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Factors Associated with SARS-CoV-2 Infection in Resident Physicians and Fellows in New York City During the First COVID-19 Wave

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Abstract: Risk factors for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection are not well-defined in resident physicians and fellows (trainees). We aimed to identify sociodemographic, occupational and community factors associated with SARS-CoV-2 infection among trainees during the first wave of the coronavirus disease 2019 (COVID-19) pandemic in New York City (NYC). In this retrospective cohort study, we administered an electronic survey between June 26 and August 31, 2020 to trainees at the Mount Sinai Health System in NYC to assess risk factors for SARS-CoV-2 infection between February 1 and June 30, 2020. We used Bayesian generalized linear mixed effect regression and structural equation models to examine associations. SAR-CoV-2 infection was determined by self-reported IgG antibody and reverse transcriptase-polymerase chain reaction results and confirmed with laboratory results. Among 2354 trainees invited to participate, 328 (14%) completed the survey and reported test results. The cumulative incidence of SARS-CoV-2 infection was 20.1%. Assignment to medical-surgical units (odds ratio [OR], 2.51; 95% CI, 1.18-5.34), and training in emergency medicine, critical care and anesthesiology (OR, 2.93; 95% CI, 1.24-6.92) were independently associated with infection. Deployment to care for unfamiliar patient populations was protective against infection (OR, 0.16; 95% CI, 0.03-0.73). Community factors were not significantly associated with infection after adjustment for occupational factors. Our findings may inform tailored infection prevention strategies for trainees responding to the COVID-19 pandemic.

Keywords: SARS-CoV-2; COVID-19; physician trainee; resident; fellow; risk factors

1. Introduction

New York City (NYC) was an early epicenter of coronavirus disease 2019 (COVID-19) in the U.S. [1]. Following identification of the first case in NYC on March 1, 2020, incident daily cases rose to a peak of 8,593 cases on April 10, 2020 and gradually declined to a stable incidence of approximately 300 cases per day by June 2020 [2]. Healthcare workers (HCWs) experienced early unmitigated occupational exposure to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) until approximately mid-March 2020, prior to implementation of standardized infection prevention protocols including universal masking, patient symptom screening, and ubiquitous telehealth, and before risk factors for transmission in healthcare settings were identified [3-6]. Reported risk factors for SARS-CoV-2 infection in HCWs include hospital department, healthcare profession, personal

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protective equipment (PPE) availability and use, performance of aerosol-generating procedures (AGPs), and duty hours [7]. Previously reported non-occupational (community) factors include household contacts with COVID-19 and public transportation use [7,8].

Resident physicians and fellows (trainees) may represent a vulnerable subgroup of HCWs. On average, trainees work more hours per week and have fewer years of experience compared with attending physicians [8]. Additionally, evidence suggests that trainees are at increased risk of con–tracting respiratory infections, including influenza, compared with the general population [8,9]. Data are lacking regarding risk factors for SARS-CoV-2 infection in trainees. Further, it is unclear whether assignment of trainees to unfamiliar clinical roles during the COVID-19 patient surge (hereafter referred to as "deployment") from the usual training experience is associated with infection risk [10-13].

Comprehensive approaches that consider occupational and non-occupational factors are needed to identify risk factors associated with SARS-CoV-2 infection in trainees [14,15]. In this study, we assessed sociodemographic, occupational and community risk factors for SARS-CoV-2 infection among trainees employed by a large healthcare system in NYC during the early phase of the COVID-19 pandemic.

2. Materials and Methods

2.1. Study setting and design

Following approval from the Icahn School of Medicine at Mount Sinai institutional review board, we conducted a retrospective cohort study of trainees employed by the Mount Sinai Health System, comprised of eight hospitals in NYC and Long Island, NY. All active trainees from January 1, 2020 to June 31, 2020 (n=2543) were eligible for this study (Figure 1). Contact information, training specialty, post-graduate year (PGY) and primary hospital training site were provided by the institution's Office of Graduate Medical Education. Eligible trainees were invited to participate in an online survey through email, text messages and phone calls, and were asked to retrospectively report information for the period between February 1, 2020 and June 30, 2020. The survey collected information regarding sociodemographic, occupational and community factors hypothesized to be associated with SARS-CoV-2 infection (Figure 2). Additionally, self-reported results of serum IgG antibody and reverse transcriptase-polymerase chain reaction (RT-PCR) tests for SARS-CoV-2 were collected. Self-reported results were confirmed with laboratory data from Mount Sinai's COVID-19 Employee Health Services registry. Testing was available at no cost to all employees on a voluntary and uncompensated basis. Written informed electronic consent was obtained from all participants.

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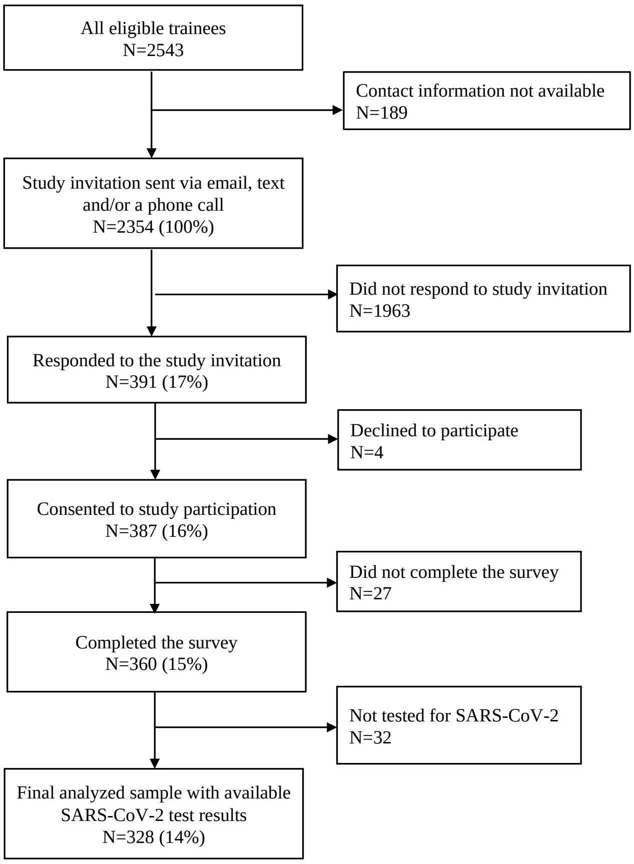

Figure 1. Flow chart of participant recruitment and survey responses.

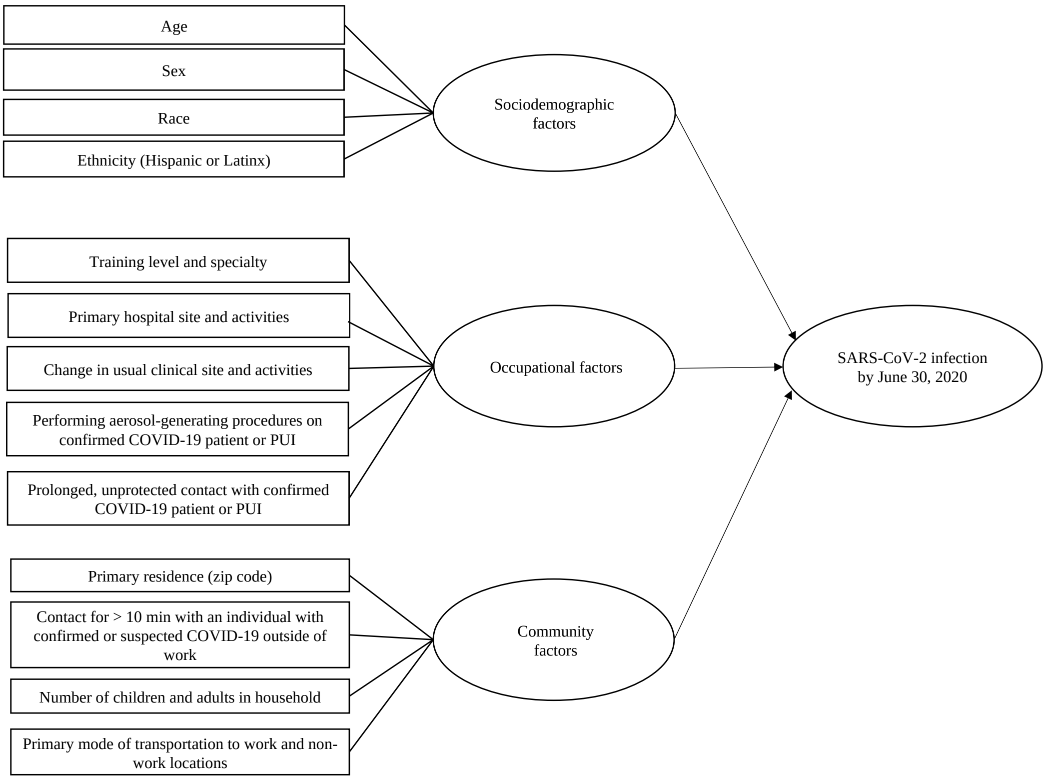

Figure 2. Risk factors hypothesized to be associated with SARS-CoV-2 infection in physician trainees.

2.2. Participant enrollment and survey response

2354 eligible trainees with valid contact information were invited to participate through email and text message links to the electronic consent and survey on June 26, 2020. Up to five reminder invitations were sent to non-responders through August 31, 2020. Of those initially contacted, 391 trainees (17%) responded to the invitation and 360 (15%) completed the survey (Figure 1).

To increase participation and to promote equitable representation of trainees from all affiliated hospitals, a subset of eligible trainees (n=281, 11%) selected using proportionate random sampling and stratified by hospital within the Mount Sinai Health System. Valid contact information was available for 267 selected trainees, of whom 72 (27%) consented to participate in the study. The randomly selected sample with a higher response rate was used to ascertain potential selection bias in the overall study sample.

2.3. Institutional process for employee COVID-19 testing

On March 6, 2020, Mount Sinai's Employee Health Services (EHS) established an online registry for employees to voluntarily report high-risk exposures and daily symptoms of COVID-19. Healthcare providers counseled registered employees on symptom monitoring and coordinated testing and clearance for return to work. RT-PCR swabs and IgG antibody testing were available to all symptomatic employees on April 7, 2020, and to asymptomatic employees by May 6, 2020. Sensitivity and specificity of the Mount Sinai Hospital Clinical Laboratory COVID-19 ELISA antibody test is 92.5% (95% CI: 80.1%-97.4%) and 100% (95% CI: 95.1-100%), respectively [16]. Sensitivity and specificity of the Roche Cobas RT-PCR test offered is 100% [17].

2.4. Assessment of SARS-CoV-2 infection

We ascertained SARS-CoV-2 infection status by self-reported test results and categorized the results as positive (by IgG antibodies, RT-PCR, or both), negative (by IgG antibodies, RT-PCR, or both) or never tested. To reduce the likelihood of differential misclassification bias,[18] we excluded participants who denied testing at the time of survey completion, and for whom there was no record of an IgG antibody result through July 15, 2020 in the EHS COVID-19 registry (n=32). Among a subset of 199 participants who consented to review of test results, there was 100% agreement between self-reported and laboratory-confirmed results.

2.5. Assessment of potential risk factors for SARS-CoV-2 infection

The survey collected information regarding sociodemographic, occupational and community factors hypothesized to be associated with SARS-CoV-2 infection (Figure 2). The complete survey is available in Supplemental Table 1. Occupational factors included department of work during the study period, exposure to patients with confirmed or suspected (i.e., persons under investigation or PUI) SARS-CoV-2 infection, unprotected contact (without N95, eye shield, gown, or gloves) with confirmed cases or PUI, performing or attending AGPs, and factors related to deployment. Deployment was defined as a temporary assignment away from usual clinical duties to assist in the COVID-19 surge response, which could have required relocation to an affiliated but unfamiliar hospital within the health system, department, or change in usual patient population. For the analysis, we categorized trainees by specialty including 1) primarily non-procedural specialties, 2) high-risk, primarily procedural specialties and 3) surgical specialties (Supplemental Table 2).

Community factors assessed included primary residence (zip code), contact for more than 10 minutes with an individual with confirmed or suspected COVID-19 outside of work, number of adults and children in household, and primary mode of transportation to work and non-work locations.

2.6. Statistical analysis

Sociodemographic, occupational and community variables were compared between groups using Fisher's exact test for categorical variables and the Wilcoxon rank-sum test for continuous variables. Variables with a p-value < 0.30 in the bivariate analysis were included in Bayesian Generalized Linear Mixed Effect Regression (BGlmer) to estimate the adjusted odds of SARS-CoV-2 infection. We used BGlmer to stabilize estimates for predictors with zero or small numbers of observations in specified subgroups according to SARS-CoV-2 infection status.[19] We first tested associations in BGlmer models that were separately adjusted for sociodemographic factors (Model 1), occupational factors (Model 2) and community factors (Model 3). To control for over-adjustment, variables with a p-value < 0.30 after backward elimination in the BGlmer model were retained in the final adjusted models. Finally, the model was simultaneously adjusted for sociodemographic, occupational and community factors (Model 4) to test whether associations remained robust in a fully adjusted BGlmer model.

We used Structural Equation Models (SEMs) to evaluate associations of sociodemographic, occupational and community factors with SARS-CoV-2 infection. Three unobserved latent sociodemographic, occupational and community functions were estimated using variables associated with SARS-CoV-2 infection in the BGlmer analysis (Table 2) and regressed to SARS-CoV-2 test result (Table 3). All SEMs were fitted using diagonally weighted least squares and a probit link function.[20] The root mean square error of approximation (RMSEA) for the final SEMs was < 0.05.

Sensitivity analyses included: 1) exclusion of trainees with RT-PCR test results but no IgG antibody results (n=314); 2) model adjustment for date of the SARS-CoV-2 test if available (n=186); and 3) comparison of main characteristics between the analysis population (n=328), the trainees from the randomly selected sample who reported SARS-CoV-2 test results (n=62), and all initially eligible trainees (n=2543). All statistical analyses were conducted using R version 3.6.1. Missing data for covariates (approximately 1%) were imputed using random forests with the Multivariate Imputation by Chained Equations R package [21]. The SEM analysis was conducted using the "lavaan" R package [22].

3. Results

3.1. Participant characteristics

Participants were of median (IQR) age 31 (29-33) years. Most identified as female (58% vs. 42% male), White (62% vs. 25% Asian, 8% Black and 4% other race), and non-Hispanic/Latinx (89% vs. 10% Hispanic/Latinx) (Table 1). Sixty trainees (18%) reported deployment to a different hospital from their primary training site during the COVID-19 patient surge, 21% reported a change in primary clinical duties, 25% reported a department change, 12% reported greater time spent on telemedicine compared with usual clinical activities, and 10% reported a change in usual patient population (e.g., from pediatrics to adult patients).

Table 1. Sociodemographic, occupational and community risk factors by SARS-CoV-2 test status.

Variable	Negative SARS-CoV-2 test (n = 262)	Positive SARS-CoV-2 test (n = 66)	*P*-value
Sociodemographic factors			
Age, years, median (IQR)	31 (29-33)	30 (28-33)	0.36
Sex, no. (%)			0.27
Female	155 (82)	34 (18)	
Male	107 (77)	32 (23)	
Race, no. (%)			0.25
White	156 (77)	46 (23)	
Asian	71 (87)	11 (13)	
Black	19 (73)	7 (27)	
Other	10 (83)	2 (17)	
Missing	6	0	
Hispanic/Latinx, no. (%)			0.18
No	237 (81)	56 (19)	
Yes	24 (71)	10 (29)	
Missing	1	0	
Occupational factors			
Training specialty, no. (%)			0.002
Hospital-based, primarily non-procedural	180 (85)	33 (15)	
High-risk procedural	32 (62)	20 (38)	
Surgical	41 (77)	12 (23)	
Missing	9	1	
PGY level, no. (%)			0.57
1	55 (75)	18 (25)	
2	51 (82)	11 (18)	
≥3	156 (81)	37 (19)	

Resident or fellowship, no. (%)			0.88
Fellowship	69 (81)	16 (19)	
Residency	193 (79)	50 (21)	
Primary hospital site, no. (%)			0.27
Beth Israel Medical Center	23 (82)	5 (18)	
Elmhurst Hospital Center	15 (100)	0 (0)	
Institute for Family Health	4 (67)	2 (33)	
Mount Sinai Hospital	166 (79)	45 (21)	
North Central Bronx	1 (100)	0 (0)	
Queens Hospital Center	6 (86)	1 (14)	
South Nassau Communities Hospital	2 (50)	2 (50)	
St. Luke's Roosevelt Hospital	45 (80)	11 (20)	
Occupational setting			
Medical-surgical unit, no. (%)			0.24
No	89 (84)	17 (16)	
Yes	173 (78)	49 (22)	
Emergency department, no. (%)			0.64
No	194 (80)	47 (20)	
Yes	68 (78)	19 (22)	
ICU, no. (%)			>0.99
No	154 (80)	39 (20)	
Yes	108 (80)	27 (20)	
Ambulatory clinic, no. (%)			0.04
No	174 (77)	53 (23)	
Yes	88 (87)	13 (13)	
Telemedicine, no. (%)			0.047
No	181 (77)	54 (23)	
Yes	81 (87)	12 (13)	
High-risk occupational exposures			
Direct care for confirmed COVID-19 case or PUI, no. (%)			0.29
No	33 (87)	5 (13)	
Yes	229 (79)	61 (21)	
Performed or attended an AGP on confirmed COVID-19 case or PUI, no. (%)			0.05

No	127 (85)	23 (15)	
Yes	134 (76)	43 (24)	
Missing	1	0	
Contact > 10 mins with confirmed *without N95* COVID-19 case or PUI, no. (%)			0.07
No	182 (83)	37 (17)	
Once	42 (76)	13 (24)	
Twice or more	36 (69)	16 (31)	
Missing	2	0	
Contact > 10 mins *without eye protection* with confirmed COVID-19 case or PUI, no. (%)			0.09
No	155 (83)	31 (17)	
Once	44 (80)	11 (20)	
Twice or more	61 (72)	24 (28)	
Missing	2	0	
Contact > 10 mins *without gown* with confirmed COVID-19 case or PUI, no. (%)			0.01
No	174 (84)	32 (16)	
Once	37 (77)	11 (23)	
Twice or more	48 (68)	23 (32)	
Missing	3	0	
Contact > 10 mins *without gloves* with confirmed COVID-19 case or PUI, no. (%)			0.12
None	225 (81)	52 (19)	
Once or more	34 (71)	14 (29)	
Missing	3	0	
Deployment factors			
Change in usual hospital, no. (%)			0.59
No	212 (79)	56 (21)	
Yes	50 (83)	10 (17)	
Change in usual clinical activities, no. (%)			0.87
No	206 (80)	53 (20)	

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Yes	56 (81)	13 (19)	
Change in usual patient population, no. (%)			<0.001
No	230 (78)	66 (22)	
Yes	32 (100)	0 (0)	
Change in usual department, no. (%)			0.34
No	193 (78)	53 (22)	
Yes	69 (84)	13 (16)	
More time on telemedicine than usual, no. (%)			0.05
No	226 (78)	63 (22)	
Yes	36 (92)	3 (8)	
Community factors			
Primary residence, no. (%)			0.06
Manhattan	202 (77)	60 (23)	
Queens	28 (93)	2 (7)	
Brooklyn	12 (100)	0 (0)	
Bronx	5 (100)	0 (0)	
Outside of NYC	13 (76)	4 (24)	
Missing	2	0	
Contact > 10 mins with individual confirmed or suspected COVID-19 outside of work, no. (%)			0.008
No	212 (83)	43 (17)	
Yes	50 (68)	23 (32)	
Number of adults in household, no. (%)			0.64
1 (self)	72 (82)	16 (18)	
≥ 2	189 (79)	50 (21)	
Missing	1	0	
Number of children in household, no. (%)			0.19
0	214 (78)	59 (22)	
≥ 1	46 (87)	7 (13)	
Missing	2	0	
Primary mode of transportation to work			

Public transit (subway or bus), no. (%)			0.32
No	165 (82)	37 (18)	
Yes	97 (77)	29 (23)	
Cab or rideshare, no. (%)			0.37
No	183 (81)	42 (19)	
Yes	79 (77)	24 (23)	
Private vehicle, bicycle or walking, no. (%)			0.86
No	53 (82)	12 (18)	
Yes	209 (79)	54 (21)	
Primary mode of transportation to non-work location			
Public transit (subway or bus), no. (%)			0.07
No	220 (82)	49 (18)	
Yes	42 (71)	17 (29)	
Cab or rideshare, no. (%)			0.049
No	220 (82)	48 (18)	
Yes	42 (70)	18 (30)	
Private vehicle, bicycle or walking, no. (%)			0.08
No	12 (63)	7 (37)	
Yes	250 (81)	59 (19)	

Abbreviations: IQR, interquartile range; PGY, post-graduate year; PUI, patient under investigation (suspected to be positive for SARS-CoV-2 and pending laboratory result); ICU, intensive care unit; AGP, aerosol-generating procedure.

3.2. SARS-CoV-2 infection

The cumulative incidence of SARS-CoV-2 infection by June 30, 2020 was 20.1%. Of the 66 (20.1%) participants who tested positive for SARS-CoV-2 during the study period, 71% (n=47) were positive by IgG antibodies, 26% (n=17) were positive by both IgG antibodies and RT-PCR and 3% (n=2) were positive by RT-PCR only (Supplemental Table 3).

3.3. Sociodemographic factors and SARS-CoV-2 infection

SARS-CoV-2 infection was more common among males (23% vs. 18% females; P=0.268), Hispanic/Latinx trainees (29% vs 19% non-Hispanic/Latinx; P=0.18) and least common among Asian trainees (13% vs. 17%-27% for other races, P=0.25) (Table 1). After multivariable adjustment, the odds of infection were increased among Hispanic and Latinx trainees compared with non-Hispanic or Latinx trainees (fully adjusted Model 4: OR, 1.98; 95% CI, 0.72-5.46) (Table 2).

Table 2. Adjusted effect estimates for associations of sociodemographic, occupational and community factors with SARS-CoV-2 infection.

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Variable	Model 1: Sociodemographic factors		Model 2: Occupational factors		Model 3: Community factors		Model 4: Final adjusted model	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Race								
White (ref)	1.00	-					1.00	-
Asian	0.53	0.23, 1.24					0.53	0.24, 1.15
Black	1.34	0.45, 3.98					1.42	0.50, 4.01
Other	0.43	0.08, 2.47					0.64	0.14, 2.92
Hispanic/Latinx								
No (ref)	1.00	-					1.00	-
Yes	2.18	0.73, 6.47					1.98	0.72, 5.46
Change in usual patient population								
No (ref)			1.00	-			1.00	-
Yes			0.09	0.01, 0.67			0.16	0.03, 0.73
Medical/surgical unit								
No (ref)			1.00	-			1.00	-
Yes			2.96	1.27, 6.91			2.51	1.18, 5.34
Ambulatory clinic								
No (ref)			1.00	-			1.00	-
Yes			0.53	0.24, 1.17			0.61	0.29, 1.30
Contact > 10 mins *without N95* with confirmed COVID-19 case								
Never (ref)			1.00	-			1.00	-
Once			1.47	0.62, 3.48			1.24	0.55, 2.75
Twice or more			1.72	0.75, 3.94			1.59	0.74, 3.43
Training specialty								
Hospital-based, primarily non-procedural (ref)			1.00	-			1.00	-
High-risk procedural			4.29	1.62, 11.33			2.93	1.24, 6.92
Surgical			1.98	0.81, 4.89			1.51	0.65, 3.50
Number of children in household								

0 (ref)	1.00	-	1.00	-
≥ 1	0.52	0.20, 1.38	0.59	0.23, 1.48
Contact > 10 mins with individual confirmed or suspected COVID-19 outside of work				
No (ref)	1.00	-	1.00	-
Yes	2.38	1.14, 4.98	1.58	0.78, 3.17
Primary mode of transportation to location other than work: ***public transit (subway or bus)***				
No (ref)	1.00	-	1.00	-
Yes	2.25	1.01, 5.01	1.85	0.85, 3.99
Primary mode of transportation to location other than work: ***private vehicle, bicycle, walking***				
No (ref)	1.00	-	1.00	-
Yes	0.44	0.14, 1.40	0.42	0.14, 1.27
Primary residence (zip code)				
Manhattan (ref)	1.00	-	1.00	-
Queens	0.24	0.06, 0.94	0.34	0.10, 1.20
Brooklyn	0.21	0.03, 1.64	0.30	0.06, 1.62
Bronx	0.40	0.04, 3.98	0.48	0.08, 3.08
Outside of NYC	1.48	0.40, 5.49	1.51	0.44, 5.20

Abbreviations: OR, odds ratio; CI, confidence interval; ref, reference.

3.4. Occupational factors and SARS-CoV-2 infection

The adjusted odds of SARS-CoV-2 infection were increased for trainees in high-risk, primarily procedural specialties including EM, critical care and anesthesiology (OR, 2.93; 95% CI, 1.24-6.92), and for trainees who reported working on inpatient medical-surgical units (OR, 2.51; 95% CI, 1.18-5.34) (Table 2). Deployment to care for unfamiliar patient populations was associated with decreased odds of infection (OR, 0.16; 95% CI, 0.03-0.73).

Assignment to work in an emergency department (ED) or intensive care unit (ICU), independent of deployment, was not statistically significantly associated with infection in the bivariate analysis. Similarly, SARS-CoV-2 infection was less frequent among trainees who worked in ambulatory clinics and on telemedicine compared to those who reported never working in these settings, whereas infection more likely among trainees who performed AGPs and who reported at least once instance of unprotected contact without N95, eye shield, gown, or gloves for over 10 minutes with a confirmed COVID-19 patient or PUI (Table 1). However, these associations were attenuated and not statistically significant after adjustment for other occupational factors (Table 2).

3.5. Community factors and SARS-CoV-2 infection

After multivariable adjustment for community factors (Table 2, Model 3), contact for more than 10 minutes with an individual with confirmed or suspected COVID-19 outside of work (OR, 2.38; 95% CI, 1.14-4.98), and use of public transit (subway or bus) as the primary mode of transportation to non-work locations (OR, 2.25; 95% CI, 1.01-5.01) were associated with increased odds for infection. Primary residence in boroughs of NYC outside of Manhattan was associated with decreased odds of infection in the bivariate analysis, however, associations of community factors with SARS-CoV-2 infection were attenuated and not statistically significant after adjustment for occupational factors (Table 2, Model 4).

3.6. Structural equational model

The SEM analysis (Table 3) produced concordant results with the multivariable adjusted regression (Table 2). The likelihood of SARS-CoV-2 infection was statistically significantly increased with an overall increased in the latent function of occupational factors. This association remained after adjustment for sociodemographic and community latent functions (adjusted SEM estimate 0.35; 95% CI, 0.15-0.54). The magnitude of the associations of sociodemographic and community factors with SARS-CoV-2 infection was attenuated and not statistically significant compared with occupational factors.

Table 3. Adjusted effect estimates for associations of sociodemographic, occupational and community latent functions with SARS-CoV-2 infection.

Exposure latent functions	SEM 1[a]		SEM 2[b]		SEM 3[c]		SEM 4[d]	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Sociodemographic factors	0.09	-0.07, 0.25					0.13	-0.06, 0.31
Occupational factors			0.33	0.13, 0.53			0.35	0.15, 0.54
Community factors					0.12	-0.08, 0.32	0.10	-0.12, 0.33

Abbreviations: SEM, structural equation model; OR, odds ratio; CI, confidence interval.

[a]SEM 1 adjusted for the latent function of sociodemographic factors

[b]SEM 2: adjusted for the latent function of occupational factors

[c]SEM 3: adjusted for the latent function of community factors

[d]SEM 4: simultaneously adjusted for all latent functions

3.7. Sensitivity analysis

Associations in the multivariable adjusted models remained statistically significant after excluding trainees with RT-PCR results but who did not report IgG antibody results, and after adjustment for the date of the SARS-CoV-2 test (Supplemental Table 4). Trainees based at Mount Sinai Hospital, the largest of all affiliated sites, were overrepresented in the analysis sample (64% vs. 55% among all initially eligible trainees). We did not observe additional statistically significant differences between the final analysis sample compared with eligible trainees, or with the randomly selected sample (Supplemental Table 5).

4. Discussion

In this study of physician trainees in a large NYC-based healthcare system, assignment to inpatient medical-surgical units and training in high-risk procedural specialties, including EM, anesthesiology, and critical care, were statistically significantly associated with SARS-CoV-2 infection. Assignment to unfamiliar hospital sites or clinical responsibilities was not associated with SARS-CoV-2 infection, and assignment to unfamiliar patient populations was associated with decreased risk of infection, suggesting that deployment of trainees was a safe mitigation strategy during the first wave of COVID-19 in NYC. Associations of community factors and SARS-CoV-2 infection were not statistically significant after adjustment for occupational factors, indicating that infection in trainees was largely attributable to occupational exposures.

The cumulative incidence of SARS-CoV-2 infection by June 30, 2020 was 20.1%, similar to reported seroprevalences in other HCW subgroups and the general population of NYC during this period [23,24]. The NYC Department of Health and Mental Hygiene reported a 22.7% seroprevalence among 5101 grocery store customers tested between April 19-28, 2020, suggesting that the prevalence of SARS-CoV-2 infection among trainees did not exceed the frequency of infections in the general population of NYC during the initial COVID-19 wave [25].

In this study, assignment to inpatient medical-surgical units was a statistically significant risk factor for SARS-CoV-2 infection, contrary to prior studies of HCWs, in which the minority (less than 10%) were physicians [23,24]. Medical-surgical units may have been less familiar to trainees who, prior to the COVID-19 pandemic, spent a greater proportion of duty hours in ambulatory care sites, or in operating rooms or procedural environments. Among trainees from surgical and primary care specialties, decreased familiarity with routine infection prevention protocols specific to medical-surgical units may further explain our findings. Additionally, caring for PUI in medical-surgical units may have diminished the urgency of adherence to optimal infection prevention protocols, compared with caring for confirmed COVID-19 patients. Finally, working in an ED or ICU was not associated with SARS-CoV-2 infection in this study, consistent with prior reports of HCWs in the greater New York area [23,24].

Trainees in high-risk procedural specialties were at increased risk for SARS-CoV-2 infection in this study, consistent with prior studies. Breazzano et al. reported a higher frequency of SARS-CoV-2 infections among trainees in EM and anesthesiology compared with other specialties [10]. Trainees in EM, anesthesiology and critical care routinely perform endotracheal intubation, and likely had unmitigated exposure to aerosolized virus from undiagnosed COVID-19 patients early in the study period, prior to implementation of routine infection prevention protocols [26-28].

Deployment to unfamiliar hospital sites and clinical responsibilities was not a statistically significant risk factor for SARS-CoV-2 infection, despite limited time for patient surge planning [14,15]. Moreover, we found that deployment to care for unfamiliar patient populations was associated with decreased adjusted odds of infection. Among survey respondents, pediatrics trainees most frequently reported a patient population change, most commonly to care for adult patients in ED or ICU environments. Deployment strategies differed according to department in the Mount Sinai Health System, and the Department of Pediatrics and Mount Sinai Hospital deployed trainees on a voluntary basis. It is plausible that trainees who cared for unfamiliar patient populations may have performed more administrative tasks and had fewer instances of direct patient care, thus reducing direct exposures and SARS-CoV-2 transmission risk.

Use of public transportation, particularly use of the subway or bus, was associated with increased risk of SARS-CoV-2 infection, similar to prior reports of HCWs [10, 29].

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Our findings suggest that community exposure, defined by area of residence, use of transportation and direct contact with individual with suspected or confirmed COVID-19 outside of work, may contribute to infection risk among NYC-based trainees, albeit less significantly than occupational exposures.

Strengths of our study include collection of robust data directly from physician trainees pertaining to both occupational and community exposures in NYC, an early epicenter of COVID-19 in the U.S. Associations of occupational factors and SARS-CoV-2 infection are strengthened by our ability to verify self-reported test results with laboratory-confirmed data. Additionally, results of a sensitivity analysis indicate similar sociodemographic characteristics among all eligible trainees, the randomly selected subset, and study participants in the analysis sample, suggesting reduced likelihood of selection bias. The limitations include the retrospective design and the potential for measurement error pertaining to trainees who reported having been tested for SARS-CoV-2 without results available for review in the EHS registry, indicating that testing may have been performed outside of the Mount Sinai Health System. The sensitivities and specificities of external tests were unknown and may differ from tests performed at our institution. Finally, underestimation of the cumulative incidence of SARS-CoV-2 infection is possible if participants were infected but asymptomatic and never tested. Finally, results may not be generalizable to trainees outside of NYC, as hospital infection prevention protocols and community transmission vary by geographic location.

5. Conclusions

Among physician trainees at a large healthcare system situated in an early U.S. epicenter of COVID-19, assignment to medical-surgical units and training in high-risk procedural specialties were most robustly associated with SARS-CoV-2 infection, out of a comprehensive list of occupational, community and sociodemographic factors assessed. Assignment to unfamiliar or non-routine hospital sites or clinical responsibilities was not associated with SARS-CoV-2 infection, and assignment to unfamiliar patient populations was noted to be protective, suggesting that deployment was a safe mitigation strategy during the initial wave of COVID-19. Our findings can inform more tailored infection prevention strategies for trainees during the COVID-19 pandemic.

Supplementary Materials: The following are available online at www.mdpi.com/xxx/s1, Table S1: Survey instrument to assess risk factors hypothesized to be associated with SARS-CoV-2 infection in trainees from February 1 through June 30, 2020; Table 2: Categorization of trainees who responded to the online survey between June 26, 2020 and August 31, 2020; Table 3: Self-reported SARS-CoV-2 test results; Table 4: Comparison of main characteristics between study participants (n=328), the randomly selected sample (n=62) and all initially eligible trainees (n=2543); Table 5: Sensitivity analysis

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Institutional Review Board of the Icahn School of Medicine at Mount Sinai (Reference: IRB-20-03850) on June 19, 2020.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available by request from the corresponding author. The data are not publicly available due to privacy restrictions.

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