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Short Communication

Racial/ethnic minority and neighborhood disadvantage leads to disproportionate mortality burden and years of potential life lost due to COVID-19 in Chicago, Illinois

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ABSTRACT

Epidemiological studies have highlighted the disparate impact of coronavirus disease 2019 (COVID-19) on racial and ethnic minority and socioeconomically disadvantaged populations, but data at the neighborhood-level is sparse. The objective of this study was to investigate the disparate impact of COVID-19 on disadvantaged neighborhoods and racial/ethnic minorities in Chicago, Illinois. Using data from the Cook County Medical Examiner, we conducted a neighborhood-level analysis of COVID-19 decedents in Chicago and quantified age-standardized years of potential life lost (YPLL) due to COVID-19 among demographic subgroups and neighborhoods with geospatial clustering of high and low rates of COVID-19 mortality. We show that age-standardized YPLL was markedly higher among the non-Hispanic (NH) Black (559 years per 100,000 population) and the Hispanic (811) compared with NH white decedents (312). We demonstrate that geomapping using residential address data at the individual-level identifies hot-spots of COVID-19 mortality in neighborhoods on the North-east, West, and South areas of Chicago that reflect a legacy of residential segregation and persistence of inequality in education, income, and access to healthcare. Our results may contribute to ongoing public health and community-engaged efforts to prevent the spread of infection and mitigate the disproportionate loss of life among these communities due to COVID-19 as well as highlight the urgent need to broadly target neighborhood disadvantage as a cause of pervasive racial inequalities in life and health.

1. Introduction

The novel coronavirus disease 2019 (COVID-19) has disproportionately impacted racial and ethnic minorities and socioeconomically disadvantaged communities in the United States (US) due, in large part, to historical discrimination and enduring structural racism (Wadhera et al., 2020; Price-Haywood et al., 2020; Berkowitz et al., 2020). Data from New York City (NYC), one epicenter of COVID-19 in the US, demonstrate that boroughs with higher proportions of racial/ethnic minorities have had the highest rates of hospitalizations and mortality from COVID-19 (Wadhera et al., 2020). Similarly, more than three-quarters of COVID-19 hospitalizations in one Louisiana health system-based cohort were Black, despite Black patients comprising less than one-third of their total patient population (Price-Haywood et al., 2020). After controlling for comorbid health factors, however, there was no difference in in-hospital mortality between Black and white patients, suggesting that racial/ethnic hospitalization and mortality differences stem from variation in COVID-19 prevalence and baseline health differences between populations. Therefore, identifying root causes that may contribute to the disproportionate burden of premature mortality related to COVID-19 as a result of differences in infection susceptibility, transmission, and severity, is critical.

While COVID-19 surveillance has predominantly focused at the county-level, this larger geographic scale does not adequately capture neighborhood-level disadvantage that may underlie the disparate burden of infection severity and mortality (Yancy, 2020). Health

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inequities at the census tract-level are well-described in the US (Firebaugh and Acciai, 2016; Wang et al., 2018), and neighborhood-level disparities are among the most pronounced in Chicago with a life expectancy gap exceeding 30-years within a 9-mile radius (Centers For Disease Control And Prevention National Center For Health Statistics, 2020). It is very likely that similar neighborhood-level patterns have now emerged for COVID-19 mortality in Chicago, which has the second highest number of COVID-19 deaths in the US as of June 2020. Quantifying and identifying geospatial patterns of underlying racial and economic segregation that may be contributing to the differential COVID-19 mortality burden at the neighborhood-level is needed to direct resources and inform community-engaged interventions. To address these knowledge gaps, we conducted a city-wide analysis at the census-tract level using individual-level data of COVID-19 decedents in Chicago, Illinois to identify characteristics of communities disparately impacted by COVID-19, noting that census-tracts are an imperfect proxy for neighborhood characteristics. We also quantified premature mortality within different racial and ethnic groups and at the census-tract level by estimating the years of potential life lost (YPLL) due to COVID-19 because this population-level metric integrates absolute mortality rates with age at death to quantify burden in a population.

2. Materials and methods

We used individual-level death certificate data (3/16/20–6/1/20) from the Cook County Medical Examiner, which includes data on the age, sex, race/ethnicity, and street address of all COVID-19-related deaths in Chicago (Cook County Government, 2020). Deaths suspected to be due to COVID-19 in Cook County, Illinois are required to be investigated by the Cook County Medical Examiner. Deaths in which "COVID" was listed as a primary or secondary cause of death were included in this analysis based on national reporting guidelines for COVID-19 mortality, and the definition was consistent across the time period of the analysis. The proportion of COVID-19 deaths in each racial/ethnic group (non-Hispanic [NH] Black, NH white, Hispanic) was calculated. Next, we geomapped the street addresses of COVID-19 decedents in Chicago to their corresponding census tracts and performed geospatial clustering analyses of census tracts using the Getis-Ord (G_i*) statistic (Beck et al., 2015; Scott and Janikas, 2010) to identify hot and cold spots where COVID-19 deaths per 100,000 demonstrated statistically significant high and low clustering at the $\alpha < 0.05$ level ($z > |1.96|$). The G_i* statistic quantifies the degree to which the number of events in any given spatial cluster (i.e. several neighboring census tracts) deviates from the overall distribution of events (i.e. COVID-19 mortality rate of the city of Chicago), thereby allowing the determination of statistically significant hot and cold spots (Getis and Ord, 1992). As a result, two neighboring census tracts with COVID-19 mortality rates on opposing ends of the distribution may not deviate significantly from the overall COVID-19 mortality rate in Chicago and thus would not constitute a hot or cold spot. We then compared sociodemographic (percent of residents age >65 years, male, NH Black, Hispanic, below poverty, unemployed, and less than high school-level education) and health characteristics (lack of health insurance and percent of residents with hypertension, coronary heart disease [CHD], and chronic obstructive pulmonary disease [COPD]) of the census tracts determined to be hot- and cold-spots using *t*-tests. Sociodemographic characteristics were selected to identify segregated and/or socioeconomically deprived census tracts, and health characteristics were selected to identify census tracts with high rates of chronic comorbidities that may predispose to higher rates of COVID-19 mortality. Census tract characteristics were extracted from the single year American Communities Survey data from 2018 (UNITED STATES CENSUS BUREAU, 2020) and Centers for Disease Control and Prevention 500 Cities database (Centers for Disease Control and Prevention, 2020). Other racial/ethnic groups (i.e. Asian, Native Hawaiian or Pacific Islander, American Indian or Alaska Native) were excluded from this analysis due to low or zero documented events.

To quantify differences in pre-mature mortality due to COVID-19 by race/ethnicity, we calculated age-standardized YPLL per 100,000 population for each racial/ethnic group because YPLL is an important public health metric that integrates total mortality rates with age at death to comprehensively quantify burden from a disease. Age-standardized YPLL was calculated according to the formula:

$$YPLL_{(LE_{census\ tract})} = \sum_{age-groups}\left[\left(100,000 * \left[\frac{\sum(LE_{census\ tract} - Age_{decedent})}{Population_{age-group}}\right]\right) * Age - group\ weight_{2000\ US\ population}\right]$$

where $LE_{census\ tract}$ is the census-tract-specific life expectancies derived from the US small area life expectancy estimates project (Centers For Disease Control And Prevention National Center For Health Statistics, 2020), $Population_{age-group}$ is the population of Chicago in 2018 in each age group derived from the National Historic Geographical Information System (Manson et al., 2019), and $Age - group\ weight_{2000\ US\ population}$ is the proportion of the standard population belonging to each age group (<5, 5–9, 10–14, 15–24, 25–34, 35–44, 45–54, 55–64, 65–74, and 75–84) according to the standard 2000 US population. Because of the marked disparities in life expectancy across the city of Chicago, we applied census-tract specific life expectancies to calculate YPLL, noting that this leads to a more conservative estimation of racial/ethnic disparities in YPLL than uniformly applied life expectancies (e.g. 85 years for all decedents). Two-tailed $p < 0.05$ was considered statistically significant. STATA/IC version 16.1 (College Station, TX) and ArcGIS version 10.6.1 (Esri, Redlands, CA) were used for statistical analyses and geomapping, respectively. This study was exempt from institutional review board review at Northwestern University Feinberg School of Medicine due to the publicly available, deidentified nature of the data.

3. Results

As of June 1, 2020, there were 1859 COVID-19 related deaths in Chicago. Mean age at death was 71.8 (standard deviation [SD] 15.1) years; 43.2% of deaths in Chicago occurred among NH Black and 23.5% among Hispanic residents compared with 27.3% among NH white residents. Age-standardized years of potential life lost (YPLL) due to COVID-19 differed by race/ethnicity with 559 years per 100,000 population in the NH Black community and 811 years per 100,000 population in the Hispanic community compared with 312 years per 100,000 population in the NH white community.

Significant heterogeneity in COVID-19 death rates was also observed with statistically significant geospatial clusters or hot spots on the South, West, and Northeast areas in contrast with cold spots in central downtown (Fig. 1). Hot spots were characterized as having higher proportions of minority and socioeconomically disadvantaged neighborhoods compared with cold spots that had a higher proportion of NH white and affluent residents when examining census-tract level characteristics (Table 1). There was more than 3-fold higher proportion of NH Black (39.4 [38.0] versus 12.3 [19.7], $p < 0.0001$) and Hispanic (26.4 [29.8] versus 7.1 [5.5], $p < 0.0001$) residents compared with NH white residents in hot versus cold spots. There was also more than a 2-fold higher proportion of residents living below the federal poverty line (24.1 [9.8] versus 11.8 [8.3], $p < 0.0001$) and higher rates of unemployment (11.3 [6.6] versus 3.9 [2.6], $p < 0.0001$) in hot versus cold spots. The prevalence of comorbid chronic lung disease was higher in hot spots (7.0 [1.5]) compared with cold spots (3.5 [1.4], $p < 0.0001$).

4. Discussion

In Chicago, we demonstrated a greater proportion of COVID-19 mortality occurred among NH Black residents, and a higher burden of age-standardized YPLL occurred among both NH Black and Hispanic

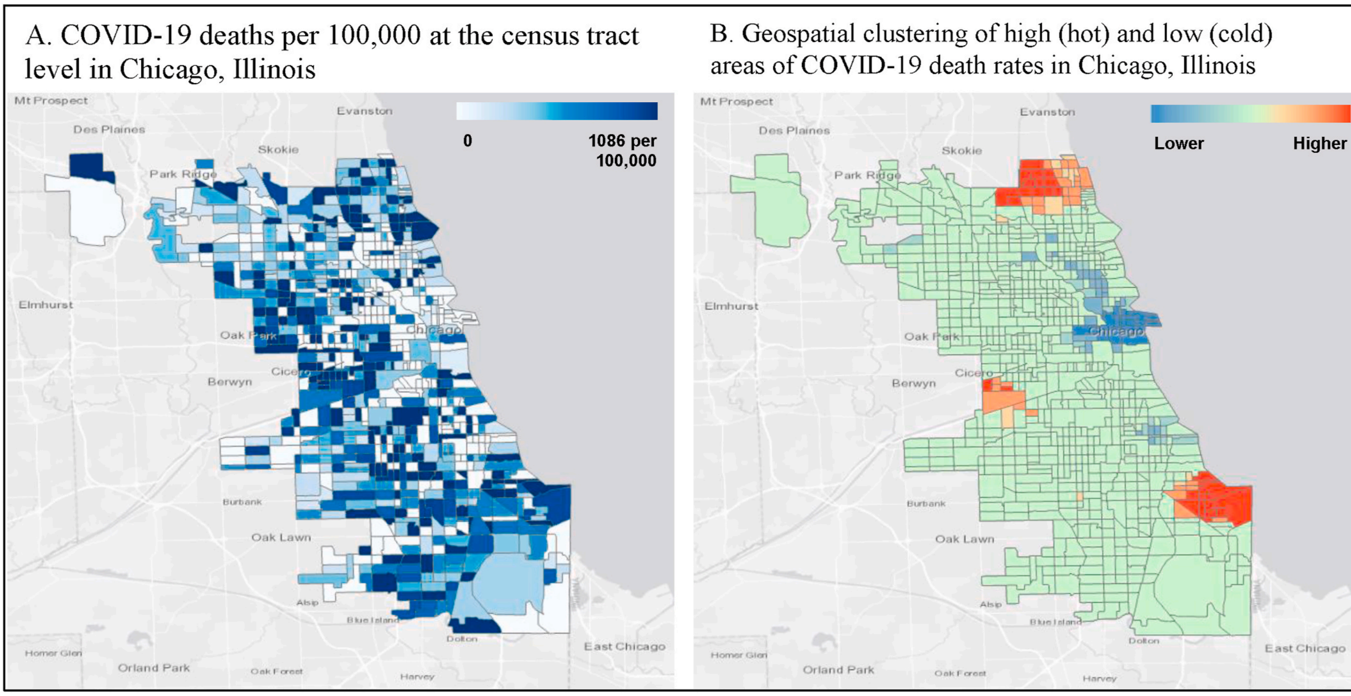

Fig. 1. Geographic distribution of COVID-19 related deaths in Chicago at the census tract level (A) and geospatial clustering of high and low values adjusted for multiple testing and spatial dependence (B). Hot and cold spots were classified based on G_i* statistic meeting the pre-specified $\alpha < 0.05$, and z-scores were mapped as a continuous variable with higher z-scores in red and lower in blue.

Table 1
Census-tract level characteristics among Chicago overall and stratified by Hot and Cold Spots for COVID-19 deaths per 100,000, 2018 American Communities Survey.

	Chicago (N = 801 census tracts)	Hot spots (N = 56 census tracts)	Cold spots (N = 44 census tracts)	p-value (Hot vs. cold spots)
Demographic characteristics[a]				
65 years and older, %	12.3 (6.4)	13.1 (6.0)	11.4 (7.6)	0.21
Male, %	48.2 (5.0)	47.8 (4.5)	48.7 (4.0)	0.32
NH Black, %	35.8 (39.8)	39.4 (38.0)	12.3 (19.7)	<0.0001
Hispanic, %	25.9 (28.7)	26.4 (29.8)	7.1 (5.5)	<0.0001
Socioeconomic characteristics[a]				
Below poverty, %	21.2 (13.6)	24.1 (9.8)	11.8 (8.3)	<0.0001
Unemployed, %	11.1 (9.0)	11.3 (6.6)	3.9 (2.6)	<0.0001
< High school education, %	16.2 (11.8)	18.5 (12.7)	3.0 (3.7)	<0.0001
Health Characteristics[b]				
Lack of health insurance, %	18.0 (8.1)	19.5 (8.6)	8.4 (2.6)	<0.0001
Hypertension, %	31.6 (10.8)	33.5 (8.3)	20.9 (7.3)	<0.0001
CHD, %	5.4 (2.1)	6.0 (1.4)	3.1 (1.5)	<0.0001
COPD, %	6.5 (2.7)	7.0 (1.5)	3.5 (1.4)	<0.0001

[a] Demographic and socioeconomic characteristics are obtained for Chicago and at the census tract level from the American Communities Survey (2018) and the US Census Bureau.
[b] Health characteristics for Chicago and at the census tract level are obtained from the Centers for Disease Control 500 Cities Project.

residents compared with NH white residents based on individual-level data. Geospatial analysis identified hot and cold-spots of COVID-19 mortality within Chicago similar to analyses performed in other cities. Hot spots had higher proportions of racial and ethnic minority residents, higher degrees of socioeconomic disadvantage, and higher rates of chronic comorbid disease. Our study quantifies the disproportionate YPLL among communities with larger populations of NH Black and Hispanic individuals in Chicago and identifies census tracts where local, community-engaged public health interventions are most needed. These findings expand upon prior analyses that have demonstrated similar geographic patterning for multiple chronic conditions (e.g. hypertension) in Chicago that predispose to greater risk of COVID-19 severity and are attributed, in part, to racial discrimination and residential segregation (Kershaw et al., 2017).

Our results are consistent with analyses from NYC boroughs (Wadhera et al., 2020) and Louisiana (Price-Haywood et al., 2020) identifying disproportionately higher burden of COVID-19 mortality in socioeconomically disadvantaged communities and communities with larger populations of NH Black and Hispanic individuals and build upon these prior findings by quantifying years of life lost due to premature mortality from COVID-19. We demonstrate that the disproportionate burden of COVID-19 in communities with larger populations of NH Black and Hispanic individuals goes beyond their higher relative mortality rates; these demographic groups experienced markedly higher loss of potential life due to COVID-19. Even when accounting for lower baseline life expectancy due to longstanding social and health inequities (Ferdinand and Nasser, 2020), there was still more than 240 additional YPLL per 100,000 NH Black residents compared with NH white residents. Similarly, the burden of YPLL per 100,000 population was twice as high among Hispanic residents compared with NH white residents. Our results highlight that underlying structural inequalities have a drastic impact on the burden of disease experienced by long-standing neighborhood disadvantage that is ultimately tied to racial and economic segregation. The legacy of residential segregation as a result of discriminatory 20th century housing policies is particularly evident in Chicago where limited economic investment into communities with larger populations of NH Black and Hispanic individuals has led to structurally vulnerable neighborhoods with crowded housing, food insecurity, employment instability, higher rates of uninsured residents, and increased reliance on crowded public transit (Berkowitz et al., 2020; Egede and Walker, 2020). In this way, structural racism has led to increased COVID-19 transmission and disease severity in communities with larger populations of NH Black and Hispanic individuals.

Limitations of our analysis include the use of death certificate data and the ecological design that does not infer causality. Other metrics of COVID-19 burden, such as hospitalizations, cases, or testing rates per capita were not publicly available and therefore could not be included in this census tract-level analysis. Due to low event rates, other racial/ethnic groups were excluded from this analysis. Finally, the G_i* statistic necessarily identifies the extremes of the geospatial distribution of COVID-19 mortality, and solitary census tracts with high COVID-19 mortality may be missed using this strategy. However, it is unlikely that census tracts with high COVID-19 mortality are markedly different from all neighboring census tracts, minimizing the likelihood of true hot spots being missed in our current strategy.

In conclusion, our findings underscore the complex interplay of multiple factors that connect race and place, including social and economic disparities that may be contributing to the observed geospatial disparities of COVID-19 mortality. Future research should target the root causes that underlie neighborhood-level social and structural determinants of health to mitigate the disproportionate burden due to COVID-19 as well as highlight the urgent need to broadly target neighborhood disadvantage as a cause of pervasive racial inequalities in life and health.

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