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COVID-19 Vaccination Uptake, Infection Rates, and Seropositivity Among Youth Experiencing Homelessness in the United States

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The authors have no conflicts of interest to report.

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Abstract

Background: People experiencing homelessness are at greater risk of exposure and poor health outcomes from COVID-19. Yet, little data exists on the prevalence and correlates of COVID-19 among homeless populations. To mitigate the spread and severity, uptake of the COVID-19 vaccine is needed. This can be challenging among youth experiencing homelessness who are more likely to be unvaccinated when compared to stably housed youth.

***Objective*:** We conducted this study to determine the prevalence and correlates of COVID-19 among youth experiencing homelessness.

Methods*:* We examined experiences of COVID-19 symptoms, self-report of infection, rates of COVID-19 antibodies and distinguished between natural and vaccinated immunity among youth experiencing homelessness (N = 265) recruited in one large metropolitan area in the South.

***Results*:** Based on self-report, very few participants experienced any symptoms, and 80% had never been diagnosed with COVID-19. Of those with COVID-19 antibodies (68%), the proportion with antibodies resulting from natural infection was 44%. The vaccination rate was 42%. Younger and vaccinated participants and those in shelters were likelier to have COVID-19 antibodies. Black and Hispanic youth were more likely than White youth to have had COVID-19. Those who adopted only one or two prevention behaviors were more likely to acquire a natural infection than those who adopted three or more prevention behaviors.

Discussion: Youth experiencing homelessness report low vaccination rates, disrupted access to health care and social supports, and underlying chronic conditions, which may explain why they face poorer outcomes when infected with COVID-19. Vaccination and risk mitigation strategies to combat the high prevalence of COVID-19 are especially needed for sheltered youth who are at high risk yet are often asymptomatic.

Keywords: antibody seroprevalence, COVID-19, homeless youth

COVID-19 Vaccination Uptake, Infection Rates, and Seropositivity Among Youth Experiencing Homelessness in the United States

People experiencing homelessness (PEH) have a mortality rate that is 5–10 times higher than the general population (Baggett et al., 2013) and are at greater risk of exposure to COVID-19, as well as poor health outcomes resulting from infection (Gibson et al., 2022). Congregate sheltering situations make adherence to public health prevention measures, such as social distancing, challenging (Mosites et al., 2020). Those staying outdoors in encampments and places not meant for human habitation lack access to basic hygiene, such as running water for hand washing and access to other preventive hygiene measures like facial masks. PEH also have higher rates of comorbidities and underlying health conditions, including chronic medical conditions, mental illness, substance use problems, and infectious illnesses, such as pneumonia and HIV that compromise immune function, which further decreases the survival rate from COVID-19 (Gibson et al., 2022; Jiang et al., 2020).

Estimates of hospitalization rates, intensive care unit bed use, and mortality rates associated with COVID-19 infection among general populations of PEH found that those who contracted COVID-19 would be two times more likely to be hospitalized, two to four times more likely to require an ICU bed during treatment, and have two to three times the mortality rate of the non-homeless general population (Culhane et al., 2020). This analysis suggests that, at that rate, approximately 400,000 beds will be needed daily to accommodate social distancing and quarantining for homeless populations, with a total estimated annual cost of $11.5 billion. These studies demonstrate the high risk for rapid COVID-19 transmission and sequela among people using shelters and suggest that universal testing may be superior to symptom assessments to

identify and mitigate COVID-19 transmission due to a high level of asymptomatic presentation.

COVID-19 Infection Rates

Data is emerging on the prevalence of COVID-19 among homeless populations. Among homeless populations in Brazil, France, and Denver, Colorado, the COVID-19 immunoglobulin (IgG) and IgM antibody prevalence rates ranged from 1.5%–54.7% (IgG) and 2.1%–15.2% (IgM; do Couto et al., 2021; Loubiere et al., 2021; Rowan et al., 2022). The data suggest low infection rates across various PEH populations when self-reporting—a method used across several studies. One Boston, Massachusetts-based shelter study reported a cluster of COVID-19 cases (Baggett et al., 2020). Using polymerase chain reaction (PCR) testing among all residents, they found that 36% of residents had COVID-19. Those who tested positive were more likely to be male ($p < 0.001$) but did not differ in other characteristics. Importantly, very few of those who tested positive reported any symptoms (cough–7.5%, shortness of breath–1.4%, and fever–0.7%). Another study in King County, Washington, reported an outbreak that occurred among three homeless shelters where universal testing for COVID-19 identified 43 cases (Tobolowsky, 2020). In a sample in California, 5 of 15 PEH were found to have antibodies despite not reporting vaccination, infection, or symptoms (Nyamathi et al., 2023). However, in a meta-analysis, 35% of PEH with COVID-19 experienced symptoms (Ahillan et al., 2023). A recent study among youth experiencing homelessness (YEH) reports that only 6% thought they had ever had COVID-19 (Tucker et al., 2020).

Vaccine Uptake and Hesitancy

COVID-19 posed many public health challenges including, difficulty in tracking

infection, contact tracing, preventing transmission, and disseminating vaccines—particularly in large metropolitan areas with a high prevalence of PEH (Tsai & Wilson, 2020). A key public health response to mitigating the spread of COVID-19 infection and development of COVID-19 disease is widespread distribution and uptake of vaccines. However, YEH are more likely to be unvaccinated and under-vaccinated when compared to those who are stably housed (Fu et al., 2021). This holds true for COVID-19 vaccination, with rates among PEH being lower than the general population (Montgomery et al., 2021; Shearer et al., 2022; Tucker et al., 2022). Additionally, YEH faces disrupted access to health care and other vital supports and higher rates of underlying chronic health conditions (Auerswald et al., 2021; O'Brien et al., 2021).

In one study of PEH (N = 736) recruited from shelters in Toronto, Canada, 80.4% self-reported receiving at least one vaccine dose, and 63.6% received two or more doses (Richard et al., 2022). This is similar to estimates of 61% from around the same time period in the general population (Barro, 2022). Using data from 2778 people in the Homeless Management Information System compared to a county in Wisconsin, PEH were less likely to be vaccinated and have received a booster, with rates being lowest among YEH and people of color (Gibson et al., 2022). In another study of YEH in California (N = 134), 29% self-reported being vaccinated; 50% were not interested in getting vaccinated, and 38%–45% had strong distrust and were worried about potential vaccine harms (Tucker et al., 2022). However, in contrast to the low vaccine uptake found in the literature, qualitative work in Houston, Texas, suggests that YEH fear contracting COVID-19—which may motivate vaccine uptake (Gibbs et al., 2023). In order to fully understand vaccine uptake and the prevalence of COVID-19 among YEH, we conducted this study using both self-report and antibody testing.

Methods

The overwhelming majority (99.2%) of participants (n = 265) were YEH aged 18–25 who were recruited— via flyers—from a large, randomized trial assessing the efficacy of an HIV prevention intervention and also from a local drop-in center. Participants enrolled in the study (HSC-SN-20-0993) were contacted via phone if they consented to receive information about future studies. After written consent was obtained, a blood draw was done by an RN, and participants completed a self-administered, computer-assisted survey delivered via smartphone or tablet. This was done in a private space at a location most convenient for the participants. Participants received a gift card worth $20 for the blood draw and survey. This study was reviewed and approved by the University of Texas Health Science Center at Houston Committee for the Protection of Human Subjects.

To determine the effect of COVID-19 and vaccine rates on a large and diverse population of YEH, we examined rates of COVID-19 antibodies to assess for the presence of vaccine-related antibodies as well as natural infection. A study team member transported the blood samples to the laboratory within 2 hr for prompt processing to preserve sample integrity. The plasma was taken off the red cells and stored for batch testing. The specimens were labeled with the study ID number used to label any subsequent vials or other storage mediums to which the sample may be transferred to for testing or storage (-80°C) in the laboratory. The plasma was tested for anti-spike antibodies (IgM and IgG) to COVID-19 with a commercially available kit manufactured by Healgen Scientific, LLC. To distinguish between natural and vaccinated immunity, an enzyme-linked immunosorbent serological assay (ELISA) test was then used on samples that were positive for COVID-19 antibodies to detect the presence of anti-nucleocapsid

antibodies. Data collection took place from March 30, 2021, to December 12, 2022.

Survey Measures

Demographic survey items were assessed. At the time of the blood draw, the RN asked participants if they had ever been diagnosed with COVID-19, had received any COVID-19 vaccines and, if so, which brand of vaccine was received. Participants answered questions in the survey regarding experiencing COVID-19 symptoms (fever, cough, shortness of breath, loss of smell or taste), testing, hospitalization, treatment, and use of preventive measures (i.e., handwashing, social distancing, masking; Gwadz et al., 2021). The survey also assessed anxiety (Lee, 2020) and fear (Ahorsu et al., 2022) related to COVID-19, in addition to the general effect on housing and health care access (Stoddard et al., 2023).

Statistical Analyses

Descriptive statistics were calculated for demographic variables, self-reported vaccine uptake, vaccine type, COVID-19 symptoms and diagnoses, COVID-19 antibody (IgG), and ELISA test results, transmission reduction strategies, and effect of COVID-19 on housing and mental health, including access to prescription medicines. For modeling immunity to COVID-19, antibodies were recoded to a three-level outcome based on the IgG antibody test and ELISA test results: no antibodies (n = 84), antibodies due to vaccine (n = 85), and antibodies due to natural infection (n = 95). Participants with a negative IgG antibody test were deemed to have no antibodies to COVID-19. In contrast, those with a positive IgG test and negative ELISA test were classified as having antibodies due to the vaccine. A positive ELISA test result was sufficient to consider the antibodies arising from natural infection. The infrequently occurring

borderline test result for ELISA was merged into positive test results to improve model performance.

A random forest approach was used to allow nonlinear and interaction effects in the model while also assessing the importance of the predictors (Hastie et al., 2009). Ten predictors in the model included age, gender identity, race/ethnicity, sexual orientation, type of prior night shelter, COVID-19 effects on housing, COVID-19 diagnosis, vaccination status, worry about mental health after COVID-19, difficulty in accessing mental health medication after COVID-19, and prevention behaviors adopted to protect against COVID-19. Data were analyzed with R version 4.3 (R Core Team, 2023) in the RStudio environment (R Studio Team, 2023), and JMP version 17.2 (SAS Institute Inc., 1989–2023) was used to compute the bootstrap forest model averaged over 100 trees with fivefold cross-validation for assessing model performance. The informative missing option was used for the model, which created a separate level for missing data in categorical variables. For missing data in a continuous predictor, splits are calculated assuming that missing values could be either at the high or low end of the distribution before the optimal split is determined based on the logworth criterion (Sall, 2002).

Results

Demographic characteristics of the participants (n = 265) are summarized in Table 1. The majority of participants identified as male (51.7%), Black (61.5%), and heterosexual (65%). About 18% of the participants were Hispanic, and 37% of youth identified as lesbian, gay, bisexual, transgender, or queer. Shelters—adult and youth—were the most common place (57.3%), and youth had stayed the night before being recruited for this study.

Distributions of COVID-19 symptoms, diagnosis, presence of antibodies, and vaccination status are summarized in Table 2. Based on participant self-reports, very few youths (12%) had experienced any symptoms of COVID-19, and 80% self-reported that they had never tested positive or been diagnosed with COVID-19 infection. The presence of antibodies was assessed with an IgG test. Participants who tested positive for antibodies to COVID-19 (n =180; 67.9%; 95% CI 0.620, 0.735) were further assessed using an ELISA test to determine whether the antibodies that were present were due to natural infection. The proportion of those youth whose antibodies were from natural infection was 44.4% (95% CI 0.372, 0.517). The vaccination rate was found to be 41.9% (95% CI 0.359, 0.478), with most youth self-reporting receiving vaccines produced by Pfizer or Moderna.

The summary of prevention behaviors adopted by participants in the wake of the pandemic, along with the effect of the pandemic on housing, mental health, and access to prescription medications for mental health, are displayed in Table 3. The majority of youth reported that they were washing their hands (82.6%), wearing a mask (77.0%), and practicing social distancing (70.9%). Youth also reported experiencing challenges with housing during the pandemic, with 34% having changes to their housing situation, nearly 30% feeling worried about their mental health, and 27% of prescription medicine users having trouble getting the medications that they needed to manage their mental health conditions.

As a precursor to the random forest model, bivariate distributions of antibodies and each of the 10 predictors are displayed in Table 4. Vaccine status ($p < .001$), worry about mental health after COVID-19 ($p = .030$), and age of the participant ($p = .034$) were associated with the

antibody type. Older participants and those who were worried about their mental health after COVID-19 but did not seek help were less likely to possess antibodies against COVID-19. Among these associations, only vaccine status was statistically significant after making the Bonferroni adjustment for multiple inferences. Unvaccinated participants were far more likely to lack antibodies for COVID-19 (OR = 5.5, 95% CI 2.6, 12.9).

Generalized R-square and entropy R-square values for the random forest model were .326 and .156, respectively, on the validation data, averaged over the five folds. The area under the receiver operating characteristic curve (AUROC) indicated that among the three levels of the outcome, prediction of absence of antibodies was the most successful (AUROC = .861), followed by antibodies due to vaccine (AUROC = .694), and antibodies due to natural infection (AUROC = .638). Overall, the misclassification rate was 46%, averaged on the five folds, with a large portion of the confusion observed between the prediction of antibodies due to vaccine and natural infection. Nearly 71% of cases without antibodies were correctly identified on validation data.

Contributions of predictors to the model are displayed in Table 5. The top five predictors were age, vaccine status, shelter type, race, and worry about mental health after COVID-19. Vaccinated participants were more likely to have antibodies due to the vaccine and less likely to have antibodies because of natural infection or lack of antibodies altogether. The relationship to age was nonlinear, with the peak chance of antibodies due to natural infection being found at age 21. Sheltering at a friend or family home was associated with a higher likelihood of antibodies due to natural infection than in adult or youth shelters or staying at one's own place. Hispanic

youth were most likely to lack antibodies to COVID-19, and White youth were least likely to possess antibodies due to natural infection; however, they were also most likely to have no antibodies to COVID-19. Participants who were not worried about their mental health had a higher chance of possessing antibodies by reason of natural infection.

In contrast, those worried but did not seek help were least likely to possess vaccine-related antibodies. It is vital to note that many interaction effects in the model result in complex relationships of the predictors to the type of antibody. The results previously described are conditional upon holding all other predictors at their most likely values.

Discussion

YEH are at greater risk of exposure due to congregate living situations and have worse health outcomes from COVID-19. To mitigate the spread, uptake of the COVID-19 vaccine is needed. Yet, YEH are often unvaccinated when compared to stably housed youth. We found that vaccine rates were moderate at 42%, better than in other studies with YEH (Tucker et al., 2022). This could, in part, be due to the high proportion of participants who were recruited from shelters where access to vaccines and vaccination requirements were often in place as transmission mitigation strategies. Vaccination uptake was likely partially attributable to the vaccine requirements put in place by the shelters once vaccines became readily available to prevent outbreaks among their residents and staff. Despite these efforts, rates of natural infection were high—as were rates of asymptomatic infection—suggesting that vaccination coupled with universal testing may further improve infectious disease control measures in youth shelters.

While infection rates were high and differences by vaccine status, age, and worry about mental health after COVID-19 were found, unlike other studies, we found no difference in infection rates by gender identity (Baggett et al., 2020). This may be due to the requirement of vaccination among those staying in shelters during the peak of the pandemic. Surprisingly, several participants with anti-spike antibodies were unvaccinated. It is likely that these anti-spike antibodies were acquired due to a natural infection. Antinucleocapsid antibodies from natural infection may be lost more rapidly than anti-spike antibody (Castro Dopico et al., 20221; Movsisyan et al., 2022).

Fewer youth reported experiencing any symptoms as compared with other PEH studies where researchers found closer to one-third of participants experienced symptoms (Ahillan et al., 2023). This could, in part, be due to a younger sample. Yet, while few youths self-reported that they had been diagnosed with COVID-19, about half had antibodies indicating that they had contracted the virus. High rates of asymptomatic infection suggest that widespread PCR testing versus symptoms assessments would be a more accurate indication of infection prevalence within homeless youth populations and could be especially beneficial following outbreaks for this group of individuals.

Limitations

This study is not without limitations that should be considered when interpreting the findings. First, this study was conducted during a pandemic that affected all aspects of community-based recruitment and implementation of study protocols. Second, the outcome measures used in this study were newly developed and lacked psychometric data customarily

found with more mature measures. Finally, the study took place over a period of the pandemic with rapid changes in information and understanding, including the development and dissemination of multiple vaccines. Further, longitudinal studies are needed to assess the long-term effect of COVID-19 infection and the pandemic among marginalized populations such as YEH.

Conclusion

YEH face poorer outcomes when infected with COVID-19, likely due to low vaccination rates, disrupted access to health care and social supports, and underlying chronic conditions. Vaccination and risk mitigation strategies are especially needed for sheltered youth who are at higher risk of contracting COVID-19 yet often are asymptomatic. Nurses, health care providers, and social services agencies such as shelters and drop-in centers can partner with city and county organizations to ensure adequate protective supplies and resources are available to promote hand washing, masking, and social distancing. Health and social service providers can work with local networks to increase vaccine availability and uptake, as well as rapid PCR testing availability, and ensure resources are readily available to help youth and shelter staff prevent the spread of infection. Providers at county and city health departments should prioritize vaccination dissemination and testing in areas of congregate living to reduce the health disparities experienced by already vulnerable populations during a pandemic. Nurses are integral to addressing the compounding and intersecting disparities experienced by YEH related to the pandemic.

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Table 1

*Sample Characteristics (*N = *265)*

Characteristic		
Average Age	21.93 (2.23)	
	n	%
Gender		
Male	137	51.7
Female	110	41.5
Transgender Male	3	1.1
Transgender Female	9	3.4
Genderqueer	3	1.1
Other	1	0.4
Decline to answer	1	0.4
Unknown	1	0.4
Race/Ethnicity		
Black	163	61.5
Hispanic	48	18.1
Other	18	6.8
White	33	12.5
Unknown	3	1.1
Sexual Orientation		
Gay	23	8.7
Lesbian	16	6.0
Straight or heterosexual	170	64.2
Bisexual	41	15.5
Pansexual	8	3.0
Something else	5	1.9
Unknown	2	0.8
Last Night's Shelter		
Youth shelter (emergency, temporary)	118	44.5
Adult shelter (emergency, temporary)	34	12.8
My own place	31	11.7
Friend's home	26	9.8
Family home	16	6.0
Hotel, motel	10	3.8
Street, park, or outside	9	3.4
Home of my boyfriend, girlfriend, sex partner	7	2.6
Transitional living program	6	2.3
Abandoned building or squat	3	1.1
Foster family home	2	0.8
Car, bus, light rail, or metro	1	0.4
Other, please specify	1	0.4
Unknown	1	0.4

Table 2

*COVID-19 Symptoms, Antibodies, and Vaccination Status (*N*=265)*

COVID-19 Characteristic	Subgroups	*n*	%
Self-Reported COVID-19 Symptoms			
Experienced 1+ symptoms		32	12.1
No symptoms		233	87.9
Self-Reported COVID-19 Diagnosis			
No		210	79.2
Yes		48	18.1
Not Sure		3	1.1
Unknown		4	1.5
COVID-19 Antibodies			
Antibody IgG present		180	67.9
	ELISA Test Results		
	Positive (Natural Infection)	80	44.4
	Negative	85	47.2
	Borderline	15	8.3
Antibody absent		84	31.7
Unknown		1	0.4
Self-Reported Vaccination Status			
Vaccinated		111	41.9
	Type of vaccine		
	Pfizer	47	42.3
	Moderna	39	35.1
	Johnson & Johnson	6	5.4
	Do not know	17	15.3
Unvaccinated		152	57.4
Unknown		2	0.8

Table 3

*Prevention Behaviors, Housing, Mental Health, and Access to Care (*N*=265)*

Behavior and Mental Health Characteristic	Subgroups	*n*	%
Prevention Behaviors			
Washed hands		219	82.6
Wear a mask		204	77.0
Social distancing		188	70.9
Try to stay in one place		134	50.6
Something else		18	6.8
Nothing		14	5.3
COVID-19 Impact on Housing			
Change experienced		90	34.0
No change		166	62.6
Unknown		9	3.4
Worried about Mental Health after COVID-19			
Yes		79	29.8
	Met with mental health provider		
	Yes	46	58.2
	No	32	40.5
	Unknown	1	1.3
No		183	69.1
Unknown		3	1.1
Mental Health Prescription Meds Used			
Usually take meds		59	22.3
	Trouble Getting Prescriptions since COVID-19		
	Yes	16	27.1
	No	35	59.3
	I have not tried since COVID-19 began	8	13.6
Non-user		203	76.6
Unknown		3	1.1

Table 4

Bivariate relationships of antibodies to predictors, sorted by their p values.

	Antibodies			
Predictor	None	Anti-spike	From Infection	*p* value[*a]
Vaccine status				< .001
Vaccinated	5 (6%)[*b]	55 (65%)	51 (54%)	
Unvaccinated	79 (94%)	29 (35%)	44 (46%)	
Worried about Mental Health after COVID-19				.030
No	50 (60%)	63 (77%)	70 (74%)	
Yes, met provider	16 (19%)	14 (17%)	16 (16%)	
Yes, but did not seek help	18 (21%)	5 (6%)	9 (10%)	
Age	22.4 (2.1)[*c]	21.6 (2.4)	21.8 (2.2)	.034
COVID-19 Impact on Housing				.061
Unchanged	46 (56%)	59 (74%)	61 (65%)	
Change experienced	36 (44%)	21 (26%)	33 (35%)	
Race				.125
Black	51 (62%)	46 (54%)	66 (69%)	
Hispanic	15 (18%)	17 (20%)	16 (17%)	
White	11 (13%)	16 (19%)	6 (6%)	
Other	5 (6%)	6 (7%)	7 (7%)	
Gender				.378
Male	37 (44%)	51 (60%)	49 (52%)	
Female	41 (49%)	30 (35%)	39 (41%)	
Other	6 (7%)	4 (5%)	6 (6%)	
Shelter				.429
Youth shelter	30 (36%)	42 (49%)	46 (48%)	
Friend/family home	14 (17%)	14 (16%)	14 (15%)	
Other	17 (20%)	9 (11%)	13 (14%)	
Adult shelter	9 (11%)	12 (14%)	13 (14%)	
My own place	14 (17%)	8 (9%)	9 (9%)	
Preventive Behaviors				.510
Three or more	64 (76%)	55 (65%)	64 (67%)	
One or two	16 (19%)	25 (29%)	24 (25%)	
None	4 (5%)	5 (6%)	7 (7%)	
Sexual Orientation				.745
Heterosexual	51 (61%)	59 (70%)	60 (63%)	
Bisexual	13 (15%)	11 (13%)	17 (18%)	
Gay or Lesbian	14 (17%)	11 (13%)	14 (15%)	
Other	6 (7%)	3 (4%)	4 (4%)	
Mental Health Prescription Meds Used				.830
Non-user	67 (81%)	63 (75%)	73 (77%)	
User, no difficulty after COVID	12 (14%)	14 (17%)	17 (18%)	
User, difficulty due to COVID	4 (5%)	7 (8%)	5 (5%)	

Note. [*a]Pearson chi-squared test for categorical variables and F-test for continuous variables.
[*b]Frequency and (Column %)
[*c]Mean and (SD)

Table 5

Contribution of predictors to the random forest model. The portion measures the contribution of each predictor to the sum of likelihood ratio chi-squared values, denoted G^2.

Term	Number of Splits	G^2	Portion
Vaccine status	114	71.81	0.418
Age	768	26.35	0.153
Shelter	331	15.05	0.088
Race	260	11.36	0.066
Sexual orientation	222	9.92	0.058
Worried about mental health after COVID-19	215	9.86	0.057
Gender	248	8.00	0.047
COVID-19 impact on housing	236	7.64	0.045
Preventive behaviors	211	7.49	0.044
Mental health prescription meds	126	4.41	0.026