiologists provided emergency orthopedic surgical care for COVID-19-positive and -negative patients and were additionally re-deployed from their usual roles to care for COVID-19 positive patients on the wards and intensive care units (ICU). In parallel, the institution developed and implemented new local policies for telehealth, PPE, and infection control practices across all clinical settings.[13,14] These processes were fully implemented by early April, 2020.

Recruitment and Participants

Figure 1 illustrates the flow of participants through the study. A recruitment email was sent to all attending surgeons, anesthesiologists, and trainees in both departments (orthopedic surgery fellows, anesthesiology fellows, and orthopedic surgery residents) as identified via an institutional listserv. An electronic survey assessing COVID-19 illness and risk factors associated with SARS-CoV-2 exposure was provided, together with an invitation to self-schedule an appointment for SARS-CoV-2 serology testing. Inclusion criteria were defined as: a positive response to the recruitment invitation, completion of the survey, and/or scheduling an appointment for serology testing. Only those participants who completed both the survey and serology testing were included in the analyses. Participation was open between May 6, 2020 and June 5, 2020. A deadline was imposed for completing both elements (June 12, 2020).

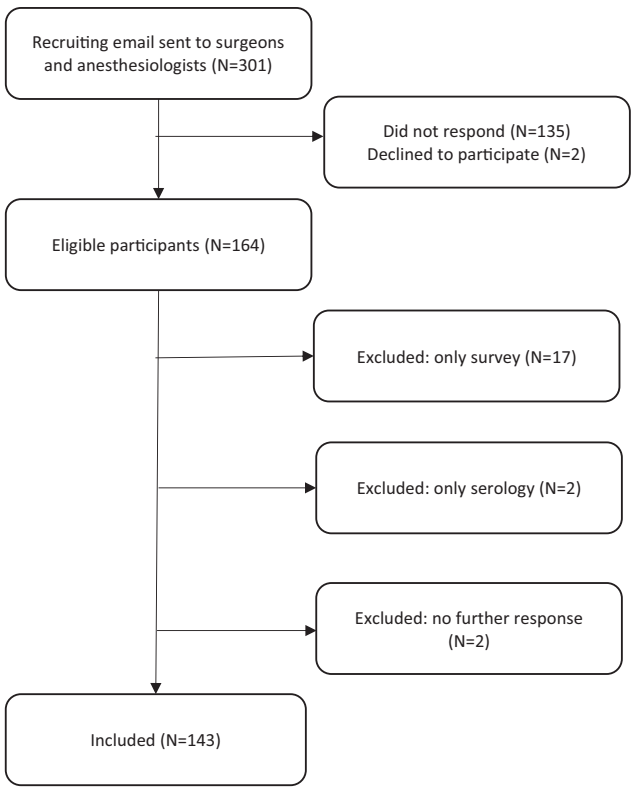

FIGURE 1. STrengthening the Reporting of OBservational studies in Epidemiology diagram. Participant flow through the study.

Survey and SARS-CoV-2 IgG Antibody Testing

The survey retrospectively assessed demographics and factors of interest which occurred between January 1, 2020 and May 5, 2020 (Fig. 2). The survey included 19 questions, separated into three domains: (1) demographics and comorbidities, (2) practice role, residential location, working patterns before and after March 16, 2020, mode of commuting to work, and (3) COVID-19-like illness, specific symptoms, prior testing, and known close contacts with confirmed COVID-19 illness and their relationship to the participant (including patients, friends, family, and community contacts with confirmed COVID-19). Participants were asked to complete the survey before or on the day of serology testing.

Whole blood samples were obtained and tested for IgG antibodies to SARS-CoV-2, according to the manufacturer's instructions (Abbott Laboratories, ARCHITECT SARS-CoV-2 IgG. H14806RO1).[15] In studies of performance evaluation, the specificity of the assay was reported to be between 99.4% and 100% and sensitivity between 94.0% and 100% at 14 or more days after symptom onset.[15–17]

Outcomes and Measurement

The primary outcome was defined a priori as the period prevalence of SARS-CoV-2 IgG antibodies by serology testing and the association with COVID-19 illness reported in the survey. Secondary outcomes included differences in the remaining survey responses between IgG antibody-positive and -negative participants. These included demographics, comorbidities, practice patterns, professional role, training status, mode of commuting to work, known close contacts with confirmed COVID-19 and relationship, and prior SARS-CoV-2 testing.

Blinding

Due to the nature of the principle data collection tool (survey-based) participant blinding was not feasible. However, to minimize reporting bias—which may have been affected by knowledge of antibody status—the survey was sent in advance of serology testing. The research assistants responsible for data collection were blinded to individual serology testing results, and participants were advised they could check the results of their serology independently by contacting the hospital's Occupational Health Department.

Statistical Analyses

The period prevalence of SARS-CoV-2 IgG is expressed as a % of the total sample who met criteria for inclusion in the final analysis. Continuous variables are summarized as median (interquartile range) or mean (standard deviation). Categorical variables are summarized as counts (%). The association between positive COVID-19 symptoms and SARS-CoV-2 IgG antibody status was measured by chi-squared testing. Univariate exact logistic regression analysis was conducted to estimate the odds ratio (OR) (95% confidence interval [CI]) of differences on variables of interest between antibody-positive and -negative participants. For all tests, the α was set at 0.05. Statistical analysis was performed using SAS (version 9.4. SAS Institute, Cary, NC).

I. Demographics and Co-Morbidities

- Birthdate
  - Age *(calculated value)*
- Gender (*multiple choice: male, female*)
- Ethnicity (*multiple choice: Hispanic, Non-Hispanic)*
- Race (*multiple choice: American Indian/Alaska native, Asian, Black/African American, Native Hawaiian/Pacific islander, White/Caucasian, Other)*
- Smoking history *(multiple choice: no smoking history, current smoker, former smoker)*
- Height *(free text)*
- Weight (*free text*)
  - BMI (calculated value)
- Number of Adults in Your Household (Including You) (*free text*)
- Number of Children in Your Household (*free text*)
- Co-morbidities (*multiple choice: HTN, DM, pulmonary disease as free text, OSA with/without CPAP, CAD/heart disease, CKD undergoing dialysis, liver disease, immunocompromised as free text, other as free text*)
- Location of Primary residence before March 16th (*multiple choice: NYC/outside NYC*)
- Location of Primary residence after March 16th (*multiple choice: NYC/outside NYC*)

II. Clinical Role and Working Patterns

- Orthopedic surgeon, anesthesiologist; clinical fellow or resident (*multiple choice*)
- Location of practice (*multiple choice: HSS main Campus, HSS satellite sites*)
- Mode of commuting to work, please select all that apply (*multiple choice: walk/bike, public transportation, car)*
- Please describe your practice pattern after March 16th (*multiple choice, please select all that apply: office, surgery only, ICU, working on the ward with SARS-CoV-2 positive patients, working on the ward with SARS-CoV-2 negative patients, worked from home, not working at all)*

III. COVID-19 History

- Have you had any close contact[1] with someone diagnosed with Covid-19? (*multiple choice: yes/no*)
  - If yes, please indicate who you were in close contact with who had Covid-19 (select all that apply. (*multiple choice: partner/spouse, family, friend, patient*)
- Did you have a COVID19-like illness (January to present)? (*multiple choice: yes/no*)
  - If yes, which symptoms did you experience? (*multiple choice: fatigue, fever, cough, trouble breathing, chills, repeated shaking with chills, muscle pain, headache, sore throat, new loss of taste or smell*)
- Were you tested for SARS-CoV-2 by PCR/viral testing? (*multiple choice: yes/no*)
  - If yes: what was the result of your SARS-CoV2 PCR test? *(multiple choice: positive, negative)*

[1] CDC defines close contact as having been with 6 feet for more than 15 minutes

FIGURE 2. Study questionnaire. Survey content assessing participant demographics, risk factors for SARS-CoV-2, exposure and symptoms of COVID-19 illness. The survey format was electronic, and responses were entered by choosing discrete selection boxes (indicated here as ''Multiple Choice''), or by free text. COVID-19, coronavirus disease 2019; SARS-CoV-2, severe acute respiratory syndrome coronavirus-2.

RESULTS

The recruitment email was sent to 301 surgeons and anesthesiologists; 135 did not respond and two declined to participate. Of the 164 (54.5%) who responded, 143 met criteria for inclusion in the final analysis (87.2%) (Fig. 1).

Participants were predominately men ($n = 117$ [81.8%]) median aged 40 (33, 58) and few medical comorbidities. None were smokers (Table 1). There were no significant associations between demographic variables and antibody status.

The period prevalence of IgG SARS-CoV-2 antibodies was 9.8% (14/143 participants). Among symptomatic participants, 12/54 were antibody positive (22% seroprevalence) as were 2/89 asymptomatic participants (2.3% seroprevalence). Among the IgG positive participants, the most frequently reported symptoms were fatigue ($n = 11$), myalgia ($n = 9$), fever ($n = 7$), and headache ($n = 7$). Hyposmia or dysgeusia was reported in six antibody-positive and two antibody-negative participants. IgG positive participants were significantly more likely to report fatigue (OR 11.4; 95% CI 2.8, 67.4; $P < 0.0002$), fever (OR 6.5; 95% CI 1.7, 24.7; $P < 0.005$), dyspnea (OR 12.0; 95% CI 1.9, 75.7; $P < 0.006$), headache (OR 8.0; 95% CI 2.1, 31.5; $P < 0.002$), and hyposmia/dysgeusia (OR 44.1; 95% CI 6.7, 514.2; $P < 0.001$).

An analysis of 11/12 IgG-positive symptomatic cases by time indicated that all cases occurred between March 8 and April 24, 2020 (Fig. 3). One participant did not report the date of symptom onset. The highest number of cases/week occurred between March 23 and 29, 2020 ($n = 4$). Symptom onset in one case occurred after the peak of the surge crisis in New York City (April 6, 2020), and after full institutional availability of PPE and implementation of infection control protocols.[18]

An equal number of attending surgeons and anesthesiologists ($n = 3$ each), and trainees in each role ($n = 4$ fellows; $n = 4$ residents) were IgG positive. Both asymptomatic IgG-positive participants were orthopedic surgery trainees. Antibody-positive participants were more likely to have been working in the operating rooms during the surge crisis (OR 7.4; 95% CI 1.1, 323.3; $P < 0.04$).

Most antibody-positive ($n = 12$, 85.7%) and -negative ($n = 67$, 51.9%) participants reported a first-degree contact with confirmed COVID-19. IgG positive participants were more likely report a partner/spouse with COVID-19 (OR 8.3; 95% CI 1.1, 56.2; $P < 0.04$).

There were no significant associations between other variables and antibody status, including mode of commuting to work (public transportation, walking/bicycling, and private), other practice settings (ICU, office and ward-based), or place of residence (New York City or suburban).

DISCUSSION

This cross-sectional study demonstrates low seroprevalence of SARS-CoV-2 IgG antibodies among a cohort of surgeons and anesthesiologists at a converted COVID-19 hospital in New York City during the surge crisis of the pandemic. IgG antibodies were found infrequently among physicians with and without symptoms. These findings highlight the imperfect nature of symptom reporting alone to guide quarantine and return to work strategies. The number of positive cases declined in parallel with implementation of institutional PPE and infection control protocols. These results add to the growing body of literature estimating the prevalence of SARS-CoV-2 among HCWs.

Early studies estimated the prevalence of COVID-19 illness among HCWs by retrospective and survey-based assessments of symptoms and mortality.[5,6,19] More recently, calls have been made to incorporate SARS-CoV-2 antibody testing to improve understanding of local patterns of disease exposure and occupational risk.[9] Reports of SARS-CoV-2 antibody status among HCWs are starting to be described. Thus far, the prevalence appears to be low, but there is high variability between published accounts, depending on geography and the professional population sampled. For example, in Germany, seroprevalence among all HCWs at an academic hospital was 1.6%[12] compared with 17.2% of practitioners at a specialty mother-child facility in Italy[20] and 5.9% among emergency department personnel in Utah.[21] Estimates of seroprevalence among surgeons have not yet been described. Coincident with our study completion, a report among anesthesiologists and intensive care physicians concluded 12.1% seroprevalence at an academic medical center in New York City.[11] The latter results are consistent with those reported here and suggest the importance of local assessment of exposure status, since community prevalence in combination with institutional PPE and infection control protocols are likely be major determinants of physician acquisition of SARS-CoV-2.

Although the effect(s) of PPE and infection control protocols on our results cannot be directly measured, the relative occupational safety of surgeons and anesthesiologists can be inferred. First, we found few positive cases of SARS-CoV-2 exposure, but equal numbers among surgeons and anesthesiologists. Anesthesiologists are among HCWs at the highest occupational risk of SARS-CoV-2 acquisition from patients due to aerosolization during airway management.[4] Thus, a higher proportion of cases among anesthesiologists was expected. In contrast, we found low overall seroprevalence, equal numbers of cases among subspecialties, and no associations between ward- or ICU-based deployment and SARS-CoV-2 exposure. These results suggest the protective benefit of PPE—an interpretation supported by a recent retrospective study from Wuhan, China, in which no cases of SARS-CoV-2 were transmitted from patient-to-anesthesiologist during 202 emergency intubations after implementation of strict PPE, infection prevention, and airway management protocols.[22] Second, we found a temporal relationship between symptom onset and institutional changes in PPE and safety protocols in which most symptomatic cases occurred prior to or coincident with protective processes being introduced to clinical practice.

The source of SARS-CoV-2 exposure in our cohort is unknown, and it is probable that some cases were community-acquired. It follows that changes in community behavior and public health strategies likely contributed to the decline in positive cases over time found here. Indeed, prior studies among HCWs have attributed cases of COVID-19 contracted early in the local pandemic to community acquisition and/or inadequate PPE as hospitals implement new infection control protocols.[23–25] Consistent with these data, we found only one case in which reported symptom-onset occurred after the peak of the local surge and after institutional implementation of COVID-19 safety processes.[18]

We found two asymptomatic physicians with IgG antibodies. If these represent true-positive asymptomatic cases, the overall risk to patients of SARS-CoV-2 acquisition from their physicians is low. However, whether and how the transmission dynamics of SARS-CoV-2 vary according to the presence and severity of symptoms is unclear.[7] Emerging reports describe presymptomatic, oligosymptomatic, and asymptomatic spread in the community, but to date, these phenomena have not been explored among physicians.[7,26,27] Conversely, if these represent false positive cases, the influence of population prevalence and the performance characteristics of the diagnostic test need to be considered. Recent evaluation estimates the positive predictive value of the test at 93.4% at 5% disease prevalence, raising concern for returning non-immune individuals to occupational risk of exposure.[28] COVID-19 prevalence varies by zip code in New York State, but local data consistently showed prevalence in excess of 5% in all evaluated regions at the time the study was conducted.[18] Notwithstanding, we cannot conclude whether these cases represent true or false positive results without serial

TABLE 1. Summary Data of Survey Responses and SARS-CoV-2 Antibody Status

Variables		SARS-CoV-2 IgG Positive	SARS-CoV-2 IgG Negative		
Number of Participants (%)		14 (9.79)	129 (90.21)	Odds Ratio (95% CI)	*P*-Value
Age	Median [IQR]	36.5 [28,39.5]	46.7 [33,57.5]	0.965 (0.923,1.000)	0.080
Sex (%)	Female	2 (14.29)	24 (18.60)	0.731 (0.075,3.624)	1.000
Race (%)	White	10 (71.43)	99 (76.74)	Reference group	
	Black or African American	2 (14.29)	6 (4.65)	1.494 (0.030,14.254)	1.000
	Asian	2 (14.29)	18 (13.95)	1.000 (0.100,5.294)	1.000
	Others/unknown	0	6 (4.65)	1.144 (0,6.524)	0.542
BMI	Mean (SD)	24.76 (2.69)	24.93 (3.88)	0.988 (0.856)	0.776
Current smoking (%)		0	0	NA	NA
Number of adults in household	Mean (SD)	2.08 (1.04)	2 (0.80)	1.126 (0.521,2.210)	0.822
Number of children in household	Mean (SD)	0.86 (1.23)	0.78 (1.15)	1.064 (0.625,1.693)	0.852
Location of primary residence before March 16	New York City (%)	12 (85.71)	101 (78.29)	1.658 (0.338,16.118)	0.804
	Outside of New York City (%)	2 (14.29)	28 (21.71)	Reference group	
Residence after March 16	New York City (%)	12 (85.71)	85 (65.89)	3.086 (0.643,29.605)	0.220
	Outside of New York City (%)	2 (14.29)	44 (34.11)	Reference group	
Comorbidities (%)	Hypertension	0	13 (10.08)	0.469 (0,2.394)	0.246
	Diabetes mellitus	0	1 (0.78)	2.220 (5.1652)	0.902
	Pulmonary disease	1 (7.14)	9 (6.98)	2.384 (0.045,26.15)	0.814
	Obstructive sleep apnea syndrome	0	0	NA	NA
	Coronary artery disease/Other cardiac conditions	0	3 (2.33)	2.397 (0,16.377)	0.732
	Chronic kidney disease	0	0	NA	NA
	Liver disease	0	0	NA	NA
	Immunocompromised	0	3 (2.33)	3.191 (0.057,43,198)	0.681
	Other	1 (7.14)	10 (7.75)	0.586 (0.013,4.476)	1.000
Role at the hospital (%)	Orthopedic surgeon	3 (21.43)	47 (36.43)	1.000 (0.127,7.854)	1.000
	Anesthesiologist	3 (21.43)	47 (36.43)	Reference group	
	Orthopedic or anesthesiology fellow	4 (28.57)	19 (14.73)	3.238 (0.497,24.247)	0.270
	Orthopedic resident	4 (28.57)	16 (12.40)	3.827 (0.580,29.13)	0.193
Location of practice	Main campus	13 (92.86)	123 (95.35)	0.637 (0.068,31.386)	1.000
	Satellite site	1 (7.14)	6 (4.65)	0.891 (0.192,3.326)	1.000
Mode of commuting to work	Walk/Bike	11 (78.57)	75 (58.14)	2.624 (0.651,15.343)	0.228
	Public transportation	3 (21.43)	20 (15.50)	1.482 (0.244,6.329)	0.795
	Car	5 (35.71)	56 (43.41)	0.726 (0.181,2.572)	0.797
Practice pattern after March 16	Office	3 (21.43)	43 (33.33)	0.548 (0.093,2.222)	0.560
	Operating room	13 (92.86)	82 (63.57)	7.381 (1.046,323.274)	**0.042**
	ICU	4 (28.57)	30 (23.26)	1.317 (0.281,4.995)	0.872
	Working on the ward with SARS-CoV-2 positive patients	7 (50.00)	39 (30.23)	2.293 (0.639,8.240)	0.232
	Working on the ward with SARS-CoV-2 negative patients	3 (21.43)	19 (14.73)	1.573 (0.258,6.756)	0.735
	Worked from home	5 (35.71)	53 (41.07)	0.798 (0.198,2.831)	0.930
	Did not work	1 (7.14)	7 (5.43)	1.338 (0.028,11.859)	1.000
Close contact to someone diagnosed with COVID-19 (%)	Yes	12 (85.71)	67 (51.94)		
	Partner or spouse	3 (21.43)	4 (3.10)	8.275 (1.077,56.178)	**0.041**
	Family	0	1 (0.78)	2.220 (5.1652)	0.902
	Friend	2 (14.29)	20 (15.50)	0.909 (0.092,4.582)	1.000
	Patient	8 (57.14)	54 (41.86)	1.844 (0.526,6.848)	0.415
Covid-like illness (January to present) (%)	Yes	12 (85.71)	42 (32.56)		
	Fatigue	11 (91.67)	31 (73.81)	11.351 (2.767,67.369)	**0.0002**
	Fever	7 (58.33)	17 (40.48)	6.457 (1.705,24.710)	**0.005**
	Cough	6 (50.00)	26 (61.90)	2.943 (0.771,10.677)	0.122
	Trouble breathing	4 (33.33)	4 (9.52)	12.035 (1.943,75.664)	**0.006**
	Chills	5 (41.67)	16 (38.10)	3.871 (0.903,14.941)	0.069
	Repeated shaking with chills	1 (8.33)	5 (11.90)	1.897 (0.037,18.968)	0.934
	Muscle pain	9 (75)	21 (50.00)	9.046 (2.441,38.030)	**0.0005**
	Headache	7 (58.33)	14 (33.33)	8.015 (2.074,31.467)	**0.002**
	Sore throat	2 (16.67)	23 (54.76)	0.769 (0.078,3.830)	1.000
	New loss of taste or smell	6 (50.00)	2 (4.76)	44.142 (6.646,514.198)	**<0.0001**
SARS-CoV-2 PCR test (%)	Yes	8 (57.14)	10 (7.75)		
	Positive	6 (75.00)	0	24.916 (3.754)	**0.001**

Boldface type indicates significant results at $P < 0.05$.
BMI, body mass index; ICU, intensive care units; IQR, interquartile range; SARS-CoV-2, severe acute respiratory syndrome coronavirus-2; SD, standard deviation.

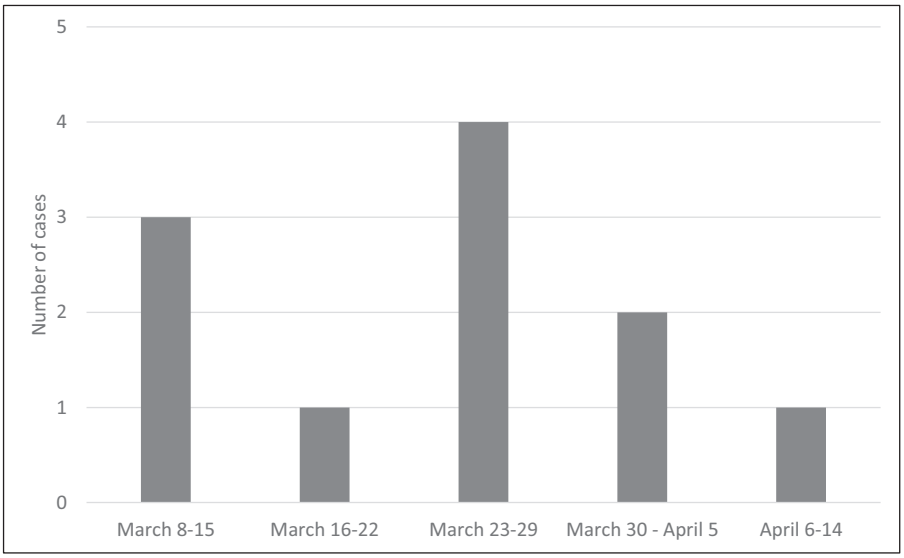

FIGURE 3. Frequency of cases reporting COVID-19 symptom onset by date. Data shown for all symptomatic cases where the date of symptom onset was provided by participants ($n = 11$). Two IgG-antibody positive cases were reported to be asymptomatic, and one participant did not record the date of first symptom onset. COVID-19, coronavirus disease 2019.

antibody testing of IgG positive participants and ongoing assessment of community prevalence.

Concern for false-negative cases is suggested by our finding that a substantial proportion of participants reported a COVID-19-like illness but were subsequently antibody-negative. Although not dispositive, the negative predictive value of the test was recently estimated at 100% at 5% disease prevalence, although these data may derive from higher acuity hospitalized patients and not milder outpatient disease.[18] An alternative explanation is the illnesses reported in IgG-negative participants reflected non-SARS-CoV-2 infections. The US Centers for Disease Control estimated 39 to 56 million cases of influenza in the United States between October 1, 2019 and April 4, 2020.[29] Influenza and COVID-19 share an overlap in symptoms, including fever, cough, and myalgia, which could account for the frequency of these symptoms in IgG-negative participants. Conversely, hyposmia and dysgeusia are more strongly associated with COVID-19 than influenza, although both symptoms are found in other viral infections (herpes zoster and HIV).[30] Interestingly, two IgG-negative participants reported these symptoms, which raises the possibility that a proportion of our IgG-negative cases may reflect true COVID-19 illness with failure to mount an appropriate or detectable antibody response. Resistance to SARS-CoV infection is associated with both innate and adaptive immune responses and the innate immune response has not been well defined.[31] Some studies implicate a maladaptive innate immune response to SARS-CoV-2 in critical illness with development of acute respiratory distress syndrome and the cytokine storm.[32] However, others demonstrate the beneficial role that macrophages and dendritic cells play in coronavirus destruction.[32] Although speculative, it is possible these pathways account for some of the IgG-negative symptomatic cases reported here.

Strengths and Limitations

This study is one of few to estimate physician exposure to SARS-CoV-2 by antibody testing, and to our knowledge is the first to correlate symptom history with seroprevalence among a cohort of surgeons and anesthesiologists. Using a combined approach to estimate the prevalence of SARS-CoV-2 exposure mitigates the disadvantages associated with serology or retrospective symptom reporting used alone and helps strengthen the conclusions reported here. However, there are several limitations.

Retrospective survey-based research suffers from recall and reporting bias, the validity of the survey depends on the response rate, and our instrument has not been validated for research or diagnosis of COVID-19 illness. To minimize these biases, we asked participants to report symptoms over a short interval, sent the survey prior to serology testing, and restricted survey content to elements with known associations with COVID-19 illness. Our initial response rate to study recruiting approximated 55%, although a high proportion of interested participants completed both required elements of the study (87.2%). These patterns are consistent with studies suggesting physicians have lower response rates to study participation compared with the general population.[33] It is also possible our design suffered from response bias in which those who suspected they had had SARS-Co-V2 exposure were more likely to participate, thereby overestimating seroprevalence. Conversely, a late-look bias could have led to an underestimation.

Our cohort was predominately young, white, and male, with few medical comorbidities, limiting the generalizability of our results. Interestingly, in contrast to pre-pandemic times, our status as a specialty orthopedic surgery hospital is not a major factor limiting external validity. On the contrary, we suggest that this is a particular strength of the study: conversion of our free-standing hospital to a city-wide COVID-19 care facility expanded our patient population from specialized to generalized, and more likely to reflect broader demographics and risk factors for physician exposure to SARS-CoV-2.

CONCLUSIONS

The prevalence of SARS-CoV-2 IgG antibody positive status was 9.8% among surgeons and anesthesiologists at a converted COVID-19 hospital. Antibody status was highly correlated with COVID-19-like illness. Despite several caveats, these results highlight the protective benefit of PPE and infection control protocols, and low risk for oligosymptomatic spread. Although we conclude low seroprevalence overall, the consequences of a 9.8% positive prevalence could be devastating if extrapolated to HCWs, healthcare systems and communities, and raise multiple opportunities for future research. Studies which serially measure antibody status together with repeat symptom-assessment could inform the debate surrounding duration of immune status and the immune-protection afforded by a positive IgG response. Including influenza or additional viral testing in future protocols may help clarify the symptom

overlap between COVID-19 and influenza, and advance understanding of the (potential) false negative cases reported here. Prospective studies incorporating contact-tracing should help determine the major risks and sources of SARS-CoV-2 exposure among HCWs in defined communities. For example, we did not collect data regarding risk factors for HCW-to-HCW transmission, which may be a significant source of acquisition—particularly among trainees. Additionally, the risk of transmission between family members/close contacts and the time-course of such transmissions should be addressed. Finally, the work should be repeated in other medical specialties and among allied HCWs, so that specialty-specific risks can be understood and procedures for mitigation can be developed.

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