COVID-19 MORTALITY IN NEW YORK CITY ACROSS NEIGHBORHOODS BY RACE, ETHNICITY, AND NATIVITY STATUS

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ABSTRACT. New York City has lost more lives from COVID-19 than any other American city. This study examines variation in COVID-19 deaths across neighborhoods as it relates to variation in the racial, ethnic, and nativity-status composition of neighborhoods. This topic has received little scholarly attention and is imperative to explore, given the absence of racial and ethnic specific COVID-19 mortality rates by neighborhood. New York City is a racially and ethnically segregated city, and a longstanding destination of immigrants, making some neighborhoods more susceptible to greater levels of COVID-19 mortality than others. Using ZCTA-level data on COVID-19 deaths and demographic data from the American Community Survey, our descriptive and bivariate choropleth mapping analyses reveal that a racial, ethnic, and nativity-status hierarchy exists in the geographic distribution of COVID-19 mortality. Implications of these findings are discussed as they relate to residential segregation and persistent spatial inequalities faced by neighborhoods of color.

Keywords: covid-19, residential segregation, racial/ethnic inequality, immigration

New York City (NYC) has experienced a significant share of deaths from COVID-19 within the United States (Wadhera and others 2020). At the time of this writing, four of the five counties—Bronx, Kings, Queens, and New York—that make up NYC have numbers of deaths in the top 20 counties out of the more than 3000 counties in the United States (USA Facts 2021). Out of all deaths from COVID-19 in the United States, one in 17.8 was in NYC (USA Facts 2021).

Research has shown that COVID-19 mortality rates in the United States vary by race and ethnicity (U.S. Centers for Disease Control and Prevention 2020). The percentages of Blacks and Hispanics dying from COVID-19 exceed their shares of the population, respectively, which is not the case for Whites and Asians (U.S. Centers for Disease Control and Prevention). Blacks and Hispanics in NYC also have higher rates of age-adjusted mortality than their White and Asian counterparts (Hooper and others 2020).

Racial- and ethnic-specific mortality rates are unavailable at the neighborhood level in NYC, making it difficult to pinpoint neighborhoods of color and immigrants that may be hardest hit by the pandemic. Recent research has found that nonwhite neighborhoods in NYC have higher numbers of positive COVID-19 tests than majority-White neighborhoods (DiMaggio and others 2020; Lieberman-Cribbin and others 2020). However, little research has explored the geographic variation in COVID-19 mortality rates across neighborhoods in NYC alongside the

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spatial variation in the racial, ethnic, and nativity-status composition of these neighborhoods. Byoungjun Kim and others (2021) and Usama Bilal and others (2021) explore variation at the neighborhood level in NYC, but they do not examine racial and ethnic groups by nativity status.

This study seeks to fill this gap and explores the geographic variation in COVID-19 mortality rates across neighborhoods in NYC, defined by Zip Code Tabulation Areas (ZCTA), as patterned by the racial, ethnic, and nativity-status compositions of the population. Moreover, we seek to advance the literature by using bivariate choropleth maps to describe the patterns of COVID-19 mortality across ZCTAs of color and immigrants in NYC. This study’s use of the bivariate choropleth mapping methodology provides a systematic way for researchers to simultaneously examine the geographic variation in COVID-19 mortality rates and the racial, ethnic, and nativity-status compositions of neighborhoods in NYC, and identify neighborhoods of color and immigrants that have endured the most deaths from the pandemic.

BACKGROUND

NEW YORK CITY AS A RESIDENTIALLY SEGREGATED CONTEXT AND IMMIGRANT DESTINATION

To understand how COVID-19 mortality rates vary across NYC’s neighborhoods and relate to the geographic variation in their racial, ethnic, and nativity-status composition of these neighborhoods, we first focus on two important characteristics that set NYC apart from many other cities in the United States. First, NYC has had unusually high levels of racial and ethnic residential segregation (Hotchkiss 2015; Massey and Tannen 2015). With respect to Black-White residential segregation, NYC has been demarcated as a “hyper-segregated” city continuously for five decades since 1970 (Hotchkiss 2015; Massey and Tannen 2015). In 2010, the index of dissimilarity or D-score (a measure of community segregation) was 81.4 indicating that, 81.4 percent of either Blacks or Whites would have to move to achieve an even distribution within the city (Logan and Stults 2011). This level of segregation falls in what is considered to be the “high range,” and in 2010, this score was the second-highest score among the 200 largest cities in the United States. (Massey and Denton 1993; Logan and Stults 2011). The D-score gauging Hispanic-White residential segregation was in the high range at 65.8 and was the second-highest level of Hispanic-White segregation out of the 200 largest cities in the United States (Logan and Stults 2011). The Asian-White level of segregation in NYC—50.6—was lower than the Black-White and Hispanic-White D-scores, but it was the seventh-largest value out of 200 of the largest cities in 2010 (Logan and Stults 2011).

Second, NYC has historically been a premier destination for immigrants from many countries throughout the world (Lobo and Salvo 2013). According to data from the 2019 American Community Survey (ACS), NYC had the largest foreign-born population, numbering 3.1 million, of any American city (U.S.
Census Bureau (2020a). What is unique about NYC’s immigrant population is that no one group of immigrants dominates the flow of foreign-born persons to the city, resulting in large shares of each racial and ethnic group having foreign-born origins (Lobo and Salvo 2013). According to 2019 ACS data, in NYC, the share of Whites, Blacks, Hispanics, and Asians who were born outside of the United States were 22 percent, 32 percent, 40 percent, and 71 percent, respectively; in the United States, the share of Whites, Blacks, Hispanics, and Asians who were born outside of the United States were 4 percent, 10 percent, 33 percent, and 66 percent, respectively (U.S. Census Bureau 2020b). Such large shares of immigrants within each racial and ethnic group not only have an impact on how they settle in NYC, especially relative to the segregation that exists in the city, but their residential location will also have implications for how COVID-19 affects neighborhoods of color and immigrants.

RESIDENTIAL SEGREGATION AND GEOGRAPHIC VARIATION IN NEIGHBORHOOD-LEVEL HEALTH

How does residential segregation impact the health of residents in neighborhoods of color and immigrants? There is ample evidence that residential segregation is linked to adverse health outcomes and mortality among infants and adults of color, particularly for Blacks, primarily through the structural racism underlying residential segregation that constrains their residential choices (LaVeist 1993, 2003; Williams and Collins 2001; Kramer and Hogue 2009; White and Borrell 2011; Phelan and Link 2015). Residential segregation has been deemed a “fundamental cause” of racial health disparities that is independent of socioeconomic status (Williams and Collins 2001).

There are at least three mechanisms by which residential segregation affects health outcomes of people of color: through its negative impact on the socioeconomic status of residents via a spatial mismatch from better-paying jobs; by its adverse impact on the social and physical environments in neighborhoods through greater levels of social disorganization and crime, poorer access to adequate supermarkets and recreational greenspaces, greater levels of exposure to environmental toxins, and worse quality housing; and through its negative impact on individual behaviors via stress like smoking, substance abuse, and a lack of physical exercise (Williams and Collins 2001; Kramer and Hogue 2009). Racial and ethnic residential segregation essentially creates unequal neighborhood and housing opportunity structures between Whites and people of color (Bernard and others 2007). Stressors, the engagement in unhealthy behaviors, and exposure to toxins are greater in segregated neighborhoods of color, and access to quality health care is lower leading to higher levels of chronic diseases and mortality for populations in these neighborhoods, relative to those in predominantly White neighborhoods (Williams and Collins 2001; Kramer and Hogue 2009).

An alternative argument about the link between segregation and health—the ethnic-density hypothesis—suggests that the concentration of people among
those of their own race and ethnicity has a positive effect on their health (Bécares and others 2009; Grady and McLafferty 2007; Kramer and Hogue 2009; Pickett and Wilkinson 2008). The residential isolation created by discriminatory and segregating forces could result in stronger coethnic social networks, increased social support, and greater empowerment that may mitigate the harmful effects of residential segregation (LaVeist 1993; Kramer and Hogue 2009). Living among members of one’s own racial and ethnic group is thought to reduce the stressors from the stigma coming from people outside of these neighborhoods, which can have a positive impact on health (Pickett and Wilkinson 2008; Bécares and others 2009). Also prominent among the mechanisms that link ethnic density to better health is the social capital of neighborhoods that can affect health by promoting informal social control, healthy norms, and increased social support (Kawachi 1999; Bécares and others 2009; Kramer and Hogue 2009).

A systematic review found mixed evidence in support of the ethnic density hypothesis (Bécares and others 2012). In the United States, for Hispanics, ethnic density appears to be positively associated with health, particularly health behaviors, but for Blacks it is more often negatively associated with health, consistent with the fundamental-causes perspective (Bécares and others 2012). Others have found more support for the ethnic density hypothesis among immigrant communities in promoting positive health outcomes (Osypuk and others 2009; McLafferty and others 2012).

SPATIAL INEQUALITY AND COVID-19 MORTALITY IN NYC NEIGHBORHOODS DURING THE PANDEMIC

The preceding discussion suggests that residential segregation puts predominantly Black neighborhoods at a unique disadvantage in terms of health outcomes, relative to neighborhoods that are disproportionately Hispanic and Asian and predominated by immigrants. Against this backdrop, we now must consider the spread of COVID-19, a highly contagious virus, and the geographic distribution of COVID-19 mortality. Ethnically dense neighborhoods may not be shielded from the negative consequences of COVID-19 as is the case from chronic health conditions. Residential isolation among coethnics and household crowding, which both foster social networks and support, can create significant vulnerability to populations when it comes to highly contagious diseases (Acevedo-Garcia 2000; 2001).

In NYC, Blacks and Hispanics will already be at risk of greater exposure to COVID-19 because of the underlying poorer health present in largely Black and Hispanic neighborhoods in terms of diabetes, hypertension, and cardiovascular disease resulting from segregation (Williams and Collins 2001). These chronic conditions are related to the vulnerability of the Black and Hispanic population to COVID-19 (Ssentongo and others 2020; Bajgain and others 2021). Areas with large shares of Asians and Hispanics will also be at risk of greater levels of COVID-
19 mortality because of their higher levels of household crowding than in predominately White neighborhoods (Rosenbaum and Friedman 2007).

Sara McLafferty (2010) discusses the idea that geographic mobility is an important phenomenon that could raise or lower population exposure to infectious pathogens. This is particularly important in NYC. As mentioned above, one of the consequences of residential segregation that results from structural racism in the housing market against Blacks is that there is a spatial mismatch between where they live and work (Kain 2004). Daily, Blacks are likely to be highly mobile throughout NYC and potentially have a greater exposure to COVID-19 than other groups who do not experience this spatial mismatch. One study finds that the nature of the commuting patterns of Blacks that results from spatial mismatch and the segregated nature of Black residential areas produces high incidence rates of COVID-19 among African-Americans (Bassolas and others 2021).

Another way that mobility may affect the exposure of populations in neighborhoods that are composed largely of nonwhites and immigrants to COVID-19 is through employment in transportation occupations that involve contact with people in transit (for example, bus and taxi drivers). In their study of variation in COVID-19 positive tests across ZCTAs in NYC, Milena Almagro and Angelo Orane-Hutchinson (2020) find that the percentage employed in transportation occupations is positively associated with the percentage of COVID-19 positive tests. In NYC in 2019, among males, 3.5 percent of Whites were employed in transportation occupations as compared to 10.5 percent of Blacks, 10.0 percent of Hispanics, and 11.9 percent of Asians (U.S. Census Bureau 2020d). In NYC, in transportation, warehousing, and utilities occupations, immigrants made up 53 percent of the workforce (DiNapoli and Bleiwas 2019). It is likely that COVID-19 mortality will be greater in nonwhite and immigrant neighborhoods through the exposure to the virus via these occupations and because of the segregated nature of Black, Hispanic, and Asian neighborhoods in NYC, thereby concentrating contact with coethnics and magnifying exposure of the virus to these populations.

The final way mobility could be linked to COVID-19 exposure is via the out-migration that occurred from NYC during the pandemic, which could have lowered exposure to the virus. According to Kevin Quealy (2020), the richest neighborhoods in NYC, which overlap with the Whitest neighborhoods, experienced the most significant exodus from NYC as of 1 May 2020. This out-migration could have made the COVID-19 mortality rate lower in predominantly White neighborhoods than in predominately nonwhite neighborhoods. However, analyses by Kim and others (2021) that use mobility data from Quealy (2020) does not find a significant association between out-migration and COVID-19 mortality rates.

This suggests that there is likely to be a racial and ethnic hierarchy with respect to the way COVID-19 mortality rates are distributed across neighborhoods
by racial, ethnic, and nativity status composition. We expect that COVID-19 mortality rates will be the highest in neighborhoods with large shares of native-born Black population and the lowest in neighborhoods with large shares of native-born White population, where many people have left NYC. Neighborhoods with large shares of foreign-born Black and native- and foreign-born Hispanic populations will likely fall in between these two extremes because these populations have experienced constraints in their residential opportunities but not to the extent, historically, that native-born Blacks have faced. However, it is unclear where neighborhoods with large percentages of Asians and foreign-born Whites will fall on this continuum. The contagious nature of the virus, high levels of ethnic density, and nature of their employment will likely put them more at risk than neighborhoods that are largely native-born White, but the benefits of ethnic density do not put them as much at risk as predominately Black and Hispanic neighborhoods.

**Data and Methods**

Two main data sources are used for our analysis of COVID-19 mortality rates in NYC neighborhoods. Data on COVID-19 deaths at the ZCTA level are acquired from data released daily by the New York City Department of Health, which we obtained on 1 February 2021 (NYC DOH [New York City Department of Health] 2021). Data on the racial, ethnic, and nativity-status composition of ZCTAs are acquired from the 2014–2018, five-year release of the American Community Survey (ACS) available via the IPUMS NHGIS website maintained by the University of Minnesota Population Center (https://www.nhgis.org/). Our unit of analysis is at the neighborhood level, defined by ZCTAs. In total, there are 177 ZCTAs included in our analysis. While ZCTAs are conveniently used by researchers as a proxy for neighborhoods, they are not without their limitations. ZCTAs are areas that align with postal-service distribution and are not defined as meaningful communities by the residents themselves. Research has shown that statistical relationships are often more consistent at the census-tract and block-group levels than at the ZCTA level because of more heterogeneity found within ZCTAs, although with respect to studies focused on mortality, the evidence is not substantially different by geographic level (Krieger and others 2002).

The primary outcome of interest is the COVID-19 mortality rate for each ZCTA, calculated as the total number of COVID-19 deaths in a ZCTA per 100,000 population. Our main independent variable of interest gauges the racial, ethnic, and nativity status composition of ZCTAs. We measure this composition with the following variables: the percentages of native- and foreign-born Whites, Blacks, Hispanics, and Asians. Because we are examining the native- and foreign-born segments within racial and ethnic groups, we are limited to the ACS summary tables provided by the U.S. Census Bureau. They provide
native- and foreign-born segments only within the non-Hispanic White population and do not disaggregate other racial groups by their Hispanic origin. Thus, in our data, Blacks include Hispanics and non-Hispanics, and our Black and Hispanic compositional variables are not mutually exclusive. However, in NYC, Blacks and Hispanics are, for the most part, distinct groups. In 2019, only 12 percent of Blacks identified that they were of Hispanic origin, and among Hispanics, only 10 percent identified as being Black (U.S. Census Bureau 2020d).

To examine the association between racial, ethnic, and nativity-status composition and COVID-19 mortality, first we present descriptive statistics. We run bivariate correlations between COVID-19 mortality rates and each racial, ethnic, nativity-status compositional variable, separately. In addition, we calculate weighted means of COVID-19 deaths per 100,000 for each racial, ethnic, nativity-status compositional group. To do this, we take the COVID-19 death rate in each ZCTA and multiply it by the size of the group of interest, sum these values, and divide by the total number of that group across all ZCTAs (Malega and Stallings 2016).

Then, we show a univariate choropleth map of the spatial variation of COVID-19 deaths per 100,000 population across ZCTAs in NYC. Finally, we present bivariate choropleth maps of variation in COVID-19 mortality across ZCTAs by their racial, ethnic, and nativity status composition. Bivariate choropleth mapping is an underutilized technique, although previous research recommends it (Leonowicz 2006; Biesecker and others 2020). For our purposes, this mapping technique is ideal because two ZCTA-level variables can be mapped simultaneously. Because COVID-19 mortality rates are not available by race, ethnicity, or nativity status, the bivariate choropleth mapping technique shows areas that have a range in COVID-19 mortality rates simultaneously by the racial, ethnic, and nativity-status composition of areas. Thus, this mapping procedure reveals whether areas with disproportionally high shares of specific racial, ethnic, and nativity-status groups are also areas with high COVID-19 mortality rates. We adopt the color schemes recommended by Joshua Stevens (2015) because it is easier for readers to distinguish between areas with low and high COVID-19 mortality rates and low and high native- and foreign-born shares of specific racial and ethnic groups. Stevens (2015) offers four different color templates that are ideal. We use one for each of our four racial and ethnic groups. In all the maps, we keep the low-mid-high color ramp for the COVID-19 mortality rate variable in the same color scheme.

For the categorization of the variables in our maps, we use the quantile classification method (ArcGIS Pro 2021). Specifically, we split the values of each variable into three, equally sized ranges. In the bivariate choropleth maps, this results in nine categories of colors that are visualized on the 3 × 3 cross-tabulation legend. This method is preferable for making comparisons across several maps.
Results

DESCRIPTIVE STATISTICS

Column 1 of Table 1 presents the bivariate correlation coefficients. The first result, for native-born, non-Hispanic Whites⁴ indicates that there is a negative and statistically significant, moderate correlation between percentage native-born Whites and COVID-19 mortality rates across ZCTAs in NYC. As the percentage of native-born Whites increases, the COVID-19 mortality rate decreases. While there is also a negative correlation between the percentage of foreign-born Whites and COVID-19 mortality, this relationship is not significant. Both the percentages of native-born and foreign-born Blacks are significantly and positively associated with COVID-19 mortality rates in ZCTAs. The magnitude of the association is stronger between the percentage of native-born Blacks and COVID-19 mortality rates than it is between the percentage of foreign-born Blacks and COVID-19 mortality rates. Both the percentages of native-born and foreign-born Hispanics are also significantly and positively associated with COVID-19 mortality rates in ZCTAs at similar magnitudes. With respect to the percentages of native- and foreign-born Asians, however, there are negative associations with COVID-19 mortality rates, although the latter association is not statistically significant.

Column 2 of Table 1 reports the weighted means of COVID-19 mortality rates by race, ethnicity, and nativity-status group. Consistent with the results in column 1, native-born Whites live in ZCTAs, on average, with the lowest level of COVID-19 mortality rate, 213.34 per 100,000 population. Native- and foreign-born Blacks, on the other hand, live in ZCTAs with the highest averages, 291.7 and 301.08 per 100,000 population, respectively. Native- and foreign-born Hispanics live in ZCTAs with COVID-19 mortality rates in the middle, and native-

| GROUP | BIVARIATE CORRELATION COEFFICIENTS | MEAN COVID-19 MORTALITY RATE (WEIGHTED BY GROUP POPULATION SIZE) |
|-------|-----------------------------------|---------------------------------------------------------------|
|       |                                   | (1)                                                          |
| Native-born White | −0.522*** | 213.34 |
| Foreign-born White | −0.112 | 254.22 |
| Native-born Black | 0.338*** | 291.70 |
| Foreign-born Black | 0.279*** | 301.08 |
| Native-born Hispanic | 0.290*** | 277.85 |
| Foreign-born Hispanic | 0.276*** | 288.73 |
| Native-born Asian | −0.220** | 249.02 |
| Foreign-born Asian | −0.033 | 267.91 |
| N | 177 | 177 |
and foreign-born Asians live in ZCTAs with COVID-19 mortality rates that are slightly lower and slightly higher, respectively, relative to those in ZCTAs where foreign-born Whites reside.

The results in Table 1 suggest that the racial, ethnic, and nativity status composition of ZCTAs is associated with the variation in COVID-19 mortality rates and that significant variation exists in COVID-19 mortality rates depending upon the racial, ethnic, and nativity-status composition that is present in ZCTAs. We now turn to the mapping analysis to explore this variation further. First, we present the univariate choropleth map of COVID-19 mortality rates. Then, we present bivariate choropleth maps for native-born Whites and Blacks and foreign-born Hispanics and Asians. Our bivariate analysis in Table 1 shows that the percentage of these groups within ZCTAs is significantly associated with variation in ZCTA-level COVID-19 mortality rates, except for foreign-born Asians. Therefore, we wish to explore the variation in greater depth through our maps.5

COVID-19 MORTALITY MAP

Areas on the map in Figure 1 in the darkest aqua color indicate ZCTAs with the highest COVID-19 mortality rates. The share of ZCTAs in each borough that fall into the highest COVID-19 mortality rate is 56 percent in the Bronx, 41 percent in the Queens, 33 percent in Staten Island, 30 percent in Brooklyn, and only 14 percent in Manhattan. In the Bronx, places like Kingsbridge-Riverdale, Hunts Point-Mott Haven, Pelham-Throgs Neck, and northeast Bronx have the highest levels of COVID-19 mortality rates. In Manhattan, the two areas most affected by high levels of COVID-19 mortality are in Washington Heights-Inwood and East Harlem. In Queens, several ZCTAs in west Queens, Ridgewood-Forest Hills, southwest Queens, Jamaica, and Rockaway exhibit levels of COVID-19 mortality rates in the highest category. In Brooklyn, ZCTAs in Coney Island-Sheepshead Bay, Borough Park, east Flatbush-Flatbush, Bedford Stuyvesant-Crown Heights, and East New York have the highest levels of COVID-19 mortality rates. Finally, in Staten Island, ZCTAs in Willowbrook, South Beach-Tottenville, and Stapleton-St. George display the highest levels of COVID-19 mortality rates.

WHITE NATIVE-BORN MAP

Figure 2 presents the first of our bivariate choropleth maps. It examines COVID-19 mortality rates by the percentage native-born White across ZCTAs in NYC. Areas that are shaded the dark aqua color at the top left of the nine-square legend are in the highest category of COVID-19 mortality rates, but in the lowest category of percentage of native-born Whites. We focus our attention on the two categories in the upper-right portion of the nine-square legend that are shaded dark brown and brown. The dark brown category shows ZCTAs with the highest level of COVID-19 mortality rates and the highest category of the percentage of
native-born Whites. The brown category indicates ZCTAs with levels of COVID-19 mortality rates in the middle category and the highest category of the percentage of native-born Whites. As we discuss all the bivariate choropleth maps, we will focus on these two categories in the upper-right portion of the nine-square legend because they will reveal the intersection between middle-to-high levels of COVID-19 mortality rates and the highest level of the racial, ethnic, and nativity-status compositional group of interest. To make it easy for the reader to identify these categories on the map, we have outlined them in black. We also focus on the category on the bottom-right side of the nine-square legend, which shows ZCTAs with lowest levels of COVID-19 mortality rates and the highest category of the racial, ethnic, and nativity-status group of interest. We are interested in whether ZCTAs with shares of each group in the highest category reside in places with the lowest levels of COVID-19 mortality rates.

Just eight out of the 177 ZCTAs in NYC fall into the dark brown category—a neighborhood in Kingsbridge-Riverdale, Bronx; a neighborhood in Borough Park in Brooklyn; ZCTAs in Flushing-Clearview, Ridgewood-Forest Hills, southwest Queens, and Rockaway in Queens; and in Willowbrook and south Beach-Tottenville of Staten Island. Relative to Figure 1, the majority of ZCTAs where COVID-19 mortality rates are high are areas with lower shares of native-born White

Fig. 1—COVID-19 mortality rates by ZCTAs, New York City.
populations and greater shares of nonwhite populations. Regarding the middle level of COVID-19 mortality among ZCTAs with the highest level of the share of native-born White population, only 13 ZCTAs fall into this category. These ZCTAs are dispersed throughout the five boroughs of NYC.

Most of the neighborhoods in the highest category of the share of native-born White population—64 percent of ZCTAs in this category—fall in the red category at the lower right-hand corner of the legend. These ZCTAS, which number 38, are areas with the lowest levels of COVID-19 mortality rates. For example, most of the middle and southern sections of Manhattan fall in this category, as well as the southern portion of Staten Island; neighborhoods in Greenpoint and Downtown-Heights-Park Slope, Brooklyn; and in Long Island City-Astoria and Bayside-Little Neck, Queens. Notably, most of the ZCTAs in the Bronx, Brooklyn, and Queens fall in the two blue categories at the upper- and middle-leftmost corner of the legend. These neighborhoods have the lowest shares of native-born White population and COVID-19 mortality rates that are either in the highest or second highest categories. Thus, it is clear from the map that most neighborhoods with the highest level of percentage of native-born White population have the lowest levels of deaths from COVID-19 in NYC.

Fig. 2—COVID-19 mortality rate and percent native-born, non-Hispanic Whites by ZCTAs, New York City.
BLACK NATIVE-BORN MAP

The next map, Figure 3, shows the percentage of native-born Blacks by levels of COVID-19 mortality across NYC neighborhoods. It is profoundly different from the previous map. Most of the ZCTAs with percentages of native-born Black population in the highest range fall into either the highest or middle categories of COVID-19 deaths per 100,000 population. There is a total of 54 ZCTAs in these mid-to-high COVID-19 mortality rate categories out of the 59 ZCTAs that fall in the highest category of percentage native-born Black population. These ZCTAs tend to overlap with the ZCTAs shown in the middle and highest COVID-19 mortality rate category in the univariate choropleth map in Figure 1. One difference from Figure 1 is the absence of neighborhoods in the northern portion of Queens. Only five neighborhoods contain Black populations in the highest category and the lowest levels of COVID-19 mortality, shaded in pink in the lower right-hand corner of the legend, which is in sharp contrast to the map of the percentage of native-born Whites in Figure 2.

The percentage of native-born Black population in the highest range and middle-to-high levels of COVID-19 mortality rates are found mostly in ZCTAs in the Bronx, central and eastern Brooklyn, and southeastern Queens. The distribution of neighborhoods with shares of native-born Blacks in the highest level and mid-to-high rates of COVID-19 mortality is widespread in the Bronx, and

![Map of COVID-19 mortality rate and percent native-born Blacks by ZCTAs, New York City.](image)
includes ZCTAs in northeast Bronx, Fordham-Bronx Park, Crotona-Tremont, High Bridge-Morrisania, Hunts Point-Mott Haven, and Pelham-Throgs Neck; in central and eastern Brooklyn, ZCTAs are found in Bedford-Stuyvesant-Crown Heights, Williamsburg-Bushwick, Flatbush, Canarsie-Flatlands, and East New York; and in southeastern Queens, the neighborhoods are in Jamaica, southeast Queens, and the eastern portion of Rockaway. Many of these neighborhoods exhibit higher levels of poverty, unemployment, and crime, than found in the city (NYU Furman Center 2018). In Manhattan, few neighborhoods are in the highest category of the share of native-born Blacks and in the middle-to-highest ranges of COVID-19 deaths per 100,000 population; and they are in East Harlem, central Harlem-Morningside Heights, and Washington Heights-Inwood. In Staten Island, ZCTAs in Port Richmond and Stapleton-St. George fall into this range.

**HISPANIC FOREIGN-BORN MAP**

Figure 4 presents a bivariate choropleth map of COVID-19 mortality rates by the percentage of the population that is foreign-born Hispanic. Like the previous map for the native-born Black population, it is evident that most of the ZCTAs in the highest category of percentage of foreign-born Hispanic populations fall into the middle or highest categories of COVID-19 death rates, which are denoted by the two shades of darker green in the upper-right corner and far-right middle section of the legend. Out of the 59 ZCTAs that fall in the highest category of the percentage of foreign-born Hispanic population, 49 or 83 percent fall into the middle or highest categories of COVID-19 mortality rates, which is slightly lower than was the case for native-born Blacks in Figure 3. These 49 ZCTAs tend to overlap with the middle and highest COVID-19 mortality rate categories in the univariate choropleth map of COVID-19 mortality in Figure 1. The main difference, however, is that Figure 4 contains fewer neighborhoods in Brooklyn. In contrast to Figure 2 of the native-born White population, only 10 ZCTAs in Figure 4 are in the highest category of percentage of foreign-born Hispanic population and the lowest levels of COVID-19 mortality, which is shaded the lightest shade of green in the lower right-hand corner of the legend. However, the share in this category, 17 percent, is double that found in Figure 3 for the percentage native-born Black.

There are similarities but also distinct differences between Figures 3 and 4, in terms of the distribution of neighborhoods where foreign-born Hispanic population is the highest and COVID-19 mortality rates are in the middle and highest categories, relative to areas with the highest levels of native-born Black population in the same COVID-19 mortality categories. For example, there is overlap in the distributions of foreign-born Hispanic and native-born Black populations in these middle-to-high COVID-19 mortality rate ranges in ZCTAs in the central and southern sections of the Bronx in neighborhoods like Crotona-Tremont, High Bridge-Morrisania, and Hunts Point-Mott Haven; and in northern Manhattan in
Washington Heights-Inwood, central Harlem-Morningside Heights, and East Harlem.

In Brooklyn and Queens, however, Figure 4 shows that the neighborhoods in the highest category of percentage foreign-born Hispanics and that have middle-to-high levels of COVID-19 deaths are different in their distribution than those in the highest category of the share of native-born Black population and in the same COVID-19 mortality categories. In Brooklyn, there are very few neighborhoods that are in the highest category of percentage of foreign-born Hispanic population and middle-to-high levels of COVID-19 deaths, and they include ZCTAs in Sunset Park, Williamsburg-Bushwick, and East New York. In Queens, the differences in the distributions of foreign-born Hispanic population and native-born Black population are also evident. ZCTAs in the highest category of percentage of foreign-born Hispanic population are more widespread throughout the northeastern and central sections of Queens in Long Island City-Astoria, west Queens, Flushing-Clearview, and southwest Queens. As was the case for neighborhoods that fall in the highest category of the share of native-born Black populations and have high levels of COVID-19 mortality rates, many of the neighborhoods that are in the highest level of the share of foreign-born...
Hispanic population and in the highest category of COVID-19 mortality rates exhibit higher levels of poverty, unemployment, and crime, than found in the city (NYU Furman Center 2018).

**ASIAN FOREIGN-BORN MAP**

Figure 5 presents the choropleth bivariate map of COVID-19 mortality rates by the percentage of the population that is foreign-born Asian. It is evident that many ZCTAs in the highest category of the percentage of foreign-born Asian populations fall into the middle or highest categories of COVID-19 deaths (that is, 35 out of the 59 ZCTAs or 59 percent in the highest category of foreign-born Asian population), which are denoted by the two shades of brown in the upper-right corner and far-right middle section of the legend. However, this level is far lower than was the case in the native-born Black and foreign-born Hispanic maps in Figures 3 and 4, respectively. There is some overlap of these 35 ZCTAs with the middle to highest COVID-19 mortality rate categories in the univariate choropleth map of COVID-19 mortality shown in Figure 1, but not as much as was evident between the maps of native-born Blacks and foreign-born Hispanics. Most of the ZCTAs in the highest category of the share of foreign-born Asian population and highest levels of COVID-19 mortality rates are in Queens; only a few are in

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**Fig. 5**—COVID-19 mortality rate and percent foreign-born Asians by ZCTAs, New York City.
Brooklyn. Absent from the foreign-born Asian map are ZCTAs in the highest COVID-19 mortality category in the Bronx, Manhattan, and Staten Island.

In Figure 5, there are many ZCTAs—24 or 41 percent—that fall in the lowest level of COVID-19 mortality rates and the highest level of the share of foreign-born Asian population, which is shaded orange in the lower right-hand corner of the legend. Relative to the maps of the other racial, ethnic, and nativity-status compositional groups, there is a more even split of neighborhoods that are in the highest category of the share of foreign-born Asian population and fall into the lowest, middle, and highest levels of COVID-19 deaths per 100,000 population than is the case when examining ZCTAs that are in the highest levels of the shares of native-born Black and foreign-born Hispanic populations. However, relative to Figure 2, the share of ZCTAs with the highest level of the share of foreign-born Asians and the lowest COVID-19 mortality rates is lower than that for native-born Whites in the same COVID-19 mortality rate category (41 percent versus 64 percent).

The distribution of neighborhoods where foreign-born Asian population is in the highest category and COVID-19 mortality rates are in the middle-to-high categories is distinct from the previous maps, although there are some similarities in the ZCTAs in Figure 4 focused on the percentage of foreign-born Hispanics. Starting with the similarities, there is overlap occurring in Queens in some ZCTAs in southwest Queens, Jamaica, west Queens and one ZCTA in Flushing-Clearview. The distinct pattern of the intersection between middle-to-high COVID-19 mortality rates and in the highest level of the share of foreign-born Asian population is found in ZCTAs primarily located in northeastern Queens in the following neighborhoods: Flushing-Clearview, Bayside-Little Neck, and southeast Queens; and unsurprisingly in Manhattan in Union Square-Lower East Side.

**DISCUSSION AND CONCLUSIONS**

The main objective of this study was to examine the association between spatial variation in COVID-19 mortality rates and the racial, ethnic, and nativity status composition of populations across neighborhoods in NYC. We sought to identify neighborhoods of color and immigrants in NYC that have been hardest hit by the pandemic, using bivariate correlations and weighted means and a novel, bivariate choropleth mapping approach. The bivariate choropleth approach allowed us to overcome the data limitation of not having available neighborhood-level mortality rates disaggregated by race, ethnicity, and nativity status. In addition, we attempted to offer insights as to why some of these neighborhoods were more vulnerable to COVID-19 mortality than others.

Our descriptive analyses and bivariate choropleth maps reveal that a hierarchy emerges based on racial, ethnic, and, to a lesser extent, nativity-status composition, in the neighborhoods hardest hit by COVID-19 mortality.
Neighborhoods in the highest category of the share of native-born White population have fared best in terms of experiencing the lowest levels of COVID-19 mortality rates, and neighborhoods in the highest category of the shares of native- and foreign-born Black populations have fared the worst. The average COVID-19 mortality rate among foreign-born Whites is greater than that for native-born Whites, but the native-born Asian rate is lower than that for foreign-born Whites. Neighborhoods in the highest category of the percentages of native- and foreign-born Hispanic populations fare somewhat better than neighborhoods in the highest category of the share of Blacks, but the difference is not that profound. On the other hand, neighborhoods in the highest category of the share of foreign-born Asians fall toward the middle of the hierarchy of places on the continuum of COVID-19 mortality rates.

What is clear from our analysis is that the residential segregation of Blacks, Hispanics, and Asians from Whites makes neighborhoods with large nonwhite shares of the population more vulnerable to COVID-19 mortality, although at varying degrees. But the underlying reasons for the vulnerability to COVID-19 differs by the racial, ethnic, and nativity-status component of the population. Consistent with the fundamental-causes perspective, decades of structural racism and residential segregation make predominantly native-born Black neighborhoods more vulnerable to experiencing concentrated disadvantage, poorer health, and increased levels of mortality, which puts them at greater risk of mortality from COVID-19 (LaVeist 1993, 2003; Williams and Collins 2001; Kramer and Hogue 2009; White and Borrell 2011; Phelan and Link 2015). Moreover, the spatial mismatch that results from residential segregation increases the vulnerability of the populations in these neighborhoods, because of their daily travel outside of their neighborhoods to go to work (Kain 2004). Taken together, these factors explain why the largest number of predominantly native-born Black neighborhoods experienced the highest levels of COVID-19 mortality.

Our analyses, however, show that neighborhoods in the highest category of the shares of foreign-born Hispanics and Asians are also vulnerable to COVID-19 mortality. The fact that their vulnerability is not as high as that of neighborhoods falling in the highest category of percentage of native-born Blacks is suggestive of some evidence for the ethnic-density hypothesis (Kawachi 1999; Pickett and Wilkinson 2008; Bécares and others 2009; Kramer and Hogue 2009). Particularly in the case of neighborhoods falling in the highest category of the percentage of foreign-born Asians, it is likely that the ethnic density has a positive effect on the health of these areas. In addition, at least half of native-born Asians are under 18 years of age in NYC and likely live with foreign-born Asian parents (Friedman and others 2021). Because younger people have much lower levels of risk of dying from COVID-19, this demographic distribution could be driving down the overall COVID-19 mortality rates, even in neighborhoods with greater shares of foreign-born Asians. The vulnerability to COVID-19 mortality in neighborhoods with larger shares of immigrant Asians and Hispanics likely
stems from the participation in transportation occupations of populations in these areas that exposes them to the virus (DiNapoli and Blewas 2019; Almagro and Orane-Hutchinson 2020; U. S. Census Bureau 2020c).

Neighborhoods with the lowest levels of COVID-19 mortality were areas that had the highest levels of the percentage of native-born Whites. This likely stems from the benefits accrued to Whiter neighborhoods via racial and ethnic segregation in terms of the health of Whites in these areas and the fact that amenities such as jobs, access to the best health care, supermarkets, and recreational greenspaces make it easy for residents in these areas to maintain healthy lifestyles and significantly lowers their levels of chronic health conditions (Williams and Collins 2001). Moreover, during the pandemic residents in largely White neighborhoods were the most likely to flee NYC, thereby potentially lowering the COVID-19 mortality rates in these areas (Quealy 2020).

The analyses presented here makes clear that the pandemic has significantly exacerbated spatial inequalities in NYC that already existed well before COVID-19. Decades of racial and ethnic residential segregation and disinvestment, and the resultant poverty and unemployment, have contributed to COVID-19 mortality, particularly among Blacks, but also Hispanics. To put the Black-White racial inequality in perspective, Elizabeth Wrigley-Field (2020: 21854) finds that “for White life expectancy in 2020 to fall to the level of the best-recorded Black life expectancy would require an estimated 700,000 to 1 million excess White deaths.” The results in this study should help guide policy makers to invest more resources in neighborhoods of color in NYC and particularly in neighborhoods with larger shares of native-born Blacks, in terms of housing, jobs, and health care to improve the population health in these neighborhoods.

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NOTES
1 Logan and Stults (2011) calculated D-scores based upon tract-level data. D-scores are, however, sensitive to geographic scale, and those based upon larger levels of geography (e.g., tracts versus block groups) tend to be lower in value than D-scores based upon smaller levels of
geography (Wong 1997). Notably, New York City has high D-scores even using tracts as the unit of analysis (Massey and Tannen 2015).

A special tabulation from the U.S. Census Bureau is needed to obtain these data. We cannot aggregate PUMS data because the ZCTA geography is unavailable within the publicly-available PUMS data.

For the projection of the maps, we use the UTM standard by New York State (https://gis.ny.gov/coordinationprogram/workgroups/wg_1/related/standards/datum.htm). All publications by the New York State Department of Health and other state agencies use this projection.

Hereafter, for simplicity, we just refer to non-Hispanic Whites as Whites.

We limit our analyses to these groups because multivariate analyses in Friedman and others (2021) reveal an association between the percentages of these racial, ethnic, and nativity-status groups and COVID-19 mortality at the ZCTA-level. The maps for foreign-born Whites and Blacks and native-born Hispanics and Asians are available upon request of the authors.

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