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Prevalence of SARS-CoV-2 antibodies during phased access to vaccination: results from a population-based survey in New York City, September 2020–March 2021

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Short Paper

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Abstract

Repeated serosurveys are an important tool for understanding trends in severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection and vaccination. During 1 September 2020–20 March 2021, the NYC Health Department conducted a population-based SARS-CoV-2 antibody prevalence survey of 2096 NYC adults who either provided a blood specimen or self-reported the results of a previous antibody test. The serosurvey, the second in a series of surveys conducted by the NYC Health Department, aimed to estimate SARS-CoV-2 antibody prevalence across the city and for different groups at higher risk for adverse health outcomes. Weighted citywide prevalence was 23.5% overall (95% confidence interval (CI) 20.1–27.4) and increased from 19.2% (95% CI 14.7–24.6) before coronavirus disease 2019 vaccines were available to 31.3% (95% CI 24.5–39.0) during the early phases of vaccine roll-out. We found no differences in antibody prevalence by age, race/ethnicity, borough, education, marital status, sex, health insurance coverage, self-reported general health or neighbourhood poverty. These results show an overall increase in population-level seropositivity in NYC following the introduction of SARS-CoV-2 vaccines and highlight the importance of repeated serosurveys in understanding the pandemic's progression.

Repeated serological surveys of antibody prevalence can improve our understanding of the trajectory of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic by providing insight into the antibody response generated by prior and recent infections (including those that are asymptomatic), and vaccination against SARS-CoV-2. Antibodies from SARS-CoV-2 infections wane over time, and vaccination induces antibodies against the virus irrespective of prior infection, complicating the interpretation of prevalence surveys of SARS-CoV-2 antibodies and cumulative estimates of infection and immunity [1]. Nonetheless, repeated prevalence surveys of SARS-CoV-2 antibodies can provide information on the distribution of infection and vaccination within a population. They can also provide valuable details for determining risk factors for infection and seroconversion, informing public health preparedness plans for future SARS-CoV-2 epidemic waves and vaccine prioritisation strategies.

For example, epidemiological surveillance and survey data in NYC and across the country have helped identify disparities in the burden of disease from coronavirus disease 2019 (COVID-19). During 1 June–9 October 2020, the NYC Department of Health and Mental Hygiene (DOHMH) conducted a population-based serology survey for SARS-CoV-2 (NYC SARS-CoV-2 antibody prevalence survey) in NYC and found that nearly one in three Black and Latino adult residents had evidence of SARS-CoV-2 infection by October 2020, confirming early estimates from serosurveys done using convenience-based sampling [2–4]. Estimates from the NYC SARS-CoV-2 antibody prevalence survey also showed differences in antibody prevalence by borough of residence, language of interview and neighbourhood poverty, highlighting multiple factors linked to increased exposure risk in a population [2]. Improved understanding of these inequities led to targeted public health campaigns aimed at improving testing and health service utilisation among populations at high risk for SARS-CoV-2 exposures and severe outcomes due to COVID-19 and helped guide the development of a phased approach to SARS-CoV-2 vaccination in the winter of 2020/2021 [5].

In NYC, efforts to provide detailed population-based seroprevalence estimates continued with a second citywide serological survey implemented by the NYC DOHMH from 1 September 2020 to 20 March 2021. In addition to estimates stratified by participant

demographics, results from this serosurvey also provide representative temporal estimates of SARS-CoV-2 antibody prevalence to assess seroprevalence during the first months after COVID-19 vaccines became available in NYC.

Participants were recruited from Healthy NYC, a population-representative, probability-based panel of ∼13 000 NYC adults ≥18 years old, managed by the NYC DOHMH Division of Epidemiology. Panellists were recruited from address-based samples, supplemented with individuals who had completed other probability-based surveys and had agreed to be recontacted for future research.

From August 2020 to February 2021, monthly, cross-sectional surveys were conducted with Healthy NYC panellists. For each survey, a stratified random sample of ∼2000 panellists were invited by mail, email and/or text with up to five reminders for non-respondents. Surveys could be completed online, with alternative options for non-Internet users. Surveys were available in English, Spanish, Russian or Chinese (phone or mailed paper survey). Participants could either provide a self-reported antibody test result, a blood specimen for serological testing or both. Of the 7629 people who were invited to take the Healthy NYC COVID-19 surveys, 1935 agreed to be contacted to have their blood drawn; 1201 were reached by phone, 853 scheduled an appointment and 763 completed the blood draw. An additional 1333 provided self-reported serology results for a total of 2096 antibody test results.

For each consenting participant, 5 ml of whole blood was collected and transported at 4 °C to the NYC Public Health Laboratory where serum was separated from the specimen and tested for SARS-CoV-2 immunoglobulin G (IgG) antibodies against spike protein using the DiaSorin LIAISON® SARS-CoV-2 S1/S2 IgG assay as previously described [2].

We generated univariate prevalence estimates and 95% confidence intervals (CI) for combined antibody test results and self-reported test results to estimate citywide and stratified prevalence. For those who provided both a blood specimen and a self-reported test result, we used only serosurvey specimens tested by DOHMH. SAS EG v7.15 and SUDAAN 11.0.1 were used to account for weights and complex survey design. The *t* tests were used to compare antibody prevalence by sex, age, race/ethnicity, borough of residence, place of birth, language of interview, neighbourhood poverty and health insurance status. Two-sided *P* values ≤0.05 were statistically significant.

Data were grouped into three time periods corresponding to COVID-19 vaccine eligibility groups defined by the phased COVID-19 vaccine rollout in New York State (NYS): no access, limited access and expanded access [5]. Respondents were classified as having no access to the vaccine if they gave a blood specimen or reported a previous antibody test before 14 December 2020. Once a vaccine became available, vaccine priority groups were established by the New York State Department of Health based on exposure risk, and early priority for vaccine administration was given to front-line health care staff, high risk long-term care facility patients and those working in essential services [5]. Respondents who provided a blood specimen or reported a previous antibody test between 14 December 2020 and 1 February 2021 were considered to have limited access to the vaccine since access was limited to the professional categories outlined above, along with New Yorkers aged 75 years and older. Respondents who provided a blood specimen or reported a previous antibody test between 2 February 2021 and the last day of specimen collection, 20 March 2021, were classified as having expanded access to the vaccine. However, data collection was completed before vaccine eligibility expanded to all adults living or working in NYC.

Individual weights were developed to account for unequal probability of selection, nonresponse and potential overlap in sampling frames. These weights were further trimmed and raked using population control totals from the 2015–2019 and 2019 American Community Survey. In addition, three period-specific weights were generated to make each vaccine period-specific estimates representative of NYC non-institutionalised adult population by repeating the weighting method.

The NYC DOHMH Institutional Review Board determined this activity to be public health surveillance. Written consent was obtained from participants before specimen collection.

The overall combined weighted SARS-CoV-2 antibody prevalence for those who provided either a blood specimen or a self-reported result was 23.5% (95% CI 20.1–27.4; Table 1). Antibody prevalence did not vary by age, race/ethnicity, borough, education, marital status, sex, health insurance coverage, self-reported general health or neighbourhood poverty. Respondents during the expanded vaccine access period had significantly higher seroprevalence (31.3%, 95% CI 24.5–39.0, $P < 0.001$) compared with those surveyed during the no vaccine access period (19.2%, 95% CI 14.7–24.6; Table 2).

From combined self-reported data and blood specimens collected between 1 September 2020 and 20 March 2021, we estimate that at least 23% of NYC residents had antibodies to SARS-CoV-2. This is similar to the prevalence (23.4%) we reported for the first NYC SARS-CoV-2 antibody prevalence survey conducted during June through October 2020 [2]. Compared with the 2020 study, we found a lower proportion of Black and Latino residents with antibodies to SARS-CoV-2, while more White New Yorkers had antibodies. Our temporal estimates of seropositivity show a steady increase in citywide seroprevalence from September 2020 to March 2021.

Two changes during the pandemic contributed to the observed increase in citywide seropositivity over the survey period. First, the survey implementation timeline roughly corresponds to the introduction of COVID-19 vaccines. By the time the last specimen was collected, almost 70 000 doses of COVID-19 vaccine were being administered daily in NYC with more than 1.6 million doses administered since December 2020 [6]. Additionally, the second NYC SARS-CoV-2 antibody prevalence survey was implemented during a time when NYC, like much of the USA, was experiencing heightened COVID-19 transmission. During the survey implementation period alone, the city recorded more than 450 000 new COVID-19 cases [6].

Given the high prevalence of COVID-19 transmission, along with the introduction of vaccines which trigger immune responses detectable through the assay used for this serosurvey, we expected to see an increase in citywide seropositivity for the full survey period when compared to the first survey implemented in mid-2020. However, no increase was found when comparing combined specimens collected during the first and second rounds of NYC's SARS-CoV-2 antibody prevalence survey, suggesting a potential waning in population-level coverage of antibodies acquired from natural infection. Estimates prepared by the U.S. Centers for Disease Control and Prevention (CDC) using residual blood specimens collected from participating commercial laboratories suggest similar patterns across New York State. In August

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Table 1. SARS-CoV-2 antibody prevalence among adult NYC residents, stratified by demographic variables, September 2020–March 2021, healthy NYC

Characteristics	Sample size	Weighted % positive	95% CI	*P*-value
Total	2096	23.5	20.1–27.4	
Age group				
18–44	995	24.6	19.6–30.8	0.653
45–64	700	23.2	17.8–29.6	0.894
65+	388	22.5	15.4–31.7	Ref
Race/ethnicity				
White	1074	20.9	16.2–26.5	Ref
Black/African-American	258	24.2	16.2–34.3	0.540
Latino/Hispanic	400	30.1	22.5–39.0	0.065
Asian	250	16.7	9.9–26.7	0.400
Other	71	14.7	5.4–34.2[a]	0.411
BORO (NYC borough of residence)				
Bronx	258	26.3	17.8–37.1	Ref
Brooklyn	654	26.8	20.1–34.9	0.928
Manhattan	617	20.5	15.9–26.0	0.302
Queens	472	20.8	14.7–28.6	0.370
Staten Island	95	22.7	8.5–8.0	0.752
Education				
Grade 1–12 or GED (HS or less)	278	26.4	19.4–34.8	0.117
College 1 year to 3 years (some college)	351	24.4	18.6–31.2	0.192
College 4+ years or graduate/professional degree	1466	19.8	17.3–22.6	Ref
Current marital status				
Single or never married	755	21.3	15.4–28.6	Ref
Married or living with a partner (cohabitating)	991	23.6	19.2–28.7	0.576
Widowed, Divorced or separated (previously married)	348	28.0	19.2–38.8	0.271
Sex assigned at birth				
Male	751	23.9	18.6–30.2	Ref
Female	1336	23.4	19.0–28.4	0.886
Birth country				
United States, including PR, Guam, VI and U.S. territories	1510	20.9	17.0–25.4	Ref
Outside of the United States	586	28.0	21.8–35.2	0.079
Health insurance coverage				
Yes	1949	24.1	20.4–28.3	Ref
No	124	20.8	12.3–33.1[a]	0.564
Neighbourhood poverty level				
<10% below poverty	551	20.5	14.4–28.4	Ref
10 to <20% below poverty	932	24.7	19.2–31.2	0.377
20%+ below poverty	588	24.1	18.5–30.7	0.454
General health				
Excellent/very good/good	1863	24.0	20.2–28.3	0.651
Fair/poor	222	21.8	14.3–31.8	Ref

[a]Estimate should be interpreted with caution. Estimate's relative standard error (a measure of estimate precision) is greater than 30%, or the 95% confidence interval half-width is greater than 10, or the sample size is too small, making the estimate potentially unreliable.

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Table 2. SARS-CoV-2 antibody prevalence among adult NYC residents, stratified by vaccine access time period, September 2020–March 2021, healthy NYC

	Sample size	Weighted % positive	95% CI	*P*-value
Total	2096	23.5	20.1–27.4	
No vaccine access	1017	19.2	14.7–24.6	Ref
Limited vaccine access	543	23.5	16.5–32.3	0.369
Expanded vaccine access	536	31.3	24.5–39.0	<0.0001

2020, the CDC estimated that approximately 23% of New York State residents had antibodies that target the nucleocapsid proteins of the SARS-CoV-2 virus, indicating likely recent infection. By November, this estimate fell to 13% [7]. A similar assessment of spike and nucleocapsid antibodies found in donated blood showed that while nationally seropositivity for any SARS-CoV-2 antibodies increased between December 2020 and June 2021, this increase was driven by vaccination [8].

Evidence of waning immunity from other population-based serological surveys is limited. While several other serosurveys were implemented in the spring and summer of 2020 in NYC and found similar results to the first NYC SARS-CoV-2 antibody prevalence survey [3, 4] this is the first report of seroprevalence estimates from the winter of 2020–2021 in NYC and one of the few serosurveys, globally, to report on repeated population-based testing of residents [9].

While these seroprevalence estimates are helpful in understanding the potential susceptibility of NYC residents to future SARS-CoV-2 infection, there are some limitations. The assay used for this serosurvey only identifies antibodies to the spike (S) protein and does not differentiate between antibodies developed in response to natural infection and those developed following vaccination. The assay also does not provide information about the neutralising capabilities of detected antibodies. Additionally, this serosurvey did not collect the date of the self-reported antibody tests and it is possible that tests took place prior to September 2020. Seroprevalence estimates based on blood specimens alone are higher than estimates using the combined sample, around 31%, but the blood specimen sample is too small to provide reliable estimates for subgroups or vaccine access periods. Although interpretation is limited based on the small sample size, this higher prevalence may be a function of a smaller sample that includes a higher proportion of vaccinated individuals – 80% of the blood specimens were drawn after a vaccine became available compared to 52% of self-reports received before vaccine availability. Finally, while this serosurvey provides a snapshot of population-level immunity to SARS-CoV-2 infection in the winter of 2020–2021, the implementation period included only the beginning of a major vaccination campaign. As a result, we expect the seropositivity in NYC after March 2021 to be higher than that observed during the survey period, due primarily to vaccination. A third serosurvey has been implemented from April to October 2021 and is expected to help illuminate the extent of population-level seroprevalence resulting from NYC's vaccination campaign.

Finally, we caution interpretation of these temporal trends in seropositivity, which show, in contrast to the first serosurvey [2], similar seropositivity between Black, Latino and White NYC residents. These findings likely reflect the combination of inequities in SARS-CoV-2 infection as well as inequities in vaccination [6, 10]. In late January 2021, Black and Latino New Yorkers accounted for only 11% and 15%, respectively, of COVID-19 vaccinations while accounting for 24% and 29% of the city's population. Gaps in vaccination rates between White and Latino New Yorkers have diminished since data were collected for this survey, but Black New Yorkers continue to be vaccinated at lower rates and have experienced a higher burden of disease, hospitalisation and death in recent months as a result [6].

Repeated surveys of SARS-CoV-2 antibody prevalence are important tools in the city and the nation's response to the ongoing COVID-19 pandemic. Our understanding of these inequities and our ability to address them can be further advanced by use of multiple assays that distinguish between population-level prevalence of antibodies developed as a response to immunisation and recent natural infection. Continued temporal monitoring will be crucial to ensuring that the public health response, including vaccine distribution plans and prioritisation strategies, address issues of inequity.

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Conflict of interest. None.

Data availability statement. Data are available upon reasonable request to the corresponding author.

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