

COVID-19 Serology Analysis Among Universities

**Bureau of
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Executive Summary

Background

COVID-19 was first identified in Pennsylvania on March 6, 2020 and has caused widespread transmission over multiple waves through the fall of 2021. The initial wave of the pandemic in the spring of 2020 heavily affected residents and staff in long-term care facilities and healthcare personnel working in acute care settings where COVID-19 patients presented for evaluation and care. The first wave also included workers in the agricultural sector and other professions where employees worked in close proximity with each other or the public and had limited ability to work remotely.

The second wave of cases began in the early fall of 2020 where several universities seeded large community outbreaks as students returned to campus and resumed academic, athletic, and social activities. The fall wave continued into the winter and recorded the highest burden of case counts for the state at the same time when the first vaccines became available. Vaccine administration initially focused on the long-term care environment, essential workers, and other people at higher risk for severe disease and began being offered to college aged healthy adults in March of 2021. By April, all adults ages 18 and older became eligible to receive COVID-19 vaccine. Initial vaccination efforts, universal masking, and continued social distancing were working to decrease case counts as the winter progressed, however as warmer weather returned and vaccine supply continued to not meet demand, cases began to increase in March and April causing a significant 3rd wave. By July of 2021 in Pennsylvania, most people seeking vaccine had received their series, case counts fell to early pandemic lows and social distancing and masking were relaxed on a wide scale.

As the summer of 2021 progressed, large waves of cases predominated by variant strains spread throughout areas of the world and southern United States. To assess ongoing risk for community spread of SARS-CoV-2, the Pennsylvania Department of Health Bureau of Epidemiology (BOE) has been tracking previous infection and response to vaccination through antibody testing and administering questionnaires among select populations of interest. The Bureau has identified students and staff at major universities as populations for introduction and transmission of SARS-CoV-2 due to the nature of academic learning (athletic, health professional, international and performing arts programs), dormitory living, recent travel and social behaviors that undermine disease control and prevention recommendations.

In February of 2021, the BOE through its Serology Workgroup developed a protocol describing three main objectives:

1. Estimate the seroprevalence of SARS-CoV-2 among high-risk populations associated with universities in Pennsylvania and identify those with previous infection or vaccination.
2. Identify community and work-related behaviors that may have led to protection from infection among those without antibodies compared to those with antibodies.

3. Follow a cohort of antibody positive students and staff to assess occurrence of future infection and transmission to advise infection prevention and control management for such populations in the future.

A full protocol for recruitment, attaining consent, sample collection, laboratory analyses, and questionnaire data collection and management was developed and received approval from the Pennsylvania Department of Health Institutional Review Board (IRB). In addition, the Serology Workgroup also engaged the Centers for Disease Control and Prevention (CDC) serology task force through the Region 3 Liaison Officer of the COVID-19 Emergency Response group to review existing literature and help refine the objectives considerate of other similar studies occurring in other states.

Summary of Findings

In March and April 2021, BOE collected a total of 790 serum samples from staff and students across four universities in Philadelphia and Allegheny Counties to measure the presence of SARS-CoV-2 IgG antibodies. In addition, a total of 408 follow-up questionnaires were completed by participants that measured behaviors, perceptions, and attitudes that may impact their risk of contracting or transmitting COVID-19 and collected information on previous COVID-19 infection, hospitalization, or known exposure. Key findings from this sample are summarized below:

1. Among all study participants, 29.0% were fully vaccinated at the time samples were collected and 42.4% were unvaccinated. Staff were significantly more likely to have received at least one dose of vaccine than students (OR=3.75, 95% CI: [2.25-6.27]).
2. Across all 4 university sites, over two thirds of participants (67.2%) were positive for IgG antibodies. Among fully vaccinated participants, 98.7% were positive and among unvaccinated participants, 31.7% were positive for IgG antibodies.
3. Among students who did not yet receive a COVID-19 vaccine, 44.4% expressed some hesitancy towards the vaccine and among staff who did not yet receive a COVID-19 vaccine, 84.4% expressed some hesitancy. Importantly, this large discrepancy may be due in part to the fact that staff who were willing to receive vaccine were more likely to have already been vaccinated at the time of this study than students who were willing to receive vaccine.
4. Being an athlete and agreeing they are “not really worried about COVID-19 because they won't get severely ill” were associated with higher odds of reporting a previous COVID-19 infection among students (OR= 6.49, 95% CI: [2.47-17.08] and OR= 2.60, 95% CI: [2.60-6.40], respectively).
5. Students who reported "always" wearing a mask outside of their home had lower odds of reporting a previous COVID-19 infection on the online questionnaire compared to

students who reported wearing masks “sometimes” or “never” (OR=0.25,95% CI: [0.10-0.61]).

6. Among staff, those who were coaches had higher odds of reporting a previous COVID-19 infection (OR=8.16 95% CI: [1.53-43.61]). Staff who wore glasses or agreed that "wearing masks can prevent you from getting COVID-19" had lower odds of reporting a previous COVID-19 infection (OR=0.34, 95% CI: [0.13-0.88] and OR=0.37, 95% CI: [0.15-0.92], respectively).
7. Unvaccinated students who reported they were "not really worried about getting COVID-19 because they won't get severely ill" had higher odds of being positive for IgG antibodies (OR=3.37, 95% CI: [1.14-9.96]) while unvaccinated students who agreed that "keeping a physical distance of more than 6 feet can reduce the risk of COVID-19" had lower odds of being positive for antibodies (OR=0.19, 95% CI: [0.04-0.97]).
8. Unvaccinated staff who had direct contact with patients as part of their work, school, or internship responsibilities had higher odds of being positive for IgG antibodies than unvaccinated staff who did not have direct contact with patients (OR=47.2, 95% CI: [1.44-462.11]).

Staff and students at urban universities in Pennsylvania had considerably higher rates of infection with COVID-19 determined through antibody testing compared to case reports among the general public received through disease surveillance activities and likely contributed to community transmission. Athletic programs and health professional programs where students have direct contact with patients were associated with higher rates of infection and therefore should have more stringent and targeted disease control recommendations moving forward (testing, vaccination, mask wearing, and limiting social interactions). Student attitudes identified less concern for personal safety as many felt COVID-19 did not pose a significant health risk, therefore disease control messaging in this sector should highlight their role in community transmission and stress the importance to limit transmission to protect seniors and other people who are at greater risk for severe disease. Universities have long been known to be associated with outbreaks of infectious diseases (e.g., mumps, meningococcus) due to many factors including dormitory living, clinical education, sporting activities and social behaviors. This analysis highlights these associations related to COVID-19 and are applicable to inform disease control activities when in-person learning is occurring and COVID-19 transmission continues locally and internationally.

Methods

Recruitment of Universities

BOE targeted large universities for participation that had diverse academic programs, resources, and activities that may place certain students or staff at higher risk for transmission of COVID-19 including health professions, athletics, performing arts, student populations that resided in dormitories, Greek life, and international student programs. To recruit these sites, BOE staff contacted student health directors and county municipal health departments in the state's two largest urban areas, Philadelphia, and Pittsburgh. These efforts were successful in recruiting four universities to participate. A medical professional from each university signed and submitted the medical standing order for the antibody test and each institution created a user account in the Bureau of Laboratories (BOL) Lab Web Portal (LWP) to order tests and receive results.

Participant Recruitment and Consent

All staff, faculty, and students currently enrolled at each university site were eligible to participate in the study. Recruitment was done in partnership with directors of student health who issued email invitations to large populations of students and staff that included a QR (Quick Response) code that linked to an online questionnaire through Microsoft™ Forms where people could self-register for the antibody test 2-3 weeks before the scheduled blood collection activities. Registered students and staff received instructions on blood collection clinic details over email and flyers were posted at each university on the day of sampling to invite additional students and staff to participate. Participant consent forms were issued and signed on-site prior to study enrollment. In addition to collecting consent to participate in the study, these forms also collected participant contact information, date of birth, gender, and race/ethnicity. Consent forms and study protocols were approved by the Department's IRB.

Data Collection, Sample Collection and Results Management

Volume of students and staff who pre-registered at each university was used to develop the blood collection field team structure on each day. Registration, line management and specimen processing staff were provided from the Allegheny County Health Department and Epidemiology Research Associates located in the Southwest District Office. Nurse phlebotomists were provided by a staff augmentation agency GHR (General Healthcare Resources) and the Department's Bureau of Community Health Systems. Overall medical direction was provided on site by the BOE COVID-19 Medical Epidemiologist.

Once consent was completed and participants were enrolled in the study, staff collected information about participants' COVID-19 vaccine history (dates of dose(s), and product) by asking to see their vaccination card or by self-report. These data were recorded by study staff on paper and were later entered into an Excel document. After vaccine history was attained, a blood draw was taken for the detection of SARS-CoV-2 IgG antibodies in serum. All samples were centrifuged within 2 hours of collection on site, refrigerated, and delivered to BOL within

40 hours after collection. Samples were processed using the EUROIMMUN Anti-SARS-CoV-2 enzyme-linked immunosorbent assay (ELISA) to detect IgG antibodies to spike protein.

Results of the antibody tests were distributed over secure email to all participants with an updated fact sheet and an invitation to speak to the COVID-19 Medical Epidemiologist over defined office hours if there were questions about how to interpret their results. Individuals who were unable to access their results were referred by student health or reached out directly to the dedicated resource account for this study. Finally, a link to an online 30-item questionnaire (hosted on Microsoft™ Forms) was also distributed to all participants within the secure email results communication. This questionnaire collected information on behaviors, perceptions, and attitudes that may impact risk of contracting COVID-19. Reminder emails were sent two weeks later to encourage more participants to complete the questionnaire.

Statistical Analysis

Questionnaire data, laboratory data, and participant registration data were analyzed using SAS Enterprise Guide, version 7.1 software (SAS Institute Inc., Cary, NC, USA). Descriptive statistics were calculated to summarize participant demographics by study site, antibody results by participant vaccination status, and student and staff questionnaire response data. Chi-square tests or Fisher Exact tests were done to determine whether categorical variables from the questionnaire varied by site and Kruskal-Wallis tests were used to determine whether continuous variables varied by site.

To measure whether certain variables were associated with a previous COVID-19 diagnosis among all study participants or with positive antibody results among unvaccinated participants, multilevel models with a random intercept to account for clustering by study site were used. Models measured associations between behaviors, perceptions, or attitudes that may impact risk of COVID-19 (measured via online questionnaires) and 1) whether participants reported a previous COVID-19 diagnosis (also via online questionnaires) or 2) whether participants were positive for SARS-CoV-2 IgG antibodies (only unvaccinated participants were included in these analyses). In addition, multilevel models were also developed to determine whether staff were more likely to have received at least one dose of COVID-19 vaccine than students. Models were developed using the GLIMMX procedure in SAS Enterprise Guide (7.1). Results of multilevel models are presented for both unadjusted (only adjusted for university site as a random intercept) and adjusted models (also adjusted for gender, age, race/ethnicity as fixed effects). Those with missing data were excluded from analyses (listwise deletion) although for most analyses missing data accounted for less than 10% of the total available data. Results were not reported for variables with complete separation of the outcome variable or where model convergence could not be achieved.

Findings

Demographics by Study Site

In total, 790 serology results were gathered from the four university sites and 408 questionnaires were completed. Table 1 summarizes demographic information, serology results, and vaccination status among participants from each of the university sites. University D had the highest number of samples collected (n=357) and questionnaires completed (N=182) while University B had the lowest number of samples collected (N=125) and University C had the lowest number of questionnaires completed (N=67). Over half of participants were students (50.8%). A larger proportion of study participants from University A were students (97.4%) when compared to other sites and a larger proportion of participants from University C were staff (74.6%) compared to other sites ($p<0.01$). Most participants were female (73.0%), White (83.4%), and non-Hispanic (92.2%).

Both serology results and vaccine status differed across sites ($p<0.01$, Table 1). The proportion of positive samples collected per site was higher among the three sites where samples were collected in April 2021 compared to the site where samples were collected in the end of March 2021. This is likely due to increased availability and eligibility of vaccine in this population during March and April 2021. This is supported by higher percentages of fully or partially vaccinated participants at sites where collection was done in April 2021. A greater proportion of participants from University A received the Pfizer-BioNTech vaccine compared to other sites (79.1%). In total only 11 participants in the study (2.4%) received the Johnson & Johnson vaccine.

The proportion of participants in each gender, race, and ethnicity category differed across sites ($p<0.01$, Table 1). Overall, most participants in the study were female (73.0%) and three participants (0.4%) reported their gender as “other.” Additionally, the majority of participants were White (83.4%) and non-Hispanic (96.5%). University A had the highest proportion of Black (15.5%), Asian (8.9%), and Hispanic (5.4%) participants across the study sites.

Finally, the proportion of participants that reported university program or job type were significantly different across sites for both students and staff. The three most frequently reported student roles were living in a dormitory (reported by 42.5%), being a health professional student (31.6%), and participating in Greek life (16.7%). The three most common roles reported by staff were faculty member (43.0%), administrator (32.9%) and coach (5.0%). Importantly, because this study relied on a convenience sample of students and staff who were recruited either by email, through fliers, or onsite, the population included in this study may not be representative of the overall student and staff population at each university site.

Table 1 – Demographics, Serology, and Vaccination Data by Site

	University A	University B	University C	University D	Total	p-value ¹
Collection Dates	3/29/2021	4/19/2021	4/20/2021	4/21/2021	3/29/2021-4/21/2021	NA
Total Samples Collected	168	125	140	357	790	NA
Total Questionnaires Completed (% completed among those who submitted samples)	76 (45.2%)	83 (66.4%)	67 (47.9%)	182 (51.0%)	408 (51.6%)	NA
Serology Results, N (%):						
Positive	82 (48.8%)	93 (74.4%)	100 (71.4%)	256 (71.7%)	531 (67.2%)	<0.01
Negative	85 (50.6%)	31 (24.8%)	40 (28.6%)	95 (26.6%)	251 (31.8%)	
Borderline	1 (0.6%)	1 (0.8%)	0 (0.0%)	6 (1.7%)	8 (1.0%)	
Participant Type, N (%):²						
Student	74 (97.4%)	40 (32.0%)	17 (25.4%)	97 (53.3%)	228 (56.9%)	<0.01
Staff	2 (2.6%)	43 (34.4%)	50 (74.6%)	84 (46.2%)	179 (43.9%)	
Unknown	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.5%)	1 (0.2%)	
Vaccination Status, N (%):³						
Fully Vaccinated	17 (10.2%)	41 (32.8%)	36 (25.9%)	135 (37.5%)	229 (29.0%)	<0.01
Partially Vaccinated	42 (25.2%)	40 (32.0%)	44 (31.7%)	101 (28.1%)	227 (28.7%)	
Unvaccinated	108 (64.7%)	44 (35.2%)	59 (42.5%)	124 (34.4%)	335 (42.4%)	
Vaccine Received, N (%) (among fully or partially vaccinated):⁴						
Pfizer	34 (79.1%)	41 (47.7%)	53 (64.6%)	102 (41.1%)	230 (50.1%)	<0.01
Moderna	8 (18.6%)	42 (48.8%)	26 (31.7%)	142 (57.3%)	218 (47.5%)	
J & J	1 (2.3%)	3 (3.5%)	3 (3.7%)	4 (1.6%)	11 (2.4%)	
Gender, N (%):⁵						
Female	109 (64.9%)	94 (77.7%)	78 (70.3%)	259 (76.2%)	540 (73.0%)	<0.01
Male	58 (34.5%)	25 (20.7%)	33 (29.7%)	81 (23.8%)	197 (26.6%)	
Other	1 (0.6%)	2 (1.7%)	0 (0.0%)	0 (0.0%)	3 (0.4%)	
Race, N (%):⁵						
White	118 (70.2%)	107 (88.4%)	95 (85.6%)	297 (87.4%)	617 (83.4%)	<0.01
Black	26 (15.5%)	4 (3.3%)	8 (7.2%)	14 (4.1%)	52 (7.0%)	
Asian	15 (8.9%)	6 (5.0%)	6 (5.4%)	23 (6.8%)	50 (6.7%)	
Other	9 (5.4%)	4 (3.3%)	2 (1.8%)	6 (1.8%)	21 (2.8%)	
Ethnicity, N (%):⁵						
Hispanic	9 (5.4%)	6 (5.0%)	2 (1.8%)	8 (2.4%)	25 (3.5%)	<0.01
Non-Hispanic	144 (94.6%)	115 (95.0%)	104 (98.1%)	320 (97.6%)	683 (96.5%)	
Age Median (Range):	20 (18-67)	28 (18-72)	33 (18-76)	23 (18-70)	22 (18-76)	<0.01
University Roles, N (%) (Students):²						
Student Athlete	5 (6.8%)	9 (22.5%)	10 (58.8%)	2 (2.1%)	26 (11.4%)	<0.01
Student band/chorus or other performing arts	13 (17.6%)	0 (0.0%)	0 (0.0%)	6 (6.2%)	19 (8.3%)	<0.01
Student living in a dormitory	33 (44.6%)	11 (27.5%)	7 (41.2%)	46 (47.4%)	97 (42.5%)	<0.01

	University A	University B	University C	University D	Total	p-value ¹
Collection Dates	3/29/2021	4/19/2021	4/20/2021	4/21/2021	3/29/2021-4/21/2021	NA
Resident Assistant (RA)	5 (6.8%)	2 (5.0%)	1 (5.9%)	3 (3.1%)	11 (4.8%)	<0.01
Student participating in Greek life	8 (10.8%)	0 (0.0%)	2 (11.8%)	28 (28.9%)	38 (16.7%)	<0.01
Health professional student	8 (10.8%)	12 (30.0%)	6 (35.3%)	46 (47.4%)	72 (31.6%)	<0.01
International Student	3 (4.1%)	1 (2.5%)	0 (0.0%)	8 (8.2%)	12 (5.3%)	<0.01
University Roles, N (%) (Staff):²						
Administrator	2 (100%)	10 (23.3%)	11 (22.0%)	36 (42.9%)	59 (32.9%)	<0.01
Advisor	0 (0.0%)	0 (0.0%)	1 (2.0%)	0 (0.0%)	1 (0.6%)	0.17
Coach	0 (0.0%)	4 (9.3%)	2 (8.0%)	3 (3.6%)	9 (5.0%)	0.07
Faculty Member	0 (0.0%)	23 (53.5%)	26 (52.0%)	28 (33.3%)	77 (43.0%)	<0.01
University Roles, N (%) (Students or Staff):						
Healthcare personnel ²	3 (3.9%)	5 (6.0%)	1 (1.5%)	17 (9.3%)	26 (6.4%)	0.08

¹P-values were calculated using Chi-Square or Fisher Exact tests (when at least one group contained less than N=5) for categorical variables and using Kruskal-Wallis tests for continuous variables (i.e., age) to compare differences across sites; ²Data only available for those who completed questionnaires (total student questionnaires completed were n=74 at University A, n=40 at University B, n=17 at University C, and n=97 and University D and total staff questionnaires completed were n=2 at University A, n=43 at University B, n=50 at University C, and n=84 and University D [note 1 survey from University D completed with unknown participant type]); ³Missing for N=3; ⁴Missing for N=26; ⁵Missing for N=54.

Serology and Vaccination data by Study Site

Over two-thirds of participants were positive for IgG antibodies at the time samples were collected (67.2%, Table 1). Among those who were fully vaccinated, 98.7% were positive for IgG antibodies, among those who were partially vaccinated, 88.1% were positive for IgG antibodies and among unvaccinated participants, 31.7% were positive for IgG antibodies (Table 2). Results of a Chi-square test found no significant difference in the proportion of unvaccinated participants who were positive for IgG antibodies across sites (p=0.09). There was also no significant difference found between the proportions of unvaccinated participants that were positive for antibodies by participant types (proportions were 34% for students and 30% for staff, p=0.55). However, results of multilevel models that adjusted for gender, race, and ethnicity found that staff were significantly more likely to have received at least one dose of COVID-19 vaccine than students (OR=3.75, 95% CI: [2.25-6.27], models adjusted for age, sex, race, and ethnicity), which may reflect the availability of the vaccine to certain age groups at the time samples were collected

Table 2 – Serology Results by Vaccine Status and Site

Study Sites	Serology Results	Fully Vaccinated	Partially Vaccinated	Unvaccinated
All Sites Combined	Positive	224 (98.7%)	199 (88.1%)	106 (31.7%)
	Negative	3 (1.3%)	25 (11.1%)	222 (66.5%)
	Borderline	0 (0.0%)	2 (0.9%)	6 (1.8%)
University A	Positive	17 (100.0%)	33 (78.6%)	31 (28.7%)
	Negative	0 (0.0%)	9 (21.4%)	76 (70.4%)
	Borderline	0 (0.0%)	0 (0.0%)	1 (0.9%)
University B	Positive	41 (100.0%)	36 (90.0%)	16 (36.3%)
	Negative	0 (0.0%)	4 (10.0%)	27 (61.4%)
	Borderline	0 (0.0%)	0 (0.0%)	1 (2.2%)
University C	Positive	34 (94.4%)	40 (90.9%)	26 (44.1%)
	Negative	2 (5.6%)	4 (9.1%)	33 (55.9%)
	Borderline	0 (0.0%)	0 (0.0%)	0 (0.0%)
University D	Positive	132 (99.2%)	90 (90.0%)	33 (26.8%)
	Negative	1 (0.8%)	8 (8.0%)	86 (69.9%)
	Borderline	0 (0.0%)	2 (2.0%)	4 (3.3%)

Questionnaire Data Summary

A total of 228 questionnaires were completed by university students. Some of the roles reported by students who participated in the study included athlete, performing arts student, student living in a dormitory, resident assistant (RA), participant in Greek life, health professional student, and international student. Most students (73.2%) were on-campus at least 3 days per week at the time the questionnaire was distributed. Importantly, the study population may overrepresent the proportion of students that are on campus because both recruitment and sample collection occurred at on-campus locations.

A total of 33 students (14.6%) had been previously diagnosed with COVID-19 and one had been hospitalized for COVID-19. Over one-third of students (36.9%) had been a known close contact of someone who had been diagnosed with COVID-19 and had to quarantine. Other data collected by the student questionnaires are summarized in Table 3.

A total of 179 questionnaires were completed among university staff. Some of the roles reported by staff included healthcare personnel, administrator, advisor, coach, and faculty member. The majority of staff who participated (64.1%) were on-campus less than 3 days per week at the time the questionnaire was distributed. A total of 27 staff members (15.1%) who participated in the study had been previously diagnosed with COVID-19 and none had been hospitalized for COVID-19. 42 staff members (23.6%) had been a known close contact of someone who had been diagnosed with COVID-19 and had to quarantine. Other data collected by the staff questionnaires are summarized in Table 3.

Table 3- Questionnaire Data Summary

Questionnaire Responses	Student Questionnaires N (%)	Staff Questionnaires N (%)
Total	228	179
Among those that live in a dorm, number they share a bedroom with [Median (Range)]	1 (Range 0-3)	NA
Among those that live in a dorm, number they share a bathroom with [Median (Range)]	2 (Range 0-50)	NA
Number of Days on Campus per Week:		
0 days (fully remote)	14 (6.1%)	23 (13.3%) ⁷
Less than 1 day per week	19 (8.3%)	10 (5.6%) ⁷
1-2 days per week	28 (12.3%)	38 (22.0%) ⁷
3-4 days per week	57 (25.0%)	41 (23.7%) ⁷
5 or more days per week	110 (48.2%)	61 (35.3%) ⁷
Have direct contact with patients (through courses, internships, or work responsibilities)	62 (27.2%)	35 (19.8%) ²
Additional employment (outside of the university)	88 (38.6%)	39 (21.9%) ¹
Among those with off-campus employment, Number of Days Spent In-Person at off-Campus Employment		
0 days (fully remote)	12 (13.6%)	6 (15.4%)
Less than 1 day per week	7 (8.0%)	8 (20.5%)
1-2 days per week	25 (28.4%)	11 (28.2%)
3-4 days per week	26 (29.5%)	7 (18.0%)
5 or more days per week	18 (20.5%)	2 (5.1%)
Among those with off-campus employment, off-campus job involves direct patient care	54 (62.1%) ¹	21 (61.8%) ⁵
At least 1 pre-existing health condition	77 (33.8%)	101 (56.4%)
Wear glasses most or all of the time	99 (43.4%)	108 (60.3%)
Previously diagnosed with COVID-19	33 (14.6%) ²	27 (15.1%)
Among those previously diagnosed with COVID-19, was hospitalized with COVID-19	1 (3.0%)	0 (0.0%)
Close contact of someone with COVID-19	83 (36.9%) ³	42 (23.6%) ¹
Number in household [Median (Range)]	3 (0-40) ⁵	2 (0-8)
Number in household with who are children (under 18) [Median (Range)]	0 (0-6) ⁸	0 (0-6) ⁴
Number in household who are 65+ [Median (Range)]	0 (0-3) ⁹	0 (0-2) ⁴
Number in household with a pre-existing medical condition(s) [Median (Range)]	1 (0-9) ⁹	0 (0-4) ⁷
Household member(s) have direct contact with patients at least 1 day per week	74 (33.0%) ⁴	31 (17.5%) ²
Household member(s) work in-person at a school at least 1 day per week	46 (20.5%) ⁴	37 (20.8%) ¹
Member of household diagnosed with COVID-19	57 (25.6%) ⁵	33 (18.6%) ²
Other for work or school, from March 2020-today number of times per week they leave home		
Never	3 (2.0%) ⁶	1 (0.6%) ³
1 time	13 (8.4%) ⁶	29 (16.5%) ³

Questionnaire Responses	Student Questionnaires N (%)	Staff Questionnaires N (%)
2-4 times	72 (46.8%) ⁶	76 (43.2%) ³
More than 4 times	66 (42.9%) ⁶	70 (39.8%) ³
Traveled outside of the US at least once since March 2020	16 (7.2%) ⁴	5 (2.8%) ²
Traveled outside of Pennsylvania since March 2020		
Never	45 (20.1%) ⁴	57 (32.0%) ¹
1-3 times	118 (52.7%) ⁴	87 (48.9%) ¹
More than 4 times	61 (27.2%) ⁴	34 (19.1%) ¹
Traveled by Airplane since March 2020	59 (25.9%)	44 (24.6%)
Traveled by Train/Subway since March 2020	78 (34.2%)	8 (4.5%)
Traveled by Bus since March 2020	68 (29.8%)	16 (8.9%)
Attended a large social gathering/party with individuals from outside household since March 2020	62 (40.3%) ⁶	39 (22.2%) ³
Always wear a mask outside of home/residence	179 (80.3%) ²	140 (79.6%) ³
Always maintain 6 feet of social distance outside of home/residence	80 (35.9%) ⁵	82 (46.1%) ¹
Wash hands 5 or more times per day	185 (81.9%) ²	160 (89.9%) ¹
Knows someone who has died of COVID-19	97 (42.9%) ²	75 (42.1%) ¹
How they are thinking about vaccine:		
Received at least one dose	146 (64.3%)	146 (82.0%) ¹
Will get the vaccine as soon as it is offered	45 (19.8%)	5 (2.8%) ¹
I'd like to wait and see how it goes for others	13 (5.7%)	8 (4.5%) ¹
I'm not really sure	9 (4.0%)	7 (3.9%) ¹
It was offered to me and I declined	7 (3.1%)	2 (1.1%) ¹
I don't want to get the vaccine	7 (3.1%)	10 (5.6%) ¹
Assessment of current understanding of COVID-10 (Counted when answers are TRUE or AGREE):		
Wearing masks can prevent you from getting COVID-19.	181 (80.1%) ²	132 (74.6%) ¹
Keeping a physical distance more than 6 feet can reduce the risk of getting COVID-19.	207 (91.6%) ²	162 (91.0%) ¹
If you have COVID-19, wearing masks can prevent you from spreading COVID-19 to others.	201 (88.9%) ²	55 (87.1%) ²
You can get COVID-19 when contaminated hands touch your eyes, nose, or mouth.	204 (90.3%) ²	168 (94.4%) ¹
COVID-19 can spread by contaminated surfaces.	150 (66.4%) ²	77 (43.3%) ¹
I am not really worried about getting COVID-19 because I won't get severely ill.	38 (16.7%) ¹	19 (10.6%)

¹Missing for N=1; ²Missing for N=2; ³Missing for N=3; ⁴Missing for N=4; ⁵Missing for N=5; ⁶Missing for N=74; ⁷Missing for N=6; ⁸Missing for N=12; ⁹Missing for N=10.

Reported Vaccine Hesitancy Among Unvaccinated Participants

Among students who did not yet receive at least one dose of vaccine, (n=81), 55.6% will get the vaccine as soon as it is offered to them. The remaining 44.4% expressed some

level of hesitancy towards the vaccine (i.e., they answered, "I'd like to wait and see how it goes for others", "I'm not really sure", "It was offered to me and I declined" or "I don't want to get the vaccine" when asked how they are thinking of the COVID-19 vaccine). Among staff who did not yet receive at least one dose of vaccine, (n=32), 15.6% will get the vaccine as soon as it is offered. The remaining 84.4% expressed some level of hesitancy towards the vaccine. This larger proportion of vaccine hesitancy reported among unvaccinated university staff may reflect the higher rates of vaccination among staff than students and the time this study was completed. Specifically, staff who were willing to be vaccinated were more likely to have already received vaccine than students who were willing to be vaccinated. Despite this, some level of vaccine hesitancy in this population may impact future transmission of COVID-19 in this sample.

Fully Vaccinated Participants who were Negative for IgG Antibodies

A total of three participants in the study reported being fully vaccinated (>two weeks out from the last dose of the vaccine series) and tested negative for IgG antibodies (Table 2). Among these participants, one received the Moderna vaccine, one received Johnson & Johnson, and one received some "other" vaccine (did not state the product). Two participants were recruited from University C and one was recruited from University D. Ages were 21, 23, and 51. Demographic information was available for two of the three participants; both were white, non-Hispanic, one was male and the other was female. A questionnaire was completed for only one of these three individuals. This individual reported that they were a faculty member with some pre-existing health conditions (i.e., heart, high cholesterol, overweight). They did not report a previous COVID-19 diagnosis.

Variables Associated with Previous Self-Reported COVID-19 Diagnosis

Tables 4 and 5 summarize results of multilevel logistic regression models that measured associations between key variables of interest from the questionnaire and a previous self-reported COVID-19 diagnosis among university students (Table 4) and staff (Table 5). No associations were found between age, gender, and race and self-reported previous COVID-19 infection among university students or staff (Table 4 and 5). Due to complete separation of the outcome variable in both populations, analyses were not done to assess whether Hispanic ethnicity was associated with previous COVID-19 diagnosis (no participants who reported Hispanic ethnicity also reported a previous COVID-19 diagnosis).

Among university students (Table 4) being a student athlete or reporting that they "are not really worried about getting COVID-19 because they won't get severely ill" were associated with a higher odds of reporting a previous COVID-19 diagnosis (OR= 6.49, 95% CI: [6.49-17.08] and OR= 2.60, 95% CI: [1.05-6.40], respectively, Table 4). Reporting they "always" wear a mask outside of their home was associated with a lower odds of reporting a previous COVID-19 diagnosis among university students (OR= 0.25, 95% CI: [0.10-0.61], Table 4). Finally, the number of individuals students reporting sharing a household with was positively associated with a reported previous COVID-19 diagnosis among university

students (OR=1.09, 95% CI: [1.01-1.10]), however, this association became non-significant after adjusting for age, race, ethnicity, and sex (Table 4).

Among university staff, Table 5, being a coach was associated with a higher odds of reporting a previous COVID-19 diagnosis (OR= 8.16, 95% CI: [1.53-43.61], Table 5). In addition, wearing glasses most or all of the time and agreeing that "wearing masks can prevent you from getting COVID-19" were associated with lower odds of a previous COVID-19 diagnosis among university staff (OR=0.34, 95% CI: [0.13-0.88] and OR=0.37, 95% CI: [0.15-0.92], respectively). No other variables measured were associated with reporting a previous COVID-19 infection among university staff or students.

Table 4. Associations between Questionnaire Variables and Previous Self-Reported COVID-19 Diagnosis Among Students (bolded if significant)

Questionnaire Variable	N	Unadjusted Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)
Age	213	0.91 (0.80-1.05)	0.95 (0.82-1.09)
Female (referent is Male) ¹	213	0.94 (0.37-2.14)	0.99 (0.37-2.69) ²
White (referent is non-white) ³	213	7.79 (1.01, 59.98)	6.95 (0.88-54.76) ⁴
University Roles:	213	7.38 (2.88-18.90)	6.49 (2.47-17.08)
Student Athlete			
Student band/chorus or other performing arts	213	1.32 (0.34-5.13)	1.18 (0.29-4.74)
Student living in a dormitory	213	0.90 (0.41-1.97)	0.64 (0.26-1.54)
Resident Assistant (RA)	213	1.22 (0.25-6.09)	1.54 (0.28-8.37)
Student participating in Greek life	213	0.49 (0.13-1.83)	0.39 (0.11-1.42)
Health professional student	213	0.76 (0.32-1.80)	0.57 (0.22-1.49)
International student	213	1.84 (0.35-9.66)	6.54 (0.78-54.91)
Healthcare Personnel	213	1.18 (0.24-5.76)	1.03 (0.21-5.16)
On campus 3 or more days per week	213	1.81 (0.70-4.71)	1.38 (0.50-3.83)
Has additional off-campus employment	213	0.48 (0.20-1.15)	0.49 (0.20-1.20)
Have direct contact with patients	213	0.82 (0.34-1.98)	0.88 (0.35-2.16)
Have at least 1 pre-existing Health Condition	213	0.47 (0.19-1.16)	0.49 (0.19-1.21)
Wear Glasses	213	0.52 (0.23-1.18)	0.59 (0.26-1.35)
Number living in home	213	1.09 (1.01-1.18)	1.07 (0.99-1.16)
Leave home more than 4 times per week	143	2.17 (0.84-5.58)	1.56 (0.59-4.11)
Travel Outside of PA at least once	209	0.73 (0.30-1.78)	0.64 (0.25-1.60)
Attended a large social gathering/party with individuals from outside household since March 2020	143	1.76 (0.65-4.78)	1.61 (0.58-4.50)
Always wear a mask outside of home/residence	208	0.23 (0.09-0.54)	0.25 (0.10-0.61)
Always maintain 6 feet of social distance outside of home/residence	208	0.68 (0.29-1.60)	0.78 (0.32-1.86)
Wash hands 5 or more times per day	211	0.75 (0.26-2.13)	0.75 (0.26-2.18)
Knows someone who has died of COVID-19	211	0.75 (0.34-1.65)	0.80 (0.36-1.79)
Assessment of current understanding of COVID-19 (Counted when answers are TRUE or AGREE): Wearing masks can prevent you from getting COVID-19.	211	0.56 (0.23-1.35)	0.56 (0.22-1.43)

Questionnaire Variable	N	Unadjusted Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)
Keeping a physical distance more than 6 feet can reduce the risk of getting COVID-19.	211	0.46 (0.13-1.57)	0.33 (0.08-1.30)
If you have COVID-19, wearing masks can prevent you from spreading COVID-19 to others.	211	0.78 (0.24-2.52)	0.67 (0.20-2.29)
You can get COVID-19 when contaminated hands touch your eyes, nose, or mouth.	211	3.40 (0.43-26.90)	3.53 (0.44-28.41)
COVID-19 can spread by contaminated surfaces.	211	0.77 (0.34-1.71)	0.85 (0.38-1.93)
I am not really worried about getting COVID-19 because I won't get severely ill.	212	2.81 (1.18-6.72)	2.60 (1.05-6.40)

¹Female compared to Males, those with gender = "Other" (n=1) removed from analysis; ²Adjusted for site, race, ethnicity, and age; ³Non-White category includes Black, Asian, other; ⁴Adjusted for site, ethnicity, age, gender.

Table 5. Associations between Questionnaire Variables and Previous Self-Reported COVID-19 Diagnosis Among Staff

Questionnaire Variable	N	Unadjusted Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)
Age	163	1.03 (0.97-1.10)	1.03 (0.96-1.11)
Female (referent is Male) ¹	163	0.84 (0.32-2.20)	0.81 (0.31-2.13) ²
White (referent is non-white) ³	163	2.08 (0.25-17.14)	2.58 (0.28-23.49) ⁴
University Roles:			
Administrator	163	0.56 (0.21-1.49)	0.56 (0.21-1.51)
Coach	163	6.38 (1.47-27.80)	8.16 (1.53-43.61)
Faculty Member	163	0.59 (0.24-1.48)	0.63 (0.25-1.59)
Healthcare personnel	163	3.10 (0.85-11.31)	2.94 (0.71-12.24)
On campus 3 or more days per week	157	1.18 (0.49-2.83)	1.03 (0.42-2.57)
Have direct contact with patients	161	2.31 (0.89-6.04)	2.26 (0.81-6.32)
Have at least 1 pre-existing Health Condition	163	0.81 (0.34-1.91)	0.82 (0.34-1.98)
Wear Glasses	163	0.39 (0.16-0.94)	0.34 (0.13-0.88)
Number living in home	162	1.25 (0.83-1.68)	1.24 (0.92-1.67)
Leave home more than 4 times per week	160	1.57 (0.67-3.73)	1.47 (0.61-3.57)
Travel Outside of PA at least once	162	1.30 (0.50-3.36)	1.17 (0.43-3.17)
Attended a large social gathering/party with individuals from outside household since March 2020	160	1.97 (0.76-5.10)	2.20 (0.83-5.79)
Always wear a mask outside of home/residence	161	0.75 (0.27-2.08)	0.67 (0.23-1.96)
Always maintain 6 feet of social distance outside of home/residence	162	0.61 (0.25-1.47)	0.56 (0.22-1.45)
Wash hands 5 or more times per day	162	0.34 (0.04-2.73)	0.34 (0.04-2.77)
Knows someone who has died of COVID-19	162	0.70 (0.29-1.71)	0.65 (0.25-1.66)

Questionnaire Variable	N	Unadjusted Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)
Assessment of current understanding of COVID-19 (Counted when answers are TRUE or AGREE): Wearing masks can prevent you from getting COVID-19.	162	0.39 (0.16-0.94)	0.37 (0.15-0.92)
Keeping a physical distance more than 6 feet can reduce the risk of getting COVID-19.	162	2.73 (0.34-22.13)	2.72 (0.33-22.20)
If you have COVID-19, wearing masks can prevent you from spreading COVID-19 to others.	162	0.42 (0.15-1.21)	0.37 (0.12-1.13)
You can get COVID-19 when contaminated hands touch your eyes, nose, or mouth.	162	1.49 (0.18-12.66)	1.61 (0.19-13.94)
COVID-19 can spread by contaminated surfaces.	162	0.72 (0.30-1.76)	0.71 (0.29-1.76)
I am not really worried about getting COVID-19 because I won't get severely ill.	162	1.31 (0.34-5.03)	1.31 (0.33-5.26)

¹Female compared to males, those with gender = "other" (n=1) removed from analysis; ²Adjusted for site, race, ethnicity, and age; ³Non-White category includes Black, Asian, and other; ⁴Adjusted for site, ethnicity, age, gender.

Variables Associated with Positive Serology Results among Unvaccinated Participants

Tables 6 and 7 summarize results of multilevel logistic regression models that measured associations between key variables of interest from the questionnaire and positive serology results among unvaccinated students (Table 6) and staff (Table 7). No associations were found between age, gender, and race and serology results among unvaccinated university students or staff (Table 6 and 7). Due to complete separation of the outcome variable in both populations, analyses were not done to assess whether Hispanic ethnicity was associated with previous COVID-19 diagnosis (no participants who reported Hispanic ethnicity also reported a previous COVID-19 diagnosis).

Among unvaccinated university students, agreeing that they "are not really worried about COVID-19 because they won't get severely ill" was associated with a higher odds of being positive for IgG antibodies (OR=3.37, 95% CI: [1.14-9.96]). Agreeing that "keeping a physical distance more than 6 feet can reduce the risk of getting COVID-19" was associated with lower odds of being positive for antibodies among unvaccinated students in the adjusted models (OR=0.19, 95% CI: [0.04-0.97]) but not the unadjusted models. Being an athlete was associated with a higher odds for being positive for antibodies in the unadjusted models (OR=3.58, 95% CI: [1.05-12.26]), however this association became non-significant after controlling for age, gender, race, and ethnicity. Among unvaccinated university staff, having direct contact with patients was associated with higher odds of being positive for antibodies (OR=47.2, 95% CI: 1.44-462.11). No other associations were found between questionnaire variables and serology results among unvaccinated students and staff.

Table 6. Associations between Questionnaire Variables and Positive Serology Results Among Unvaccinated Students

Questionnaire Variable	N	Unadjusted Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)
Age	94	0.87 (0.74-1.02)	0.88 (0.76-1.02)
Female (referent is Male) ¹	94	1.74 (0.60-5.03)	1.59 (0.53-4.78)
White (referent is non-white) ³	94	4.15 (0.47-36.33)	2.95 (0.32-27.60)
University Roles:	94	3.58 (1.05-12.26)	3.03 (0.87-10.59)
Student Athlete			
Student band/chorus or other performing arts	94	0.59 (0.11-3.18)	0.27 (0.03-2.50)
Student living in a dormitory	94	0.77 (0.32-1.86)	0.36 (0.12-1.04)
Resident Assistant (RA)	94	0.60 (0.06-6.25)	0.59 (0.05-6.56)
Student participating in Greek life	94	0.46 (0.12-1.79)	0.32 (0.08-1.32)
Health professional student	94	2.48 (0.84-7.33)	2.28 (0.73-7.16)
International student	94	1.88 (0.11-32.20)	6.13 (0.20-184.70)
Healthcare Personnel	94	2.95 (0.46-19.10)	3.44 (0.48-24.73)
On campus 3 or more days per week	94	1.17 (0.46-2.99)	0.66 (0.23-1.93)
Have direct contact with patients	94	1.47 (0.46-4.75)	1.39 (0.40-4.87)
Have at least 1 pre-existing Health Condition	94	0.46 (0.16-1.30)	0.45 (0.15-1.34)
Have additional off-campus employment	94	0.96 (0.38-2.44)	1.21 (0.42-3.38)
Wear Glasses	94	1.40 (0.58-3.39)	1.35 (0.54-3.38)
Number living in home	91	0.97 (0.87-1.08)	0.95 (0.83-1.08)
Leave home more than 4 times per week	55	0.94 (0.31-2.84)	0.96 (0.30-3.05)
Travel Outside of PA at least once	91	0.62 (0.22-1.74)	0.43 (0.14-1.33)
Attended a large social gathering/party with individuals from outside household since March 2020	55	1.20 (0.40-3.63)	1.26 (0.40-3.94)
Always wear a mask outside of home/residence	90	0.65 (0.26-1.63)	0.55 (0.20-1.47)
Always maintain 6 feet of social distance outside of home/residence	90	1.34 (0.51-3.52)	1.38 (0.50-3.85)
Wash hands 5 or more times per day	93	0.61 (0.21-1.78)	0.63 (0.21-1.92)
Knows someone who has died of COVID-19	93	0.65 (0.26-1.63)	0.50 (0.18-1.36)
Assessment of current understanding of COVID-19 (Counted when answers are TRUE or AGREE):			
Wearing masks can prevent you from getting COVID-19.			
Keeping a physical distance more than 6 feet can reduce the risk of getting COVID-19.	92	0.42 (0.13-1.40)	0.19 (0.04-0.97)
If you have COVID-19, wearing masks can prevent you from spreading COVID-19 to others.	92	0.58 (0.19-1.81)	0.36 (0.10-1.31)
You can get COVID-19 when contaminated hands touch your eyes, nose, or mouth.	92	1.44 (0.26-8.03)	1.54 (0.27-8.94)
COVID-19 can spread by contaminated surfaces.	92	0.77 (0.32-1.84)	0.80 (0.33-1.97)
I am not really worried about getting COVID-19 because I won't get severely ill.	93	2.86 (1.06-7.73)	3.37 (1.14-9.96)

¹Female compared to males, those with gender = "other" (n=1) removed from analysis; ²Adjusted for site, race, ethnicity, and age; ³Non-White category includes Black, Asian, Other; ⁴Adjusted for site, ethnicity, age, gender.

Table 7. Associations between Questionnaire Variables and Positive Serology Results Among Unvaccinated Staff

Questionnaire Variable	N	Unadjusted Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)
Age	36	1.02 (0.96-1.08)	1.03 (0.96-1.11)
Female (referent is Male) ¹	36	1.04 (0.20-5.40)	0.80 (0.14-4.53)
White (referent is non-white) ³	36	0.61 (0.08-4.66)	0.61 (0.04-10.10)
University Roles:			
Administrator	36	0.57 (0.09-3.57)	0.65 (0.10-4.32)
Faculty	36	0.33 (0.06-2.01)	0.28 (0.04-1.83)
Healthcare Personnel	36	5.33 (0.39-73.16)	5.41 (0.35-82.77)
On campus 3 or more days per week	35	2.31 (0.48-11.17)	1.84 (0.32-10.51)
Have direct contact with patients	35	16.0 (1.36-187.83)	47.2 (1.44-462.11)
Have at least 1 pre-existing Health Condition	35	0.73 (0.16-3.32)	0.45 (0.08-2.50)
Additional off-campus Employment	35	4.00 (0.77-20.71)	5.02 (0.90-28.00)
Wear Glasses	36	0.45 (0.10-2.05)	0.52 (0.11-2.49)
Number living in home	36	1.06 (0.66-1.69)	1.12 (0.68-1.86)
Leave home more than 4 times per week	36	2.14 (0.46-9.91)	0.42 (0.08-2.27)
Travel Outside of PA at least once	36	2.46 (0.50-12.22)	3.18 (0.50-20.40)
Attended a large social gathering/party with individuals from outside household since March 2020	36	2.14 (0.46-9.91)	2.76 (0.53-14.49)
Always wear a mask outside of home/residence	36	2.89 (0.58-14.34)	2.92 (0.52-16.36)
Always maintain 6 feet of social distance outside of home/residence	36	0.88 (0.19-3.93)	0.52 (0.09-3.01)
Knows someone who has died of COVID-19	36	1.19 (0.22-6.35)	0.69 (0.09-5.30)
Assessment of current understanding of COVID-19 (Counted when answers are TRUE or AGREE):			
Wearing masks can prevent you from getting COVID-19.	36	1.11 (0.25-4.86)	1.28 (0.26-6.29)
Keeping a physical distance more than 6 feet can reduce the risk of getting COVID-19.	36	3.16 (0.30-32.77)	2.18 (0.19-25.16)
If you have COVID-19, wearing masks can prevent you from spreading COVID-19 to others.	36	0.55 (0.11-2.72)	0.51 (0.10-2.66)
You can get COVID-19 when contaminated hands touch your eyes, nose, or mouth.	36	0.18 (0.01-2.57)	0.14 (0.01-2.51)
COVID-19 can spread by contaminated surfaces.	36	0.35 (0.07-1.72)	0.37 (0.07-2.05)
I am not really worried about getting COVID-19 because I won't get severely ill.	36	0.70 (0.11-4.50)	0.99 (0.13-7.41)

¹Female compared to Males, those with gender = "Other" (n=1) removed from analysis; ²Adjusted for site, race, ethnicity, and age; ³Non-White category includes Black, Asian, Other; ⁴Adjusted for site, ethnicity, age, gender.

Conclusions

Staff and students at urban universities in Pennsylvania had considerably higher rates of infection with COVID-19 determined through antibody testing compared to case reports among the general public received through disease surveillance activities and likely contributed to community transmission. Athletic programs and health professional programs where students have direct contact with patients were associated with higher rates of infection and therefore should have more stringent and targeted disease control recommendations moving forward (testing, vaccination, mask wearing, and limiting social interactions). Student attitudes identified less concern for personal safety as many felt COVID-19 did not pose a significant health risk, therefore disease control messaging in this sector should highlight their role in community transmission and stress the importance to limit transmission to protect seniors and other people who are at greater risk for severe disease. Universities have long been known to be associated with outbreaks of infectious diseases (e.g., mumps, meningococcus) due to many factors including dormitory living, clinical education, sporting activities and social behaviors. This analysis highlights these associations related to COVID-19 and are applicable to inform disease control activities when in-person learning is occurring and COVID-19 transmission continues locally and internationally. Specific findings from this report are summarized below:

1. Among all study participants, 29.0% were fully vaccinated at the time samples were collected and 42.4% were unvaccinated. Staff were significantly more likely to be fully vaccinated than students (OR=3.75, 95% CI: [2.25-6.27]).
2. Across all 4 university sites, over two thirds of participants (67.2%) were positive for IgG antibodies. Among fully vaccinated participants, 98.7% were positive and among unvaccinated participants, 31.7% were positive for IgG antibodies.
3. Among students who did not yet receive a COVID-19 vaccine, 44.4% expressed some hesitancy towards the vaccine and among staff who did not yet receive a COVID-19 vaccine, 84.4% expressed some hesitancy. Importantly, this large discrepancy may be due in part to the fact that staff who were not hesitant were more likely to be vaccinated at the time of this study than students who were not hesitant.
4. Being an athlete and agreeing they are “not really worried about COVID-19 because they won't get severely ill” were associated with higher odds of reporting a previous COVID-19 infection among students (OR= 6.49, 95% CI: [2.47-17.08] and OR= 2.60, 95% CI: [2.60-6.40], respectively).
5. Students who reported "always" wearing a mask outside of their home had lower odds of reporting a previous COVID-19 infection on the online questionnaire compared to students who reported wearing masks “sometimes” or “never” (OR=0.25,95% CI: [0.10-0.61]).

6. Among staff, those who were coaches had higher odds of reporting a previous COVID-19 infection than staff members who were not coaches (OR=8.16 95% CI: [1.53-43.61] and staff who wore glasses or agreed that "wearing masks can prevent you from getting COVID-19" had lower odds of reporting a previous COVID-19 infection (OR=0.34, 95% CI: [0.13-0.88] and OR=0.37, 95% CI: [0.15-0.92], respectively).
7. Among unvaccinated students, those who reported they were "not really worried about getting COVID-19 because they won't get severely ill" had higher odds of being positive for IgG antibodies (OR=3.37, 95% CI: [1.14-9.96]) while unvaccinated students who agreed that "keeping a physical distance of more than 6 feet can reduce the risk of COVID-19" had lower odds of being positive for antibodies that unvaccinated students who disagreed with that statement (OR=0.19, 95% CI: [0.04-0.97]).
8. Among unvaccinated staff, those who had direct contact with patients as part of their work, school, or internship responsibilities had higher odds of being positive for IgG antibodies than unvaccinated staff who did not have direct contact with patients (OR=47.2, 95% CI: [1.44-462.11]).