Prevalence of SARS-CoV-2 Antibodies in First Responders and Public Safety Personnel, New York City, New York, USA, May–July 2020

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We conducted a serologic survey in public service agencies in New York City, New York, USA, during May–July 2020 to determine prevalence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection among first responders. Of 22,647 participants, 22.5% tested positive for SARS-CoV-2–specific antibodies. Seroprevalence for police and firefighters was similar to overall seroprevalence; seroprevalence was highest in correctional staff (39.2%) and emergency medical technicians (38.3%) and lowest in laboratory technicians (10.1%) and medicolegal death investigators (10.8%). Adjusted analyses demonstrated association between seropositivity and exposure to SARS-CoV-2–positive household members (adjusted odds ratio [aOR] 3.52 [95% CI 3.19–3.87]), non-Hispanic Black race or ethnicity (aOR 1.50 [95% CI 1.33–1.68]), and severe obesity (aOR 1.31 [95% CI 1.05–1.65]). Consistent glove use (aOR 1.19 [95% CI 1.06–1.33]) increased likelihood of seropositivity; use of other personal protective equipment had no association. Infection control measures, including vaccination, should be prioritized for frontline workers.

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Coronavirus disease (COVID-19) was recognized in New York City (NYC), New York, USA, in late February 2020 and had spread throughout the community by March 2020 (*1*). First responders and public safety personnel have played a critical role in the COVID-19 pandemic response. Understanding the occupational risks for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection is vital for designing workplace prevention protocols to reduce transmission. Serologic surveys can identify the prevalence of previous SARS-CoV-2 infection in the population.

We conducted a serologic survey to estimate SARS-CoV-2 infection prevalence among first responders, public safety personnel, and other public service workers in NYC. The study objectives were to determine the prevalence of IgG against SARS-CoV-2 and to examine associations between characteristics and occupational exposures and previous infection among workers in emergency response and public safety settings.

Methods

This cross-sectional survey was conducted during May 18–July 2, 2020, in the 5 NYC boroughs: Brooklyn, Manhattan, Queens, Staten Island, and the Bronx. The Institutional Review Board of the NYC Department of Health and Mental Hygiene and Centers for Disease Control and Prevention (CDC) human subjects research officials determined this activity to be public health surveillance as defined in 45 CFR 46.102(l) (*2*).

Adults ≥18 years of age working onsite in a public service agency were eligible to participate, including

employees of city departments of corrections, police, fire, medical examiner, and education, for a total of ≈60,000 persons. Educational settings were limited to Regional Enrichment Centers that served children of first responders and healthcare personnel. Persons who self-reported a positive result for SARS-CoV-2 or occurrence of COVID-19 symptoms ≤2 weeks before completing the questionnaire were ineligible.

A questionnaire assessed participant demographics and relevant household, occupation, and workplace risk factors for SARS-CoV-2 infection (Appendix Table 1, https://wwwnc.cdc.gov/EID/article/27/3/20-4030-App1.pdf). Participation was voluntary. Consenting participants completed the questionnaire online and provided a blood specimen at a collection site located at or near their workplace during May 18–July 2, 2020. Samples were tested for SARS-CoV-2 antibodies by using the VITROS Immunodiagnostic Products Anti-SARS-CoV-2 IgG Test (ORTHO Clinical Diagnostics Inc., https://www.orthoclinicaldiagnostics.com). Data for this test submitted to the Food and Drug Administration indicated a sensitivity of 90% and a specificity of 100% (*2*). Some tests were not performed because of lipemia or insufficient serum. CDC did not receive personal identifiers, and individual results were not shared with employers.

Participants self-reported their race or ethnicity. Reported height and weight were used to calculate body mass index (BMI); weight status categories were defined as underweight or normal (BMI <25), overweight (BMI ≥25 but <30), obese (BMI ≥30 but <40), and severely obese (BMI ≥40). Nonhospital healthcare workers (physicians, midlevel clinicians, nurse assistants, nurses, therapists, phlebotomists, imaging technicians, and dentists) were categorized as other direct patient care providers. Frequency of use of personal protective equipment (PPE) within 6 feet of a person with suspected or confirmed COVID-19 was categorized as all of the time, not all of the time (never or rarely, sometimes, and most of the time), and not applicable.

A total of 22,647 participants were included in our analysis (Appendix Figure 1). Percentage of SARS-CoV-2 IgG seropositivity and 95% CIs were calculated by selected characteristics and exposures. In subsequent analyses assessing seropositivity by frequency of aerosol-generating procedures and PPE use, we focused on occupations for which CDC-issued recommendations for PPE were in place: police (including traffic officers), medicolegal death investigators, firefighters, correctional staff, security guards, firefighters or medical first responders, paramedics, emergency medical technicians (EMTs), dispatchers (fire, emergency medical service [EMS], or police), and other direct patient-care providers (*3*–*6*). We performed multivariable logistic regression with seropositivity as the outcome variable. Covariates were chosen a priori and checked for collinearity. Participants with implausible weight or height (n = 15) or missing housing status (n = 6) were excluded. We used SAS version 9.4 (SAS Institute, https://www.sas.com) to perform statistical analyses. We considered 2-sided p values <0.05 to be statistically significant.

Results

A total of 5,091 (22.5% [95% CI 21.9%–23.0%]) participants tested positive for SARS-CoV-2 IgG (Table); however, only 10.1% (95% CI 9.8%–10.5%]) of participants reported previous positive results for SARS-CoV-2 by reverse transcription PCR. Seroprevalence was higher among women than men, higher among non-Hispanic Black persons than other racial or ethnic groups, higher among persons 18–24 years of age compared with older age groups, and higher among persons who were severely obese compared with those with a lower weight status (Table). Seropositivity was highest among those with exposure to a household member who tested positive for SARS-CoV-2 (48.3% [95% CI 46.3%–50.3%]). In addition, seropositivity was highest among persons who resided in the Bronx (28.8% [95% CI 26.8%–30.9%]) and lowest among those residing outside of NYC (18.3% [95% CI 17.5%–19.2%]). Participants who lived in multiunit housing had higher seropositivity than those who lived in single-family housing, as did participants in very large households (≥8 persons) compared with households of ≤7 persons (Appendix Figure 2).

Seroprevalence was higher among those who worked in correctional facilities (36.2% [95% CI 33.6%–39.0%]) and EMS agencies (35.2% [95% CI 33.3%–37.2%]) compared with those who worked in other workplaces (range 11.7%–21.3%) (Table). Seroprevalence also varied by occupation (Figure 1). We also observed differences in seroprevalence by workplace borough; prevalence was highest in the Bronx (26.8%) and lowest in Staten Island (17.4%) (Table).

The remainder of the analysis focused on first responders and public safety personnel (n = 19,909) (*3*–*6*). Seropositivity increased with increasing frequency of aerosol-generating procedures performed per shift (p = 0.002), ranging from 20.7% among persons who did not conduct these procedures to 31.6% among those who conducted procedures >25 times on average per shift (Figure 2). Seropositivity also varied by frequency of PPE use when within 6 feet of a person

with confirmed or suspected COVID-19, including stratification by occupation (Figure 2; Appendix Figure 3). Overall, for each PPE component, those who reported use all of the time had a significantly higher percent positivity than those who reported not all of the time ($p<0.05$).

In adjusted analyses, women and those exposed to a patient with suspected or confirmed COVID-19 were less likely to be seropositive than their counterparts (Figure 3; Appendix Table 2). Characteristics associated with increased odds of seropositivity were self-reported exposure to a household member who

Table. Percentage of respondents who were seropositive for SARS-CoV-2 IgG, by demographic and health characteristics, in a study of first responders and public safety personnel, New York City, New York, USA, May 18–July 2, 2020*

Characteristic	No. (%)	% Seropositive (95% CI)
Total	22,647 (100.0)	22.5 (21.9–23.0)
Sex		
M	17,118 (75.6)	21.9 (21.3–22.5)
F	5,529 (24.4)	24.2 (23.1–25.4)
Age group, y		
18–24	795 (3.5)	32.0 (28.7–35.3)
25–34	6,677 (29.5)	26.4 (25.3–27.5)
35–44	8,034 (35.5)	20.2 (19.4–21.1)
45–59	6,328 (27.9)	20.3 (19.4–21.4)
60–64	589 (2.6)	20.7 (17.5–24.2)
≥65	224 (1.0)	18.3 (13.5–24.0)
Race/ethnicity		
Non-Hispanic White	10,013 (44.2)	18.5 (17.7–19.2)
Non-Hispanic Black	3,292 (14.5)	30.1 (28.5–31.7)
Non-Hispanic Asian	1,647 (7.3)	21.3 (19.4–23.4)
Hispanic or Latino	5,460 (24.1)	26.9 (25.7–28.1)
Non-Hispanic other race†	548 (2.4)	20.3 (17.0–23.9)
Decline to answer	1,687 (7.5)	19.3 (17.4–21.2)
Weight status, n = 22,632‡		
Underweight or normal weight	4,048 (17.9)	21.4 (20.2–22.7)
Overweight	10,386 (45.9)	22.1 (21.3–22.9)
Obese	7,500 (33.1)	23.1 (22.1–24.1)
Severely obese	698 (3.1)	27.8 (24.5–31.3)
Housing, n = 22,641		
Single family	15,455 (68.3)	21.1 (20.5–21.8)
Multiunit	7,186 (31.7)	25.3 (24.3–26.4)
Residence borough		
Outside New York City	8,654 (38.2)	18.3 (17.5–19.2)
Bronx	1,948 (8.6)	28.8 (26.8–30.9)
Brooklyn	3,329 (14.7)	28.0 (26.5–29.5)
Manhattan	1,207 (5.3)	21.4 (19.1–23.8)
Queens	4,834 (21.3)	25.4 (24.2–26.6)
Staten Island	2,675 (11.8)	19.8 (18.3–21.3)
Workplace§		
Correctional facility	1,272 (5.6)	36.2 (33.6–39.0)
Emergency medical services	2,418 (10.7)	35.2 (33.3–37.2)
Childcare setting (Regional Enrichment Center)	677 (3.0)	21.3 (18.2–24.6)
Fire services	6,087 (26.9)	20.8 (19.8–21.9)
Police department	11,885 (52.5)	19.8 (19.1–20.5)
Medical examiner office	394 (1.7)	11.7 (8.7–15.3)
Workplace borough		
Bronx	3,524 (15.6)	26.8 (25.4–28.3)
Brooklyn	6,075 (26.8)	24.1 (23.1–25.2)
Manhattan	5,755 (25.4)	19.7 (18.6–20.7)
Queens	6,200 (27.4)	21.9 (20.9–23.0)
Staten Island	1,093 (4.8)	17.4 (15.2–19.8)
Exposure to persons who tested positive for SARS-CoV-2‡		
Household member	2,393 (10.6)	48.3 (46.3–50.3)
Coworker	14,912 (65.9)	23.7 (23.0–24.3)
Patient	6,502 (28.7)	26.9 (25.8–28.0)
Other person	7,721 (34.1)	26.8 (25.8–27.8)

*BMI, body mass index; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.
†Non-Hispanic other race includes Native Hawaiian and other Pacific Islander and American Indian and Alaska Native.
‡Weight status categories defined as underweight or normal weight (BMI <25), overweight (BMI ≥25 but <30), obese (BMI ≥30 but <40), and severely obese (BMI ≥40).
§Workplace and self-reported exposure to persons who tested positive for SARS-CoV-2 are not mutually exclusive.

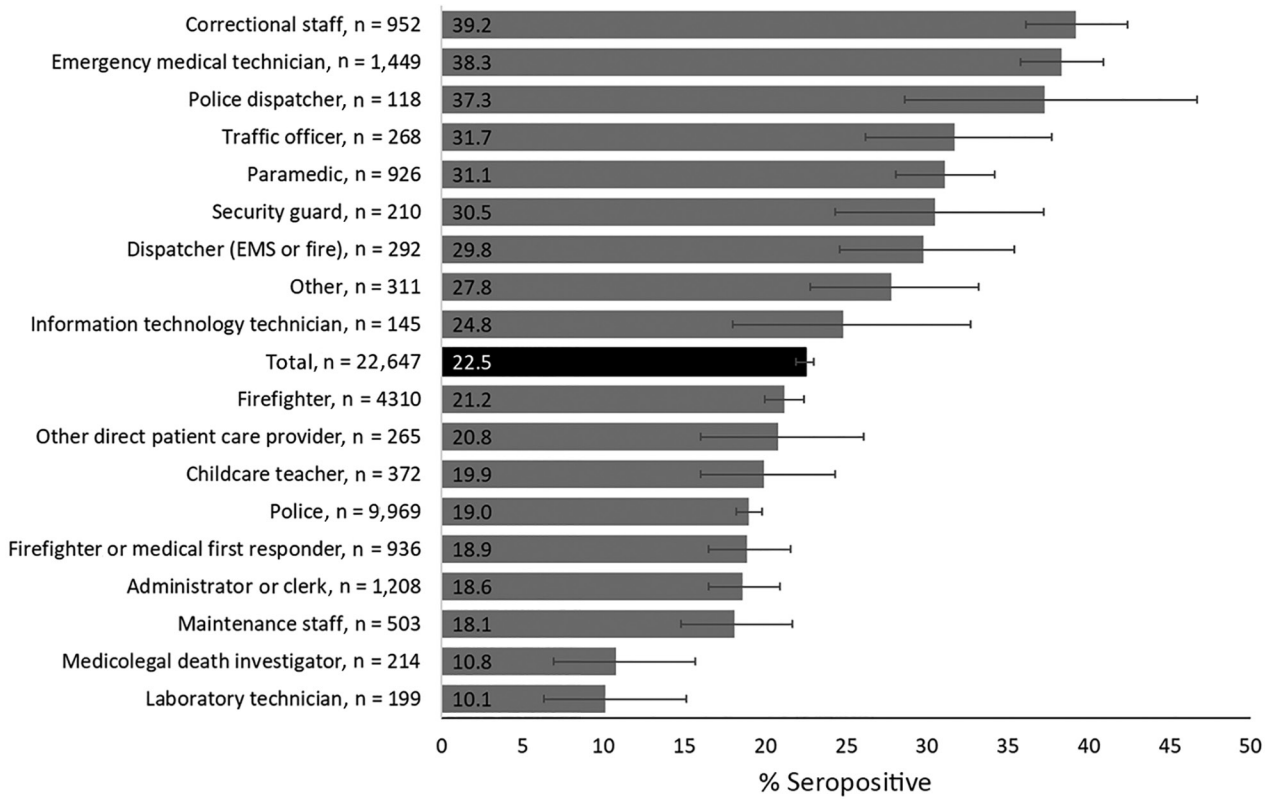

Figure 1. Percentage of respondents who were seropositive for severe acute respiratory syndrome coronavirus 2 IgG, by occupation, in a study of first responders and public safety personnel, New York City, New York, USA, May 18–July 2, 2020. Numbers within bars indicate percentage of seropositive respondents. Error bars indicate 95% CIs. Other includes students or trainees, pharmacists, medical registrars, orderlies, dietitians, medical assistants, counselors, social workers, dietary services staff, environmental services staff, and participants who selected this category and were not reassigned to an existing category. Firefighters includes fire inspectors and fire marshals. Other direct patient care providers include dentists, diagnostic imaging technicians, midlevel clinicians, nurses, nurse assistants, occupational therapists, speech therapists, physical therapists, phlebotomists, physicians, respiratory therapists, and therapy aides. EMS, emergency medical service.

tested positive for SARS-CoV-2, non-Hispanic Black versus non-Hispanic White race or ethnicity, severe obesity versus underweight or normal weight status, and residing or working in Brooklyn versus Staten Island. Correctional staff, EMTs, traffic officers, paramedics, security guards, dispatchers (EMS or fire and police), and firefighters were more likely than police to be seropositive; correctional staff had the highest likelihood of seropositivity (adjusted odds ratio [aOR] 2.55 [95% CI 2.18–2.99]). The aOR for seropositivity when using any PPE component all of the time was not significant. However, workers who reported using gloves all of the time were significantly more likely than those who used gloves not all of the time to be seropositive (aOR 1.19 [95% CI 1.06–1.33]).

Discussion

SARS-CoV-2 seroprevalence among public service agencies personnel (22.5%) was similar to the 19.5% seroprevalence estimate for NYC residents during comparative dates (*7*). However, seroprevalence varied nearly 4-fold by occupation, ranging from 10.1% in laboratory technicians to 39.2% in correctional staff. Similar to other studies, we found seroprevalence varied by nonoccupational factors such as race or ethnicity, age group, weight status, housing type, residence borough, and exposure to household members with COVID-19 (*8;* J.M. Baker, unpub. data, https://doi.org/10.1101/2020.10.30.20222877). However, even when controlling for these factors, we found that seroprevalence for police and firefighters was close to that of the general population; conversely, correctional staff and EMTs, the occupations with the highest seropositivity in our study, had a seroprevalence twice as high (*7*). These populations face unique challenges when working in congregate or uncontrolled settings and would be a critical population for vaccination and other public health efforts to reduce SARS-CoV-2 infection.

Correctional facility workers had the highest seroprevalence of SARS-CoV-2 antibodies, and the

odds of seropositivity were more than double for these workers compared with police, a group with a seroprevalence similar to the general population. COVID-19 in congregate settings has spread rapidly because of crowded living conditions and few options for isolation of exposed persons (*9*–*11*). Recent data from mass testing in correctional facilities found SARS-CoV-2 prevalence ranged from 0% to 87% (*12*). In New York state, 3,762 COVID-19 cases had been reported among staff of 28 correctional and detention facilities as of September 6, 2020 (*13*). Such recommendations as grouping persons with laboratory-confirmed infection are crucial to prevent COVID-19 outbreaks in correctional facilities, but additional

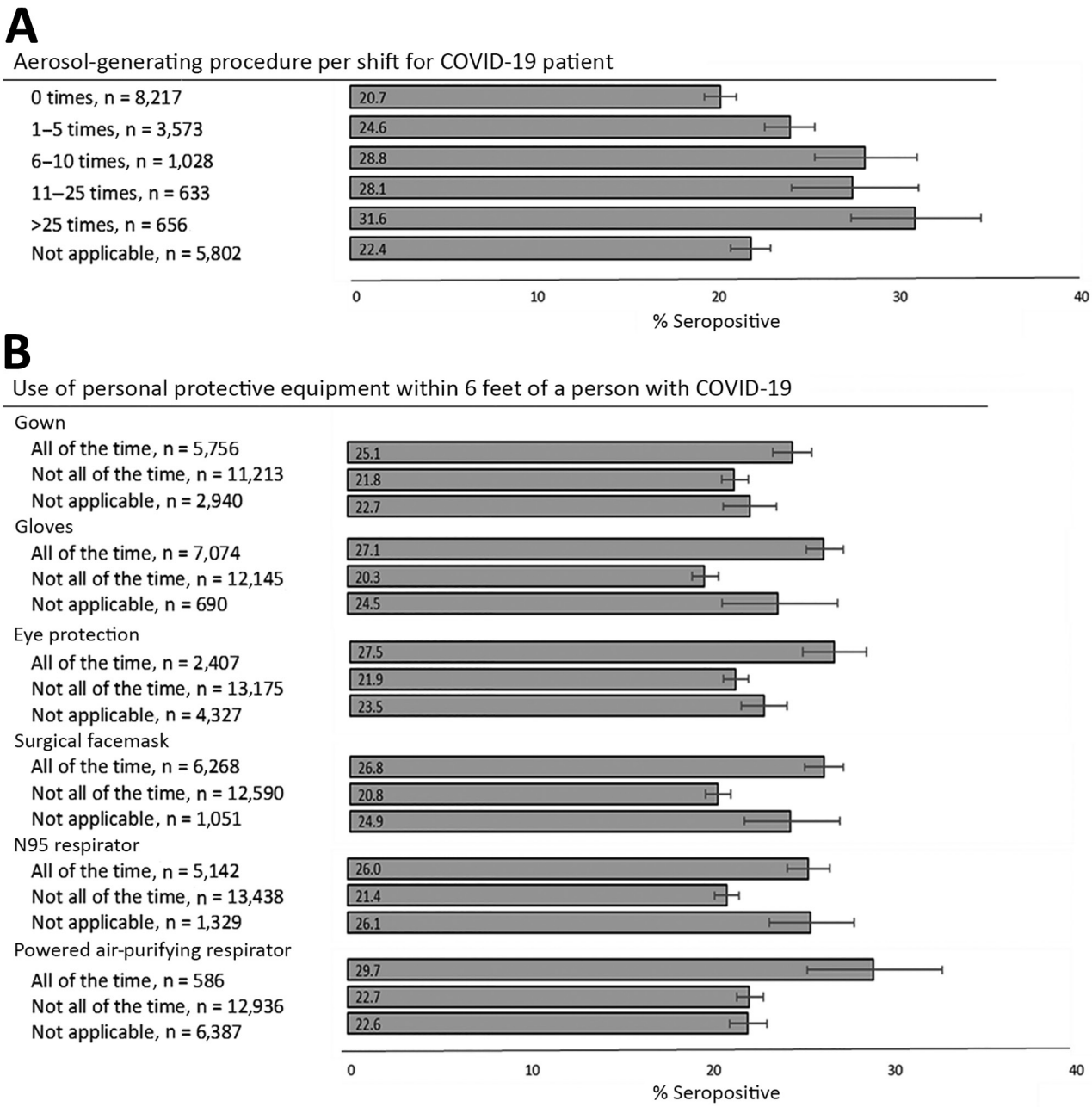

Figure 2. Unadjusted percentage of respondents who were seropositive for severe acute respiratory syndrome coronavirus 2 IgG, by aerosol-generating procedure frequency (A) and use of personal protective equipment (B), in a study of first responders and public safety personnel, New York City, New York, USA, May 18–July 2, 2020. Numbers within bars indicate percentage of seropositive respondents. Error bars indicate 95% CIs. First responders and public safety personnel include police, medicolegal death investigators, firefighters, correctional staff, security guards, traffic officers, police dispatchers, firefighters or medical first responders, paramedics, emergency medical technicians, dispatchers (emergency medical service or fire), and other direct patient-care providers. COVID-19, coronavirus disease.

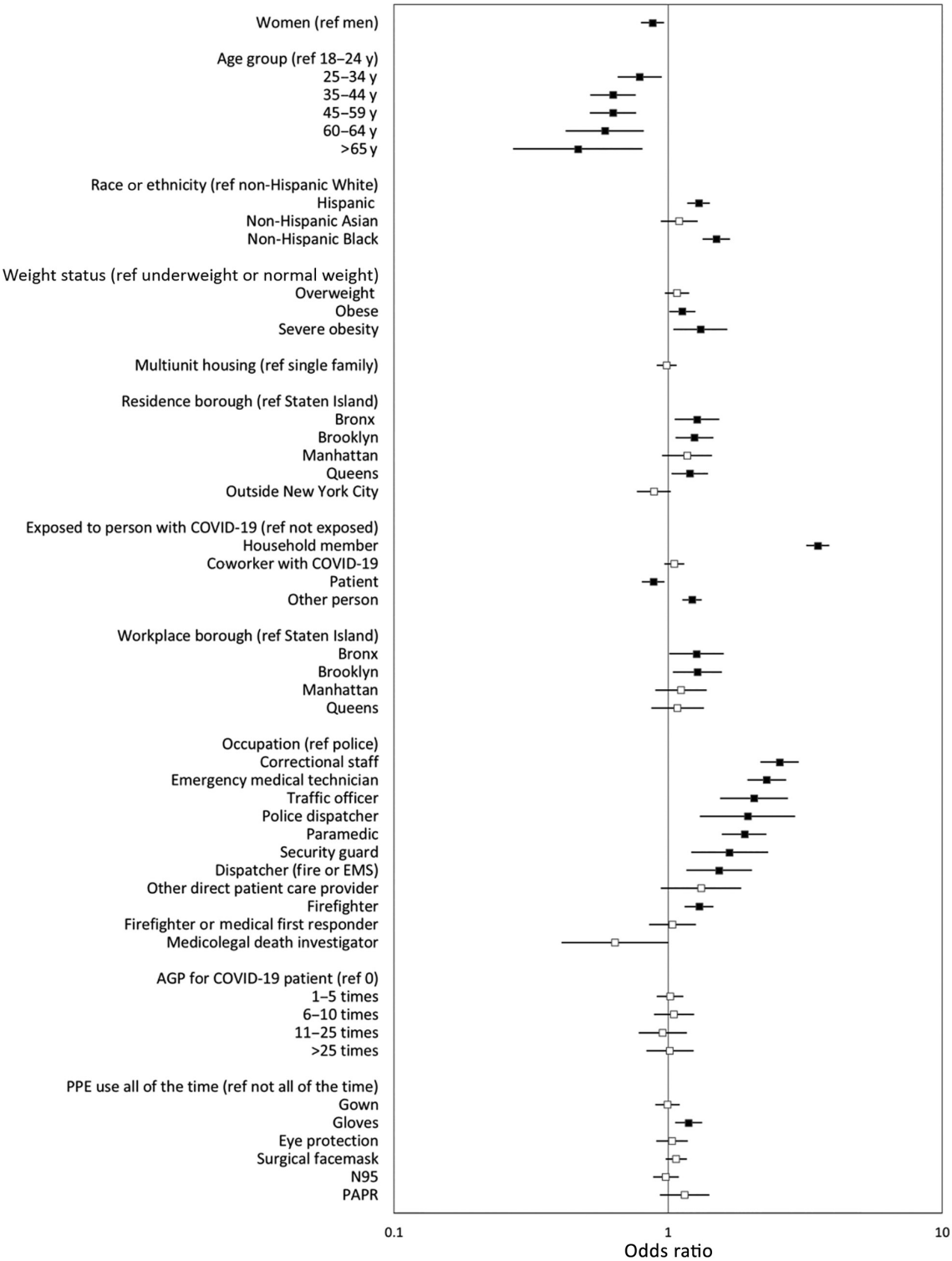

Figure 3. Adjusted odds ratios of seropositivity for severe acute respiratory syndrome coronavirus 2 IgG in a study of first responders and public safety personnel, New York City, New York, USA, May 18–July 2, 2020. Adjusted model includes all variables shown. Black boxes indicate statistically significant results; error bars indicate 95% CIs. Participants of other racial or ethnic groups or who declined to provide their race or ethnicity are included in the models but not shown as separate categories. Variables for exposure to person with COVID-19 are not mutually exclusive. AGP, aerosol-generating procedure; COVID-19, coronavirus disease; EMS, emergency medical service; ref, referent; PAPR, powered air-purifying respirator; PPE, personal protective equipment.

strategies are needed for settings in which isolating multiple persons infected with SARS-CoV-2 might not be possible (*5*,*14*).

Among healthcare workers, EMTs had a seroprevalence of 38.3% and the strongest association with seropositivity after adjustment. In contrast, other SARS-CoV-2 studies among NYC hospital-based healthcare workers found a seroprevalence ranging from 14% to 27% (*15*,*16*). EMS often occur in uncontrolled, unpredictable environments in which space is limited (e.g., ambulances) and require rapid decisions that might increase employee exposure risk. Although EMTs and paramedics both conduct procedures with a high risk for exposure (e.g., airway management), paramedics had a significantly lower seroprevalence than EMTs (*17*). Unmeasured factors, such as level of training, might account for the higher likelihood of seropositivity among EMTs compared with paramedics, who undergo an additional ≥1,000 training hours (*18*).

Other occupations with notably elevated seropositivity included traffic officers, security guards, and emergency dispatchers. Persons in these occupations have frequent and close interactions with the general public or work in environments in which space between coworkers is limited. Conversely, medicolegal death investigators and laboratory technicians, occupations with the lowest seroprevalence, might have less frequent close contact with other persons. Our findings also suggest that infection rates in the workplace might correlate with underlying community transmission, and not all observed associations are consistent with occupational risk. After adjustment, persons who worked or resided in the Bronx or Brooklyn had higher seropositivity compared with persons who worked or lived in Staten Island. This finding aligns with test results reported to the NYC Department of Health and Mental Hygiene, which found higher community seroprevalence in the Bronx (32.2%) and Brooklyn (27.0%) than in Staten Island (19.6%) (*1*).

Our finding that consistent use of gloves was associated with seropositivity was unexpected. However, among occupations without extensive training in glove use, a paradoxical association with infection has been previously observed: higher infection rates among consistent glove users was caused by cross-contamination and lack of hand hygiene after glove removal (*19*–*22*). PPE use has been demonstrated to be effective among healthcare workers in facility settings, but our study of first responders and public safety personnel in nonfacility settings demonstrates a different pattern, which warrants further investigation (*23*). Studies among healthcare workers found improper use of PPE, insufficient training, and perceived inadequacy of supplies increased transmission of other coronaviruses and might explain the higher seroprevalence documented in our study (*24*–*26*). Greater PPE use might be a surrogate for greater exposure to COVID-19 in the workplace. According to the hierarchy of controls, engineering and administrative controls (e.g., isolation and indoor ventilation) are preferred, and PPE should be the last line of defense to protect workers (*27*).

Public service personnel exposed to a SARS-CoV-2–positive household member also had higher seropositivity, a finding consistent with another study (*28*). This finding indicates the importance of managing exposure risk within households of frontline workers. Another factor to consider in NYC is the high density of living conditions, which was associated with greater likelihood of infection in our study. Even after controlling for occupation and housing type, racial and ethnic minority groups had higher seropositivity than non-Hispanic White workers. This pattern might be explained by unmeasured social disparities, such as lower income status, lack of paid sick leave, and mass transit use, which have been found to be associated with seropositivity among racial and ethnic minority groups in NYC (*29;* D. Carrion, unpub. data, https://doi.org/10.1101/2020.06.02.20120790; K.T.L Sy, unpub. data, https://doi.org/10.1101/2020.05.28.20115949). Mitigation measures should address persons working or residing in areas with high levels of SARS-CoV-2 transmission and racial or ethnic disparities.

Limitations of our study include that it was a convenience sample of public service agency personnel with limited numbers of healthcare professionals; participation ranged from an estimated 11% of ≈11,600 eligible correctional facility personnel to 81% of ≈10,300 fire services personnel. Participation might have been influenced by prior results of testing by reverse transcription PCR, expanded access to free antibody testing in the city, household exposure, and worker availability. Data collection occurred during May 18–July 2, 2020; recall bias could have affected responses for exposures 3 months before the survey. Study participants were also asked to recall PPE use during a wide period, and questions were not designed to measure adaptation to evolving PPE use. Temporality also limits our ability to know whether infection occurred before or after a potential exposure. Despite these limitations, our study provides seroprevalence estimates and factors associated with SARS-CoV-2 infection across a diverse set of occupations for which little data exist.

Nearly 25% of first responders and public safety personnel in our study were infected with SARS-CoV-2 before July 2020. Seroprevalence varied by nearly 4-fold among occupations; correctional staff and EMTs demonstrated highest levels of seropositivity. Other occupations with frequent close contact with the public also had elevated seroprevalence. We did not observe lower seroprevalence levels as expected from self-reported consistent PPE use, possibly because persons with consistent use had higher and more frequent exposure to SARS-CoV-2. Nevertheless, these results have identified high-risk occupations for which enhanced prevention measures including engineering and administrative controls and vaccination are required.

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Prevalence of SARS-CoV-2 Antibodies in First Responders and Public Safety Personnel, New York City, New York, USA, May–July 2020

Appendix

Appendix Table 1. Survey questionnaire administered in study of first responder and public safety personnel, New York City, New York, USA, May 18–July 2, 2020*

Question no.	Questionnaire item	Response categories
1.	Name (not provided to CDC)	First Last
2.	Home address (not provided to CDC)	Street City State Zip
3.1	Phone number (mobile) (not provided to CDC)	Area code, phone number
3.2	Verify phone number (mobile) (not provided to CDC)	Area code, phone number
4.1	Email address (not provided to CDC)	(fill)
4.2	Verify email address (not provided to CDC)	(fill)
5.	County/borough of workplace	[scroll] (jurisdictions to provide list) Other (fill)
6.	Date of birth (not provided to CDC)	MM/DD/YYYY
7.1	Sex at birth	Male Female
7.2	Current gender (not provided to CDC)	Man Woman Transgender man/trans man/female-to-male (FTM) Transgender woman/trans woman/male-to-female (MTF) Genderqueer/gender nonconforming neither exclusively male nor female Other (fill) Decline to answer
8.	Sexual orientation (not provided to CDC)	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
10A	Please select your age group	18–29 y 30–39 y 40–49 y 50–59 y 60–64 y 65–69 y

Question no.	Questionnaire item	Response categories
		70 y or older
11.1	What is your occupation?	Nurse (e.g., RN, APRN, LPN) Midlevel clinician (e.g., PA, NP, nurse-midwife) Nurse assistant (e.g., CNA) Physician (e.g., MD, DO) Student or trainee Medical examiner Mortuary technician Police officer Firefighter Paramedic Emergency medical technician Medical first responder Corrections officer or corrections staff Respiratory therapist Occupational/physical/speech therapist Therapy aide/assistant Pharmacist, pharmacist assistant Diagnostic imagining technologist/technician Clinical laboratory technologist/technician Phlebotomist Social worker/case manager Administration, clerk Medical records specialist/medical registrar Dietary services staff Environmental services staff Maintenance staff Orderly/transportation staff Security guard
12.1	What is your main workplace or work setting? (select all that apply) (skip question 12.2 if non-hospital response)	Emergency department Hospital intensive care unit Hospital ward/floor Other hospital location Fire station/department Police station/department Correctional facility Medical examiner office Other (fill)
12.2	What hospital do you work at?	[scroll] (jurisdictions to provide list) Other (fill)
13.1	Since March 1st, how many weeks have you worked in this setting?	Weeks (scroll) [min of 1, max of 20]
13.2	Since March 1st, on average, how many shifts did you work per week in this setting?	Shifts (fill) [min of 1, max of 14]
13.3	Since March 1st, on average, how many hours did you work per shift?	Hours (scroll) [min of 1, max of 24]
15.1	In the course of your work, how often did you use personal protective equipment (PPE) when within 6 feet of a person with suspected or confirmed COVID-19? All the time; Most of the time; Sometimes; Rarely/never; Not applicable	Gown (Go to Q 18)
15.2		Gloves (Go to Q 18)
15.3		N95 respirator (Go to Q 16)
15.4		Powered air purifying respirator (PAPR) (Go to Q 17)
15.5		Goggles or face shield (Go to Q 18)
15.6		Surgical facemask (Go to Q 18)
15.7		Other respirator (Go to Q 18)
16.	In the last year, have you been fit tested for the respirator you wore?	Yes No Don't know
17.	In the last year, have you been trained to use the respirator you wore?	Yes No Don't know
18.	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)? For example,	More than 25 times

Question no.	Questionnaire item	Response categories
	open suctioning of airways; sputum induction; cardiopulmonary resuscitation; endotracheal intubation and extubation; noninvasive ventilation (e.g., BiPAP, CPAP); bronchoscopy; manual ventilation.	11–25 times 6–10 times 1–5 times 0 Not applicable
19.1	Did you spend more than 10 min within 6 feet of a coworker who tested positive for COVID-19?	Yes No Don't know
19.2	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
19.3	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
20	How many times were you tested for COVID-19? (nasal, throat, or saliva sample)	(scroll) [indicate 0 if none] (if 0 Go to 23.1)
21.	Have you ever had a positive result for COVID-19?	Yes No Don't know
22.	Approximately, when was the last time you were tested for COVID-19 in 2020 (excluding blood testing for exposure to SARS-CoV-2)?	MM/DD Don't know
23.1	Since March 1, have you experienced any of the following symptoms?	Fever Chills Cough (new onset or worsening of chronic cough) Sore throat Shortness of breath or difficulty breathing Vomiting Diarrhea (≥3 looser than normal stools/24hr period) Muscle aches New loss in sense of smell or taste Headache (new onset or worsening headache) Other (fill)
24.	When did these symptoms start? (estimate as best as possible)	mm/dd Don't know
25.	Did you seek healthcare for these symptoms?	Yes No Don't know
26.	Were you hospitalized for COVID-19 illness?	Yes No Don't know
27.	Do you live in a single-family home or multiunit housing (like an apartment)?	Single family Multi-unit Other (fill)
28.	Number of household members currently in the residence including yourself (resident, family, live-in staff, roommates, and long-term visitors)	Specify (scroll)
29.	What is your height?	Feet Inches
30.	What is your weight?	Weight in pounds
31.1	Do you have any of the following chronic medical conditions?	Diabetes Hypertension (high blood pressure)

Question no.	Questionnaire item	Response categories
		Chronic heart disease Chronic kidney disease Chronic liver disease Asthma COPD/emphysema/chronic bronchitis Immunosuppressive condition (e.g., HIV, autoimmune disease) Immune-weakening medication or therapy (e.g., cancer treatment)
32.	Since March 1, have you been or are you currently pregnant? (only when sex at birth is female)	Yes No Don't know

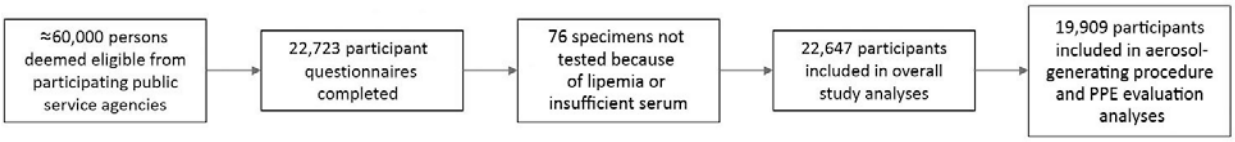
*APRN, advanced practice registered nurse; BiPAP, bilevel positive airway pressure; CDC, Centers for Disease Control and Prevention; CNA, certifying nursing assistant; COPD, chronic obstructive pulmonary disease; COVID-19, coronavirus disease; CPAP, continuous positive airway pressure; DO, doctor of osteopathy; LPN, licensed practical nurse; MD, medical doctor; NP, nurse practitioner; PA, physician assistant; RN, registered nurse; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

Appendix Table 2. Stepwise multivariable model for odds ratios of seropositivity for severe acute respiratory syndrome coronavirus 2 IgG in study of first responders and public safety personnel, New York City, New York, USA, May 18–July 2, 2020*

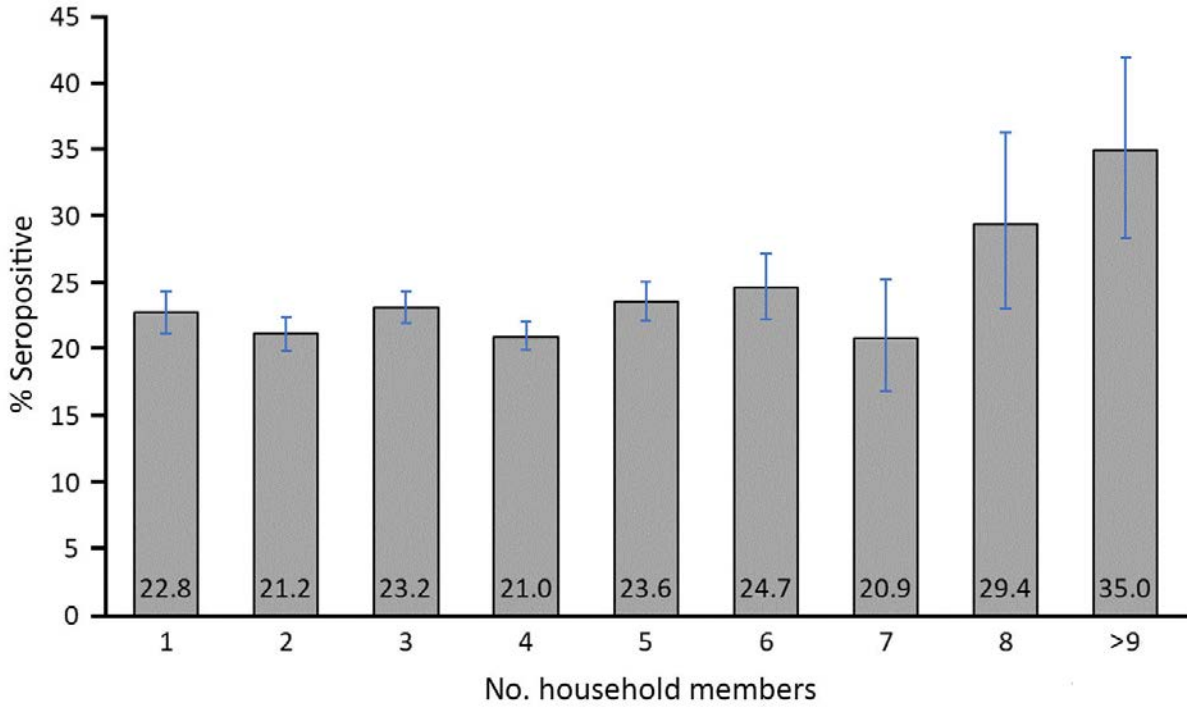
Characteristic	Unadjusted model, n = 19,909 OR (95% CI)	Adjusted model 1, n = 19,904 OR (95% CI)	Adjusted model 2, n = 19,904 OR (95% CI)	Adjusted model 3, n = 19,904 OR (95% CI)	Adjusted model 4, n = 19,904 OR (95% CI)
Sex					
M	Referent	Referent	Referent	Referent	Referent
F	1.20 (1.10–1.30)	1.02 (0.93–1.11)	0.94 (0.86–1.03)	0.89 (0.81–0.98)	0.88 (0.78–0.97)
Age group, y					
18–24	Referent	Referent	Referent	Referent	Referent
25–34	0.70 (0.59–0.83)	0.66 (0.56–0.79)	0.68 (0.57–0.81)	0.78 (0.65–0.94)	0.79 (0.66–0.95)
35–44	0.49 (0.41–0.58)	0.46 (0.39–0.54)	0.53 (0.44–0.63)	0.61 (0.51–0.74)	0.63 (0.52–0.76)
45–59	0.50 (0.42–0.59)	0.47 (0.39–0.56)	0.56 (0.47–0.67)	0.61 (0.50–0.74)	0.63 (0.52–0.77)
60–64	0.50 (0.37–0.68)	0.48 (0.36–0.66)	0.58 (0.42–0.79)	0.56 (0.41–0.78)	0.59 (0.42–0.82)
>65	0.43 (0.26–0.72)	0.41 (0.24–0.68)	0.46 (0.27–0.78)	0.45 (0.26–0.77)	0.47 (0.27–0.81)
Race or ethnicity					
Non-Hispanic White	Referent	Referent	Referent	Referent	Referent
Hispanic or Latino	1.59 (1.46–1.73)	1.54 (1.42–1.68)	1.30 (1.19–1.42)	1.31 (1.20–1.44)	1.29 (1.17–1.42)
Non-Hispanic Asian	1.16 (1.01–1.33)	1.17 (1.02–1.35)	1.08 (0.93–1.25)	1.11 (0.95–1.29)	1.10 (0.94–1.28)
Non-Hispanic Black	1.91 (1.73–2.10)	1.93 (1.75–2.14)	1.67 (1.50–1.87)	1.52 (1.35–1.71)	1.50 (1.33–1.68)
Other	1.15 (0.91–1.46)	1.19 (0.94–1.50)	1.02 (0.80–1.30)	0.98 (0.77–1.25)	0.97 (0.76–1.24)
Decline to answer	0.99 (0.86–1.13)	1.06 (0.92–1.21)	0.98 (0.84–1.13)	0.95 (0.82–1.10)	0.94 (0.81–1.08)
Weight status					
Underweight or normal weight	Referent	Referent	Referent	Referent	Referent
Overweight	1.00 (0.91–1.10)	1.07 (0.97–1.18)	1.06 (0.95–1.16)	1.07 (0.97–1.19)	1.08 (0.97–1.19)
Obese	1.07 (0.97–1.18)	1.13 (1.02–1.25)	1.12 (0.99–1.23)	1.12 (1.01–1.25)	1.13 (1.01–1.26)
Severely obese	1.36 (1.10–1.68)	1.42 (1.15–1.76)	1.39 (1.10–1.71)	1.31 (1.04–1.64)	1.31 (1.05–1.65)
Housing					
Single family	Referent		Referent	Referent	Referent
Multiunit	1.33 (1.24–1.42)		1.03 (0.95–1.12)	0.99 (0.91–1.07)	0.99 (0.91–1.08)
Residence borough					
Staten Island	Referent		Referent	Referent	Referent
Bronx	1.64 (1.43–1.88)		1.18 (0.98–1.42)	1.27 (1.06–1.54)	1.27 (1.06–1.54)
Brooklyn	1.58 (1.40–1.78)		1.24 (1.06–1.45)	1.25 (1.07–1.47)	1.25 (1.06–1.46)
Manhattan	1.10 (0.93–1.30)		1.05 (0.86–1.29)	1.16 (0.94–1.44)	1.17 (0.95–1.45)
Queens	1.38 (1.23–1.55)		1.12 (0.96–1.30)	1.20 (1.03–1.40)	1.20 (1.03–1.40)
Outside New York City	0.91 (0.82–1.02)		0.79 (0.68–0.91)	0.88 (0.76–1.01)	0.89 (0.77–1.02)
Exposure to a person with COVID-19 (Referent = not exposed)					
Household member	3.77 (3.44–4.13)		3.41 (3.10–3.76)	3.51 (3.19–3.87)	3.52 (3.19–3.87)
Coworker	1.16 (1.07–1.25)		0.97 (0.90–1.05)	1.03 (0.95–1.12)	1.05 (0.97–1.15)
Patient	1.36 (1.27–1.46)		1.13 (1.05–1.22)	0.90 (0.82–0.98)	0.88 (0.80–0.97)
Other person	1.41 (1.32–1.51)		1.15 (1.07–1.25)	1.21 (1.11–1.31)	1.22 (1.13–1.32)
Workplace borough					
Staten Island	Referent		Referent	Referent	Referent
Bronx	1.65 (1.37–1.97)		1.26 (1.17–1.83)	1.27 (1.01–1.59)	1.27 (1.01–1.60)
Brooklyn	1.43 (1.21–1.71)		1.46 (1.03–1.54)	1.27 (1.03–1.55)	1.28 (1.04–1.57)
Manhattan	1.12 (0.94–1.34)		1.26 (0.90–1.38)	1.11 (0.90–1.38)	1.11 (0.90–1.38)
Queens	1.30 (1.09–1.55)		1.11 (1.01-1.56)	1.08 (0.87–1.35)	1.08 (0.87–1.35)
Occupation					
Police	Referent			Referent	Referent

Characteristic	Unadjusted model, n = 19,909	Adjusted model 1, n = 19,904	Adjusted model 2, n = 19,904	Adjusted model 3, n = 19,904	Adjusted model 4, n = 19,904
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Correctional staff	2.75 (2.39–3.16)			2.55 (2.18–2.98)	2.55 (2.18–2.99)
Emergency medical technician	2.65 (2.35–2.97)			2.51 (2.19–2.88)	2.29 (1.95–2.69)
Traffic officer	1.98 (1.52–2.57)			2.23 (1.68–2.97)	2.06 (1.55–2.74)
Police dispatcher	2.53 (1.74–3.69)			2.04 (1.37–3.04)	1.95 (1.31–2.91)
Paramedic	1.92 (1.66–2.23)			2.07 (1.76–2.44)	1.90 (1.57–2.29)
Security guard	1.87 (1.39–2.52)			1.78 (1.29–2.46)	1.68 (1.21–2.32)
Dispatcher (Fire or EMS)	1.81 (1.40–2.34)			1.64 (1.25–2.14)	1.54 (1.17–2.02)
Firefighter	1.15 (1.05–1.25)			1.38 (1.25–1.53)	1.30 (1.15–1.46)
Other direct patient care providers†	1.12 (0.83–1.51)			1.37 (0.99–1.91)	1.32 (0.94–1.84)
Firefighter/medical first responder	0.99 (0.84–1.18)			1.12 (0.93–1.34)	1.04 (0.85–1.26)
Medicolegal death investigator	0.51 (0.33–0.79)			0.66 (0.42–1.03)	0.64 (0.41–1.00)
Aerosol-generating procedure for COVID-19 patient					
0 times	Referent				Referent
1–5 times	1.25 (1.14–1.37)				1.02 (0.91–1.14)
6–10 times	1.55 (1.34–1.79)				1.05 (0.89–1.24)
11–25 times	1.50 (1.25–1.80)				0.96 (0.78–1.17)
>25 times	1.77 (1.49–2.10)				1.02 (0.83–1.24)
Not applicable	1.11 (1.02–1.20)				1.06 (0.97–1.16)
Use of PPE within 6 feet of a person with COVID-19					
Gowns all the time	1.20 (1.11–1.29)				1.00 (0.90–1.10)
Gloves all the time	1.46 (1.36–1.56)				1.19 (1.06–1.33)
Eye protection all the time	1.36 (1.23–1.50)				1.03 (0.91–1.18)
Surgical facemask all the time	1.39 (1.30–1.49)				1.07 (0.98–1.17)
N95 respirator all the time	1.29 (1.20–1.39)				0.98 (0.88–1.09)
PAPR all the time	1.44 (1.20–1.72)				1.15 (0.94–1.42)

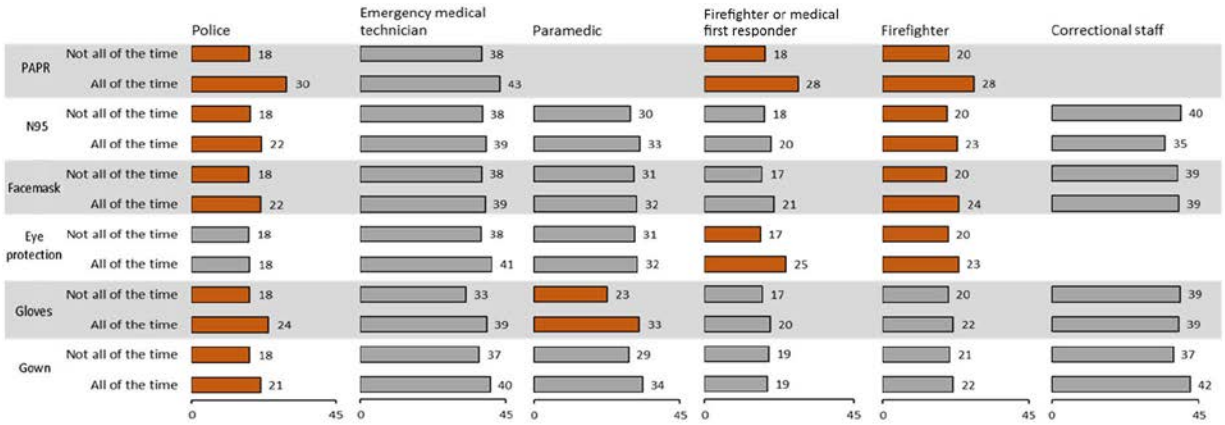
*Bold indicates significance. COVID-19, coronavirus disease; EMS, emergency medical service; OR, odds ratio; PAPR, powered air-purifying respirator; PPE, personal protective equipment.
†Other direct patient care providers include nurses, nurse assistants, physicians, midlevel clinicians, respiratory therapists, occupational therapists, speech therapists, physical therapists, therapy aides, and dentists.



Appendix Figure 1. Flowchart of eligible participants and analytic sample in study of severe acute respiratory syndrome coronavirus 2 antibodies in public safety personnel, New York City, New York, USA, May 18–July 2, 2020. PPE, personal protective equipment.



Appendix Figure 2. Percent seropositive for severe acute respiratory syndrome coronavirus 2 IgG by number of current household members in study of public safety personnel, New York City, New York, USA, May 18–July 2, 2020.



Appendix Figure 3. Percent seropositive for severe acute respiratory syndrome coronavirus 2 IgG for selected occupations, by personal protective equipment use, in study of public safety personnel, New York City, New York, USA, May 18–July 2, 2020. Red bars: Lower bound of the 95% CI for percentage positive in “all of the time” group is above the upper bound of the 95% CI for percentage positive in “not all of the time” group. Participants who reported “not applicable” were excluded. PAPR, powered air-purifying respirator.