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Brief communication

Persistent disparities in SARS-CoV-2 test percent positivity by neighborhood in New York City, March 1–July 25, 2020

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Abbreviations, SES, socioeconomic status NYC, New York City NYCDOHMH, New York City Department of Health and Mental Hygiene modZCTA, modified ZIP Code tabulation area ACS, American community survey CI, confidence interval

A B S T R A C T

Purpose: To examine neighborhood-level disparities in SARS-CoV-2 molecular test percent positivity in New York City (NYC) by demographics and socioeconomic status over time to better understand COVID-19 inequities.

Methods: Across 177 neighborhoods, we calculated the Spearman correlation of neighborhood characteristics with SARS-CoV-2 molecular test percent positivity during March 1–July 25, 2020 by five periods defined by trend in case counts: increasing, declining, and three plateau periods to account for differential testing capacity and reopening status.

Results: Percent positivity was positively correlated with neighborhood racial and ethnic characteristics and socioeconomic status, including the proportion of the population who were Latino and Black non-Latino, uninsured, Medicaid enrollees, transportation workers, or had low educational attainment. Correlations were generally consistent over time despite increasing testing rates. Neighborhoods with high proportions of these correlates had median percent positivity values of 62.6%, 28.7%, 6.4%, 2.8%, and 2.2% in the five periods, respectively, compared with 40.6%, 11.7%, 1.7%, 0.9%, and 1% in neighborhoods with low proportions of these correlates.

Conclusions: Disparities in SARS-CoV-2 molecular test percent positivity persisted in disadvantaged neighborhoods during multiple phases of the first few months of the COVID-19 epidemic in NYC. Mitigation of the COVID-19 burden is still urgently needed in disproportionately affected communities.

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Introduction

The COVID-19 burden in the United States varies by race and ethnicity and socioeconomic status (SES). Due to limited availability of individual-level data, such disparities have been evidenced by neighborhood-level data, where higher morbidity and mortality have been identified in communities of color and areas of high poverty [1]. In New York City (NYC), where neighborhoods are highly segregated demographically and socioeconomically, COVID-19 incidence, hospitalization, and mortality rates have been highest among Black/African American and Latino persons [2]. However, temporal trends in COVID-19 disparities have rarely been examined.

Several studies have examined cross-sectional relationships between neighborhood characteristics and COVID-19 burden in the United States [1,3,4]. However, cross-sectional data do not reflect the substantial changes in risk for SARS-CoV-2 infection, availability of testing, scale of reopening, and increasing public awareness related to nonpharmaceutical interventions such as mask wearing and social distancing over the course of the epidemic. During the early period of the epidemic when COVID-19 cases were surging in the United States, SARS-CoV-2 testing was limited to severe, symptomatic cases, leading to a vast underestimation of community level burden [5]. Prominent disparities in COVID-19 hospitalizations between people of color and White non-Latino residents were reported during this early phase of the epidemic [6]. Such disparities in severe COVID-19 cases may be in part attributable to

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the higher burden of comorbidities in socioeconomically disadvantaged population. A study in Georgia also found persistent COVID-19 disparities by race and ethnicity in a later phase of the epidemic after the state reopened [7], potentially reflecting infection risk in communities related to the residents’ occupation and other socially-determined exposure risks.

We aimed to describe disparities in COVID-19 during the first few months of the epidemic in NYC to understand the magnitude of the disparities in the context of changing case and testing rates and gradual reopening. We examined time-varying correlations between neighborhood characteristics and SARS-CoV-2 molecular test percent positivity during March 1–July 25, 2020, a period with increasing, declining, and plateauing COVID-19 cases in NYC. Characterizing disparities in a setting with considerable racial and social segregation can inform program planning and resource allocation for both the ongoing COVID-19 epidemic and future respiratory disease outbreaks.

Materials and methods

We divided the time frame March 1–July 25, 2020 into five periods, each starting on a Sunday to limit day-of-week effects, based on the citywide trend in cases: (1) increasing period, March 1–April 11 (42 days); (2) declining period, April 12–May 9 (28 days); and three plateau periods, in (3) May (May 10–May 30) (21 days), (4) June (May 31–June 27) (28 days), and (5) July (June 28–July 25) (28 days) [8]. The three plateau periods were defined to approximately reflect different testing guidelines and reopening phases. In NYC, testing was initially limited to hospitalized patients but was widely available commercially by mid-May, when testing was recommended for people with symptoms or exposures and staff of congregate residential settings [9]. New Yorkers were encouraged to get tested regardless of symptoms or exposures on June 2, followed by phased reopening of businesses and resumption of social gatherings on June 8, June 22, July 6, and July 20 [10–11].

The NYC Department of Health and Mental Hygiene (NYC DOHMH) receives SARS-CoV-2 test results of NYC residents from clinical and commercial laboratories and geocodes residents’ addresses. We deduplicated the molecular testing data, by person and period, and calculated percent positivity (defined as the number of individuals testing positive divided by the number of individuals tested) and testing rate per 100,000 residents (defined as the number of individuals tested divided by the population estimate in 2018 [produced by NYC DOHMH using US Census Bureau interpolated intercensal population estimates with modification]) per neighborhood (modified ZIP Code tabulation area [modZCTA], n = 177). Residents of congregate living facilities were excluded to focus on community-based transmission. We calculated the Spearman correlation coefficients (r_s) with modZCTA-level demographic and SES variables. We used SARS-CoV-2 test percent positivity instead of case rate as our COVID-19 indicator of interest to limit bias from variation in healthcare seeking behavior across neighborhoods.

We obtained neighborhood characteristics from the 2014 to 2018 American Community Survey (ACS) covering various domains, including demographics, SES, and occupations related to essential workers (specifically, healthcare, protection services, food preparation and serving, and transportation). Table 1 lists the variables analyzed and the corresponding ranges of prevalence and median values for all NYC modZCTAs. We identified characteristics showing statistically significant moderate or strong correlations, either positive (lower bound of 2-sided 95% confidence interval [CI] for r_s > 0.5) or negative (upper bound of 2-sided 95% CI for r_s < −0.5). We also conducted a hierarchical cluster analysis [12] to identify neighborhoods characterized by high proportions of consistently positive correlates of SARS-CoV-2 percent positivity across outbreak periods. Analyses were conducted using R 3.5.2 (R Foundation for Statistical Computing).

Results

SARS-CoV-2 test percent positivity declined citywide over the study period, ranging across neighborhoods from 30.4%–79.4% during the increasing period; to 7.0%–34.4% during the declining period; 0%–8.5% during May; 0.5%–3.9% during June; and 0.2%–3.4% during July (Fig. 1; Table 2). Testing rates by neighborhood grew from 1,060 to 4,732 per 100,000 residents during the increasing period to 3,628–10,590 during July (Appendix Table 1).

Correlations between percent positivity and neighborhood characteristics were generally stable over time but attenuated during July (Table 2). The following were significant positive correlates of percent positivity for at least the first four periods: the neighborhood proportion of persons aged ≥25 years with only a high school degree (r_s range: 0.62–0.86), Medicaid enrollees (r_s range: 0.76–0.84), uninsured residents (r_s range: 0.64–0.75), transportation workers (r_s range: 0.74–0.84), and Latino and Black non-Latino residents combined (r_s range: 0.68–0.74). These variables were included in the hierarchical cluster analysis. Characteristics that had significant negative correlations, with the exception of July, included the neighborhood proportion of college graduates (r_s range: −0.60–−0.86), residents with private insurance (r_s range: −0.75–−0.83), and White non-Latino residents (r_s range: −0.74–−0.82). The neighborhood proportion of Latino residents and food preparation and serving workers were significantly and positively correlated with percent positivity during some periods, but this pattern was inconsistent. No neighborhood characteristics were consistently significantly correlated with testing rate (Appendix Table 1). Several characteristics reversed directionality in correlation with testing rate between early and later periods of the epidemic. For example, despite nonsignificance, the neighborhood proportions of college graduates, residents with private insurance, and White/non-Latino residents were negatively correlated with testing rates in the increasing and declining periods but were positively correlated in June and July.

Neighborhoods with high proportions of characteristics positively correlated with percent positivity clustered in Southern and Central Bronx and Central Queens/Brooklyn (Appendix Fig. 1). These neighborhoods combined had median SARS-CoV-2 test percent positivity of 62.6%, 28.7%, 6.4%, 2.8%, and 2.2% in the five periods, respectively; in contrast, neighborhoods with low proportions of the positive correlates had median test percent positivity of 40.6%, 11.7%, 1.7%, 0.9%, and 1.0% (Fig. 1).

Discussion

Through the first five months of the COVID-19 epidemic in NYC, SARS-CoV-2 molecular test percent positivity was generally highly correlated with certain neighborhood characteristics, including a population of color, low educational attainment, lack of health insurance or enrollment in Medicaid, and a population of transportation workers, regardless of the outbreak period, testing guidelines or capacity, or neighborhood-level testing rates. These findings are consistent with previous findings [1,3,4,13], and indicate persistent COVID-19 disparities in neighborhoods with a higher proportion of people of color and residents with lower SES. The disparities likely reflect their persistence of socioeconomic disadvantages and higher burden of comorbidities, which might have contributed to a higher rate of severe disease including hospitalization, and a corresponding increased percent positivity in these neighborhoods.

The differences noted in correlation for SARS-CoV-2 molecular test percent positivity in the July period may reflect changing habits of testing over the summer of 2020. As seen in our data,
Table 1
Selected neighborhood characteristics from 2014 to 2018 American Community Survey (ACS) and the ranges of prevalence and median values across modified ZIP Code tabulation areas (n = 177) in New York City

| Neighborhood characteristics | Median prevalence (range) |
|------------------------------|---------------------------|
| Demographics                |                           |
| % Age 65+ years             | 13.6 (0.5–29.0)           |
| % Male                      | 47.8 (40.8–59.3)          |
| Race and ethnicity          |                           |
| % White non-Latino          | 36.2 (0.8–91.6)           |
| % Latino                    | 18.9 (1.1–75.8)           |
| % Black non-Latino          | 7.4 (0.4–90.5)            |
| % Latino and Black non-Latino combined | 39.9 (4.0–98.3) |
| % Asian non-Latino          | 9.4 (0.07–72.6)           |
| Highest educational attainment among population of 25+ years of age | |
| % High school graduates     | 42.5 (1.6–71.1)           |
| % College graduates         | 34.0 (7.9–92.8)           |
| Health Insurance            |                           |
| % Uninsured                 | 7.0 (0.6–23.8)            |
| % Private insurance         | 53.2 (21.3–96.7)          |
| % Medicaid                  | 25.1 (0.3–57.1)           |
| Other socioeconomic status  |                           |
| % Crowding (households with > 2 occupants per room) | 0.6 (0.0–3.9) |
| % Non-US-born               | 34.8 (2.8–70.7)           |
| % Living below the federal poverty level | 13.8 (2.2–45.9) |
| % Households with limited English speaking | 10.6 (0.3–59.5) |
| Occupation among the civilian employed population of age 16+ years | |
| % Healthcare workers        | 16.1 (4.8–31.6)           |
| % Protection service workers | 2.6 (0.0–12.5)          |
| % Food preparation and serving workers | 4.4 (0.0–16.6) |
| % Transportation workers    | 4.8 (0.0–11.5)            |

The denominator of these ACS estimates includes residents living in housing units and group quarters, which include both institutional (e.g., correctional facilities, nursing homes) and non-institutional settings (e.g., college dormitories), except for % crowding and % households with limited English speaking. For % living below the federal poverty level, the denominator also slightly differs and excludes residents in institutional group quarters and some non-institutional group quarters.

Table 2
Spearman correlation coefficients of neighborhood characteristics with SARS-CoV-2 molecular test percent positivity at modified ZIP Code tabulation area level, during 5 outbreak periods* — New York City, March 1–July 25, 2020

| Percent positivity (range) | Spearman correlation coefficient |
|----------------------------|---------------------------------|
|                            | Increasing period | Declining period | Plateauing period - May | Plateauing period - June | Plateauing period – July |
| Neighborhood characteristics |                    |                  |                          |                          |                           |
| Demographics               |                    |                  |                          |                          |                           |
| % Age 65+ years            | −0.23              | −0.21            | −0.30                    | −0.33                    | −0.32                      |
| % Male                     | 0.10               | 0.05             | 0.04                     | 0.06                     | 0.11                       |
| Race and ethnicity         |                    |                  |                          |                          |                           |
| % White non-Latino         | −0.75              | −0.82            | −0.77                    | −0.74                    | −0.46                      |
| % Latino                   | 0.46               | 0.61             | 0.60                     | 0.54                     | 0.37                       |
| % Black non-Latino         | 0.47               | 0.50             | 0.50                     | 0.47                     | 0.20                       |
| % Latino and Black non-Latino combined | 0.68 | 0.74 | 0.72 | 0.70 | 0.40 |
| % Asian non-Latino         | −0.20              | −0.19            | −0.26                    | −0.29                    | −0.16                      |
| Highest educational attainment |                    |                  |                          |                          |                           |
| % High school graduates    | 0.78               | 0.82             | 0.86                     | 0.80                     | 0.62                       |
| % College graduates        | −0.78              | −0.83            | −0.86                    | −0.81                    | −0.60                      |
| Health Insurance           |                    |                  |                          |                          |                           |
| % Uninsured                | 0.71               | 0.75             | 0.71                     | 0.64                     | 0.43                       |
| % Private insurance        | −0.75              | −0.75            | −0.83                    | −0.75                    | −0.54                      |
| % Medicaid                 | 0.76               | 0.74             | 0.84                     | 0.76                     | 0.54                       |
| Other socioeconomic status |                    |                  |                          |                          |                           |
| % Crowding                 | 0.49               | 0.47             | 0.50                     | 0.48                     | 0.36                       |
| % Non-US-born              | 0.59               | 0.60             | 0.49                     | 0.46                     | 0.32                       |
| % Living in poverty        | 0.47               | 0.48             | 0.60                     | 0.52                     | 0.41                       |
| % Limited English speaking | 0.46               | 0.46             | 0.49                     | 0.42                     | 0.35                       |
| Occupation                 |                    |                  |                          |                          |                           |
| % Healthcare workers       | 0.15               | 0.28             | 0.23                     | 0.22                     | 0.07                       |
| % Protection service workers | 0.43             | 0.51             | 0.53                     | 0.51                     | 0.36                       |
| % Food preparation and serving workers | 0.63 | 0.64 | 0.65 | 0.59 | 0.47 |
| % Transportation workers   | 0.80               | 0.84             | 0.80                     | 0.74                     | 0.54                       |

Bold text indicates statistical significance based on 2-tailed 95% confidence interval.

* Specimen collection dates covered by each period are: increasing period (3/1–4/11), declining period (4/12–5/9), plateau period – May (5/10–5/30), plateau period – June (5/31–6/27), plateau period – July (6/28–7/25).
neighborhoods of higher SES showed increasingly positive correlation with testing rates toward the end of the study period. This might be related to increasing institutional requirements or desire for testing to rule out SARS-CoV-2 infection to participate in activities such as air travel or visiting family or friends. Given healthcare access barriers, wealthier NYC residents would have been more likely to readily access testing for rule-out purposes. If the higher testing uptake in these high SES neighborhoods had led to more detection of asymptomatic cases, the correlation between test percent positivity and low neighborhood-level SES might have been attenuated. One study found decreased gap in COVID-19 incidence between White persons and other ethnic groups during the fall and winter of 2020 but highlighted that such decrease was driven by increased incidence among White persons instead of reduced incidence in other ethnic groups [14].

Our findings of the persistent disparity in COVID-19 burden suggest that vulnerable communities should continue to be prioritized for resources to mitigate infection and the impact of COVID-19. Targeted and rapid campaigns for facilitating free and accessible testing in disadvantaged communities with culturally sensitive messaging should be considered during future outbreaks of both COVID-19 and other infectious diseases. Programs for addressing acute needs arising from the COVID-19 crisis, including food insecurity and unemployment, are crucial to mitigate the disproportionate economic impacts on these communities [15,16]. As vaccination continues in NYC (available to those aged ≥12 years as of May 12, 2021 [17]), these vulnerable communities should also be prioritized for promoting vaccination. A recent report indicates a lower uptake of and less intention for vaccination in the communities of color and lower SES in NYC, potentially related to concerns about vaccine development and distrust in government [18]. Continuing effort is needed to identify opportunities for addressing vaccine hesitancy, building a trusting relationship between these vulnerable communities and government, and engaging community-based organizations and local healthcare providers in informing strategies for facilitating vaccination.

Our findings are subject to some limitations. First, ecological analyses and neighborhood-level correlations do not demonstrate causation, although they are useful for hypothesis generation for future individual-level studies and identifying neighborhoods for tailored intervention. Second, we did not account for time-varying factors during the outbreak such as out-migration and unemployment. Third, 2014–2018 ACS estimates may not reflect the current characteristics of the communities due to different time periods and inclusion of residents in congregate settings.

Conclusions

Neighborhood-level disparities by race and ethnicity and SES persisted across the first several months of the pandemic in 2020 in NYC, despite dramatic changes in testing availability and non-pharmaceutical interventions like social distancing measures across time. Such disparities likely reflect upstream factors in social and economic structures that have contributed to an inequitable bur-
den of risks on these disadvantaged communities. In NYC, a City-led taskforce charged with racial inclusion and equity in the COVID-19 response has been working with community-based organizations to target resources like vaccination to high priority areas. Local, state, and the federal governments should continue to prioritize low SES communities to mitigate exposure and infection, reduce economic impact, and promote vaccination.

**Author contributions**

**Pui Ying Chan**: Conceptualization, Methodology, Investigation, Data Curation, Formal analysis, Visualization, Project administration, Writing - Original Draft, Writing- Reviewing and Editing. **Sharon K. Greene**: Methodology, Investigation, Writing- Reviewing and Editing. **Sung woo Lim**: Methodology, Investigation, Writing- Reviewing and Editing. **Anne Fine**: Supervision, Investigation, Writing- Reviewing and Editing. **Corinne N. Thompson**: Conceptualization, Investigation, Project administration, Supervision, Writing- Reviewing and Editing

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**Appendix**

Appendix Fig. 1 and Appendix Table 1.

**Appendix Fig. 1.** Map of New York City neighborhoods (modified ZIP code tabulation areas [modZCTA]; n = 177) showing results from a hierarchical cluster analysis categorizing neighborhoods by prevalence of positive correlates with SARS-CoV-2 PCR test percent positivity. The positive correlates included neighborhood proportions of (1) Latino and Black non-Latino residents combined, (2) persons with only a high school degree, (3) transportation workers, (4) Medicaid enrollees, and (5) uninsured residents. Neighborhoods with higher proportions of the last four characteristics are labelled as “low SES” (socioeconomic status) whereas neighborhoods with lower proportions are labelled as “high SES”. Borough labels: BX = the Bronx; BK = Brooklyn, MN = Manhattan; QN = Queens; SI = Staten Island.
Appendix Table 1

| Spearman correlation coefficient | Increasing period | Declining period | Plateauing period -May | Plateauing period -June | Plateauing period -July |
|----------------------------------|-------------------|------------------|------------------------|------------------------|------------------------|
| **Neighborhood characteristics** |                   |                  |                        |                        |                        |
| Demographics                     | 1.060–4.732       | 1.152–4.860      | 1.750–24.571           | 3.292–8.446            | 3.628–10.590           |
| % age 65+ years                  | 0.26              | 0.00             | -0.02                  | -0.06                  | -0.06                  |
| % male                           | -0.03             | -0.02            | 0.00                   | -0.02                  | -0.04                  |
| Race and ethnicity               |                   |                  |                        |                        |                        |
| % White non-Latino               | -0.23             | -0.50            | 0.07                   | 0.26                   | 0.39                   |
| % Latino                         | 0.23              | 0.49             | 0.11                   | -0.06                  | -0.15                  |
| % Black non-Latino               | 0.22              | 0.41             | 0.07                   | -0.10                  | -0.16                  |
| % Latino and Black non-Latino    | 0.32              | 0.58             | 0.07                   | -0.18                  | -0.28                  |
| % Asian non-Latino               | -0.31             | -0.39            | -0.17                  | 0.07                   | -0.01                  |
| Highest educational attainment  |                   |                  |                        |                        |                        |
| % high school graduates          | 0.36              | 0.63             | -0.13                  | -0.44                  | -0.55                  |
| % college graduates              | -0.48             | -0.70            | 0.14                   | 0.49                   | 0.60                   |
| Health Insurance                 |                   |                  |                        |                        |                        |
| % uninsured                      | 0.05              | 0.37             | -0.03                  | -0.13                  | -0.31                  |
| % private insurance              | -0.22             | -0.56            | 0.00                   | 0.30                   | 0.41                   |
| % Medicaid                       | 0.21              | 0.55             | 0.00                   | -0.34                  | -0.44                  |
| Other socioeconomic status       |                   |                  |                        |                        |                        |
| % crowding                       | 0.01              | 0.30             | 0.09                   | -0.01                  | -0.12                  |
| % non-US-born                    | 0.02              | 0.17             | -0.15                  | -0.24                  | -0.44                  |
| % living in poverty              | 0.01              | 0.10             | -0.07                  | -0.11                  | -0.20                  |
| % limited English speaking       | 0.03              | 0.26             | -0.01                  | -0.07                  | -0.11                  |
| Occupation                       |                   |                  |                        |                        |                        |
| % healthcare workers             | 0.56              | 0.44             | -0.13                  | -0.45                  | -0.46                  |
| % protection service workers     | 0.65              | 0.66             | -0.21                  | -0.56                  | -0.54                  |
| % food preparation and serving workers | 0.07 | 0.37           | 0.04                   | -0.11                  | -0.23                  |
| % transportation workers         | 0.50              | 0.67             | -0.11                  | -0.49                  | -0.62                  |

Bold text indicates statistical significance based on 2-tailed 95% confidence interval.

*Specimen collection dates covered by each period are: increasing period (3/1–4/11), declining period (4/12–5/9), plateau period – May (5/10–5/30), plateau period – June (5/31–6/27), plateau period – July (6/28–7/25).

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