Circulation: Arrhythmia and Electrophysiology

ORIGINAL ARTICLE

The Association of Structural Inequities and Race With Out-of-Hospital Sudden Death During the COVID-19 Pandemic

Stavros E. Mountantonakis, MD; Laurence M. Epstein, MD; Kristie Coleman, RN; Johanna Martinez, MD; Moussa Saleh, MD; Charlotte Kvasnovsky, MD, PhD; Rachel-Maria Brown, MD; Elizabeth McCulloch, PhD; Jeffrey Kuvin, MD; Safiya Richardson, MD, MPH; Parth Makker, MD; Martin Lesser, PhD; Jennifer H. Mieres, MD; Karina W. Davidson, PhD; Robert O. Roswell, MD; on behalf of the Northwell COVID-19 Research Consortium*

BACKGROUND: Social influencers of health namely race, ethnicity, and structural inequities are known to affect the incidence of out of hospital sudden death (OHSD). We sought to examine the association between social influencers of health and the incidence of OHSD in the diverse neighborhoods of New York City during the first wave of coronavirus disease 2019 (COVID-19) epidemic.

METHODS: New York City ZIP stratified data on OHSD were obtained from the Fire Department of New York during the first wave of COVID-19 epidemic (March 1 to April 10, 2019) and the same period in 2020. To assess associates of OHSD, ZIP code-specific sociodemographic characteristics for 8 491 238 New York City residents were obtained via the US Census Bureau's 2018 American Community Survey and the New York Police Department's crime statistics.

RESULTS: Between March 1 and April 10, 2020, the number of OHSD rose to 4334 from 1112 compared with the year prior. Of the univariate ZIP code level variables evaluated, proportions of Black race, Hispanic/Latino ethnicity, single parent household, unemployed inhabitants, people completing less than high school education, inhabitants with no health insurance, people financially struggling or living in poverty, percent of noncitizens, and population density were associated with increased rates of OHSD within ZIP codes. In multivariable analysis, ZIP codes with higher proportions of inhabitants with less than high school education ($P<0.001$) and higher proportions of Black race ($P=0.04$) were independent predictors for increases in ZIP code rates of OHSD.

CONCLUSIONS: Educational attainment and the proportion of Black race in New York City ZIP codes remained independent predictors of increased rates of ZIP code level OHSD during the COVID-19 outbreak even after controlling for 2019 rates. To facilitate health equity, future research should focus on characterizing the impacts of structural inequities while exploring strategies to mitigate their effects.

GRAPHIC ABSTRACT: A graphic abstract is available for this article.

Key Words: biometry ■ death, sudden, cardiac ■ health disparities ■ population density ■ poverty

See Editorial by Chrispin et al

Sudden death is a leading cause of mortality internationally, accounting for 15% to 20% of all recorded deaths[1] and over 50% of cardiovascular deaths.[2] Malignant ventricular arrhythmias in the setting of coronary artery disease have been traditionally considered to be the primary mechanism of sudden

Correspondence to: Stavros E. Mountantonakis, MD, Director, Cardiac Electrophysiology Program, Lenox Hill Hospital, 100 E 77th St, New York, NY 10075. Email smountanto@northwell.edu

*A list of all authors in the Northwell COVID-19 Research Consortium is given in the Data Supplement.

The Data Supplement is available with this article at https://www.ahajournals.org/doi/suppl/10.1161/CIRCEP.120.009646.

For Sources of Funding and Disclosures, see page 486.

Circulation: Arrhythmia and Electrophysiology is available at www.ahajournals.org/journal/circep

WHAT IS KNOWN?

- Social and economic factors affect a broad range of health outcomes, including mortality.
- Coronavirus disease 2019 (COVID-19) has exacerbated extant health disparities in the United States, including race-based disparities.

WHAT THE STUDY ADDS?

- During the initial surge of the COVID-19 pandemic in New York City, increased rates of out-of-hospital sudden death varied greatly across residential ZIP codes.
- At the zip code level, having less than a high school education and Black race were the sociodemographic factors most strongly associated with increased out-of-hospital sudden death during the surge.

Nonstandard Abbreviations and Acronyms

COVID-19	coronavirus disease 2019
NYC	New York City
OHSD	out of hospital sudden death
SIOH	social influencers of health
ZCTA	zip code tabulated area

death and out of hospital sudden death (OHSD) in particular.[3,4]

Early reports detail a significant increase in the incidence of OHSD during the first COVID-19 outbreak. In Italy, over the first 40 days of the COVID-19 outbreak, there was a 58% increase in out-of-hospital cardiac arrests when compared with a historical control.[4] In New York City, there was a reported 4.97-fold increase in the incidence of OHSD during the surge of the COVID-19 pandemic.[5]

The cause of this dramatic increase is most likely multifactorial. There is evidence of an increased prevalence of arrhythmias in hospitalized patients with COVID-19.[6] Hypoxia, systemic inflammatory response, and metabolic disorder[7] during COVID-19 create the metabolic milieu for arrhythmogenesis. The presence of myocarditis or indolent myocardial inflammation reported in recovered COVID-19 patients may serve as a potential substrate for ventricular arrythmias. In addition, nonarrhythmic cause, such as pulmonary embolism or fulminant respiratory failure is another plausible cause for the sudden demise of those patients.[8] Last, patients feared coming to the hospital and were encouraged to stay home, resulting in a marked reduction in admissions for myocardial infarction, suggesting patients delayed or completely avoided seeking care.

Beyond the physiological and psychological contributors that may have accounted for the increased incidence of OSHD, there exists widespread report of the disproportionate burden of COVID-19 on disadvantaged communities.[9] Prior studies have demonstrated that OHSD affects Black and Hispanic residents at higher rates in the United States, possibly linked to levels of education, income, and medical insurance status.[10,11] Similarly, emerging COVID-19-related data continues to unmask the disparities that Black and Hispanic communities have disproportionately experienced from COVID-19 in New York City (NYC).[12–14]

Perpetuating these disparities are factors such as education, poverty, and employment, known as social influencers of health (SIOH), which have been shown to have a significant impact on health outcomes.[15] Indicators of structural inequities such as disparities in wealth and education have been implicated in the increased mortality rates during the COVID-19 pandemic.

New York City experienced significant mortality during the first wave of the COVID-19 epidemic. Coupled with its extraordinary racial and socioeconomic diversity, NYC presents a unique opportunity to study the relationship between SIOH and OHSD. This study aims to examine the association between SIOH and their relationship to OHSD among 178 NYC ZIP codes during the first wave of the epidemic.

METHODS

Study Sample

The data that support the findings of this study are available from the corresponding author upon reasonable request. The Fire Department of New York is the primary emergency medical service for the 8.5 million people living in the 5 boroughs of New York City, which include the Bronx, Queens, Manhattan, Brooklyn, and Staten Island. Data on the number of emergency medical service responses for out-of-hospital cardiac arrests, and the number of those responses resulting in OHSD from March 1 to April 10, 2020, as well as the same time period 1 year prior was obtained. After a cardiac arrest call, emergency medical service personnel confirm if the patient is pronounced dead or if there is another disposition. Those pronounced dead on site were labeled as sudden deaths in this study. The OHSD data were stratified by ZIP codes both for 2019 and 2020. In addition, NYC crime statistics[16] and US Census Bureau data from the 2018 American Community Survey were used to provide sociodemographic data on people living in NYC, stratified by neighborhood ZIP codes.

Zip code tabulated area (ZCTA) data were pulled from the American Community Survey 2014 to 2018 (5-year Estimates) for each corresponding zip code provided by the Fire Department of New York. ZCTAs are spatial units designed by the US Census Bureau to closely align with US Postal Service ZIP codes. We used a 2019 ZIP code-to-ZCTA crosswalk[17] file to link data provided by the Fire Department of New York to ACS ZCTAs. For the 2 instances in which a ZCTA overlaid >1 ZIP code, we summed the component ZIP code sudden deaths. When individual level data are unavailable, public health mortality analyses utilize area-based data to determine

the effects of socioeconomic status.[18] Socioeconomic status indicators at the ZIP code level have been shown to be useful for assessing disparities in health outcomes.[19]

In addition to race, ethnicity, sex, and age, the SIOH used in this analysis consisted of single parent households (social support), median income, poverty index, completion of high school diploma (education), completion of bachelor's degree (education), employment status, health insurance (private, public, or none), the Gini index, citizenship status, and crime levels. Institutional Review Board approval was not required, as this study utilized de-identified publicly available data.

Statistical Analysis

ZIP codes with fewer than 2000 inhabitants were excluded from analysis. As a surrogate of OHSD increase during the COVID-19 pandemic, we used the ratio between the recorded OHSDs during the periods March 1 to April 10 in 2020 and 2019. The distribution of this ratio was significantly skewed rightward, and we therefore used the logarithmic transformation of this ratio for regression analyses. Univariate analysis was also performed on the incidence of 2019 OHSD per 10 000 inhabitants for comparison reasons. Race and ethnicity were divided into mutually exclusive groups: Black alone, Hispanic, Asian alone, White alone, and Other. White was used as the referent category for race/ethnicity. Spearman rank correlation coefficient analysis was applied to determine the relationship between race/ethnicity and selected significant SIOH variables. Multiple linear regression was performed for the outcome of log of the ratio of OHSD using covariates that were predictive at $P<0.05$ on univariate linear regression analysis. We used stepwise elimination to achieve a parsimonious multivariable model. $P<0.05$ was considered statistically significant for all analyses. Analysis was performed on SAS 9.4 (Cary, NC).

RESULTS

In total, data were analyzed for 178 ZIP codes that cover 8 491 238 NYC residents. (Table 1) The absolute number of OHSD from March 1 to April 10, 2019 was 1112. The number increased to 4334 during the same time period in 2020. The ratio of OHSD 2020:2019 was plotted for each ZIP code (Figure 1). The OHSD ratios varied significantly among the 178 NYC ZIP codes with the lowest value of 0.25 and the highest of 19.5 (Figure 1). The results from the regression analysis were regression coefficients (β) that predict increases or decreases in ZIP code OHSD based on a variable if β is positive or negative, respectively. The higher the numerical value of β, the larger the associated predicted increase or decrease on the ratio of OHSD in the ZIP code. For example, a 10% increase in a ZIP code variable would cause a predicted $e^{(\beta \times 10\%)}$ change in OHSD in that ZIP code. For every 10% increase in proportion of inhabitants with less than high school education, there was an approximate 23% increase in the ratio of OHSD in that ZIP code ($\beta=2.08$; $P<0.001$). For every 10% increase in proportion of Black residents in a ZIP code, there was a 4.3% increase in the ZIP code ratio of OHSD, keeping all other variables in the model constant ($\beta=0.42$; $P=0.04$).

Among the respective ZIP codes, univariate analysis revealed that higher proportions of Black race ($P=0.01$), Hispanic/Latino ethnicity ($P=0.009$), single parent household ($P=0.001$), unemployment ($P=0.03$), persons completing less than high school education ($P<0.001$), persons with no health insurance ($P<0.001$), persons financially struggling or living in poverty ($P<0.001$), noncitizens ($P=0.004$), and higher population density ($P=0.04$) were associated with increased rates of OHSD during the epidemic. On the contrary, higher proportions of inhabitants age >65 ($P<0.001$), higher median income ($P<0.001$), percentage with no retirement income ($P=0.003$), and higher proportions of White inhabitants ($P<0.001$) were found to have statistically significant coefficients that were associated negatively with the increased incidence of OHSD during the epidemic (Table 1). For comparison, the SIOHs that were associated with higher incidence of OHSD per 10 000 habitats for 2019 were single parent household ($P=0.003$), persons completing less than high school education ($P=0.033$), persons financially struggling or living in poverty ($P=0.001$), and proportions of inhabitants age >65 ($P<0.001$).

Spearman rank correlation coefficient analysis was applied to examine the relationship between race/ethnicity and selected significant SIOH variables. There was a positive correlation between the percentage of Black and Hispanic populations in a ZIP code and the percentage of people whose highest level of education reached was less than high school with $r=0.40$ and 0.77, respectively (Table 2, Figure 2). There was a negative correlation between percentages of White and Asian population and percentage of people with the highest level of education reached being less than high school within a ZIP code, with correlation coefficients $r=-0.73$ and -0.18, respectively (Table 2, Figure 2).

The statistically significant variables in the univariate analysis listed in Table 1 were entered into a multivariable model and only the proportions completing less than high school education ($P<0.001$) and the proportions of Black race ($P=0.04$) in ZIP codes remained as independent predictors of increased ratio of OHSD in the model. (Figure 3).

DISCUSSION

During the COVID-19 pandemic surge in New York City, there was a 4.97-fold increase in the incidence of OHSD compared with the same time period in 2019.[2] This increase was distributed unequally across the NYC ZIP codes with the ratio of increase ranging from 0.25 to 19.5. Many of the SIOH were found to be univariate predictors of this increase with proportion of education less than high school and proportion of Black race

Table 1. NYC Demographics and Univariate Linear Regression Analysis of Log 2020:2019 Ratio Out-of-Hospital Sudden Death

Variable*	NYC (n=8491 238)	β	95% CIs	*P* value
Percent male	47.7%	1.85	(−2.32 to 6.01)	0.38
Percent age over 65	14.1%	−3.7	(−5.88 to −1.55)	<0.001
Percent White alone	29.7%	−0.97	(−1.30 to −0.6)	<0.001
Percent Black alone	24.7%	0.54	(0.23 to 0.96)	0.01
Percent Hispanic or Latino alone	23.7%	0.69	(0.18 to 1.21)	0.009
Percent Asian alone	18.3%	0.2	(−0.52 to 0.92)	0.59
Percent other race	3.3%	0.3	(−0.30 to 0.90)	0.34
Percent single parent household	23.0%	1.49	(0.61 to 2.38)	0.001
Percent unemployed	6.9%	9.1	(1.06 to 17.1)	0.03
Percent less high school	18.3%	1.26	(0.64 to 1.89)	<0.001
Percent no health insurance	8.4%	5.18	(2.56,7.79)	<0.001
†Percent poverty index under 2.0	37.3%	1.37	(0.07,2.01)	<0.001
Median household income	$66 527 (51 095 to 88 595)	−0.01	(−0.01 to −0.004)	<0.001
Percent no retirement income	12.8%	−2.10	(−3.43 to −0.75)	0.003
‡Gini index	0.48±0.07	−0.48	(−2.31 to 1.35)	0.61
Log population density (per square mile)	10.7	0.13	(0.004 to 0.26)	0.04
§Crime rate per 1000 residents	16.4±16.2	−0.003	(−0.02 to 0.01)	0.62
Percent not a citizen	16.2%	2.16	(0.72 to 3.59)	0.004

NYC indicates New York City.

*Missing variable data range from 0% to 1.6%.

†Poverty index=total family income/census poverty threshold. <1, living in poverty. Index 1–2 poor and financially struggling. https://www2.census.gov/programs-surveys/acs/tech_docs/subject_definitions/2018_ACSSubjectDefinitions.pdf?#.

‡Gini index is a measure of income inequality. 0, perfect income equality. 1, perfect income inequality.

§Major felony crimes were included.

being independent predictors of an OHSD increase at the ZIP code level.

Education is a pivotal SIOH, affecting life choices and mortality, by providing increased access to social and economic resources.[20] There is a known inverse relationship between educational attainment and cardiovascular disease in high-income countries.[21] Woodward et al[22] showed in a cohort of 90 000 participants that a primary education was associated with increased risk of cardiovascular disease, cardiovascular mortality, and all-cause mortality compared with those with a secondary or tertiary education. These population-based studies have also found higher education is inversely related to smoking, high blood pressure, diabetes, and risk of acute myocardial infarction.[23–25] In addition, individuals with lower educational attainment have been found to have more comorbidities, and cardiovascular risk factors[26,27] and are therefore more likely to have a complicated course of COVID-19.

Lower education level is associated with lower levels of health literacy, which are, in turn, associated with increased mortality risk.[28,29] The Institute of Medicine[30] suggests that health literacy explains the relationship between education and health and that educational attainment is the most important determinant of health literacy levels. A CDC report found 40.9% of adults in the United States delayed or avoided seeking medical care because of confusion related to COVID-19.[31] This is consistent with recent reports that found a significant overall decrease in emergency department visits, especially for myocardial infarction and stroke.[32–37] Confusion about when to seek urgent medical care and difficulty obtaining appropriate medical guidance or services may have had a disproportionate impact on those with low health literacy, which could explain the association seen between educational attainment and increased OHSD in this analysis.

The proportion of Black residents was the second predictor of OHSD increase in our multivariable model. The population-based REGARDS (Reasons for Geographic and Racial Differences in Stroke) study found that among 22 507 participants without a history of cardiovascular disease, Black participants had a 2-fold higher risk of sudden cardiac death[38] even when adjusting for sociodemographic, cardiovascular risk factors, comorbidities, and behavioral measures of health. Multiple community-based studies using various sudden cardiac death surveillance methodologies have shown the same conclusion: there is an increased risk of sudden death in the Black population not explained by available factors.[39]

One hypothesis for this finding is the negative physiological effects of stress associated with races who face higher levels of discrimination. Studies looking at the

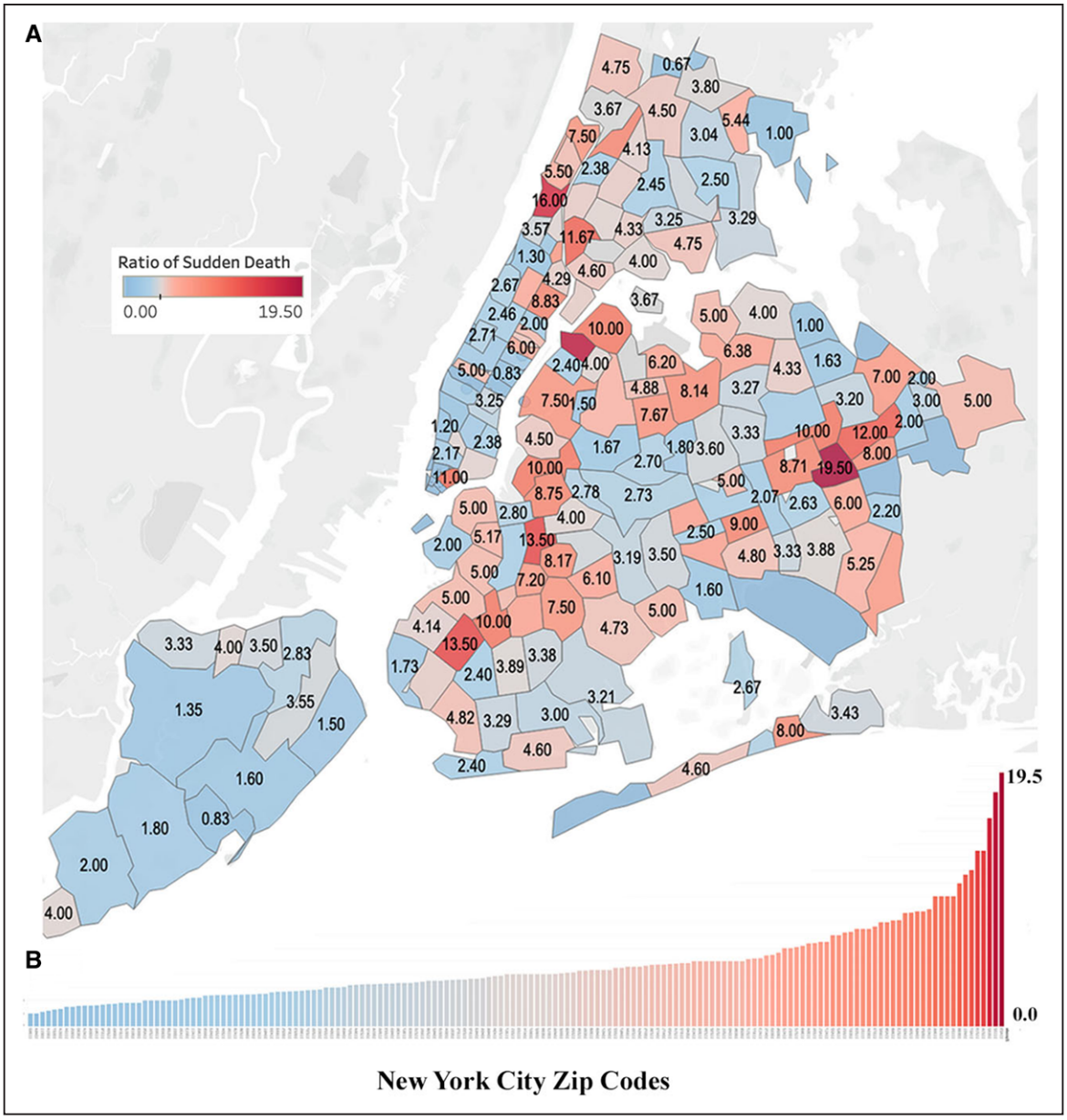


Figure 1. Out-of-Hospital Sudden Death Increase during First COVID-19 Pandemic Outbreak in New York City.
Geographic distribution of out-of-hospital sudden death ratio 2020:2019 in New York City zip codes (**A**). Graphic representation of sudden death ratios from low to high (**B**).

physiological effects of racial discrimination have shown higher chronic levels of C-reactive protein and cortisol among Black people in the United States as a result of discrimination, suggesting a physiological explanation for the finding of increased sudden death.[40–44] The association between racial discrimination, stress, and adverse cardiovascular outcomes have been recently emphasized in multiple publications, including a statement by the American Heart Association, calling for further research to build toward health equity.[45,46]

In a similar fashion, lower socioeconomic status has also been implicated as an explanation for increased sudden death. While the occurrence of higher rates of obesity, hypertension, and coronary artery disease are reported in the Black population[47] and are risk factors for COVID-19-related mortality,[1,20,48] Black residents are also more likely to live in under resourced neighborhoods lacking access to appropriate health care resources.[49] Fundamental cause theory suggests racial disparity is not driven by the disease itself, but by SIOH that may limit the group's access to essential health protective resources for preventing disease.[50] It is plausible that access to health protective resources could be driving the disparity seen in ZIP codes with higher proportion of Black residents.

The American Heart Association highlights that a positive outcome for cardiac arrest is dependent on the chain of survival.[51] Historically, disparities in emergency service response and resuscitation procedures are widely

Table 2. Correlation Between Selected Significant Univariate Variables and Race Using Spearman Rho Correlation Coefficient

	%Hispanic or Latino	%Asian	%Black	%White
Median household income (in 2018 inflation adjusted dollars)	−0.68*	0.35*	−0.51*	0.71*
% No health insurance coverage	0.64*	−0.06	0.31*	−0.68*
% Poverty index under 2.0	0.72*	−0.30*	0.50*	−0.68*
% Less than high school	0.77*	−0.18†	0.40*	−0.73*
% Unemployed	0.56*	−0.49*	0.67*	−0.69*
% Single parent family	0.58*	−0.56*	0.74*	−0.88*

Correlation of variables with percentage of race/ethnicity in a ZIP code. Values for Spearman coefficient, *r*, is denoted in the chart.
*Correlation is significant at the 0.01 level (2-tailed).
†Correlation is significant at the 0.05 level (2-tailed).

noted, Wilde et al[52] showed Black residents were less likely to receive defibrillation or cardiopulmonary resuscitation and experience a spontaneous return of circulation. An interim guideline released by the American Heart Association during the COVID-19 surge encouraged lay rescuers to perform hands only CPR. Under these guidelines, emergency medical services were also instructed to not transfer patients to a hospital after appropriate resuscitation efforts in the field did not result in return of spontaneous circulation.[53] Sasson et al[54] found that bystander-initiated CPR was less likely to be performed in patients with out-of-hospital cardiac arrest in low-income Black neighborhoods. Lai et al[14] found out of hospital cardiac arrest disproportionately affected minority populations. Fear of potential exposure to COVID-19, in conjunction with preexisting disparities in the performance of resuscitation procedures may have contributed to the increased incidence of OSHD in ZIP codes with higher proportion of Black residents.

While it is impossible to know the exact mechanism of OHSD without patient level data, ZIP code level analysis showed that a higher proportion of less than high school education and Black residents are associated with increased incidence of OSHD during the COVID-19 pandemic in NYC. These findings show that previously entrenched disparities in under resourced communities were amplified during the COVID-19 pandemic. Evidence-based social change is needed to impact health care outcomes. Clear public health mandates, encouraging patients to seek as well as providing care for acute health conditions, are needed especially in ZIP codes with low education attainment which has been shown to influence health literacy. When misinformation and widespread confusion are rampant, those with low health literacy may need targeted guidance about how and where to seek care. In addition, barriers to providing early CPR, early defibrillation, and early advanced cardiac life need to identified and addressed as part of community-based equity initiatives.[21,55]

Limitations

As the demographic and socioeconomic characteristics of individual cases are not known, we used the socioeconomic characteristics of the geographic ZIP code area as a surrogate, which can be a limitation of this analysis. Census data were reported in 2018 and were based on the American Community Survey conducted between 2014 and 2018. Although these are the most updated data, it is plausible that there are differences from the 2020 census. In addition, we could not adjust for temporary ZIP code–specific changes in population as a result of migration of wealthy individuals to vacation homes and areas that

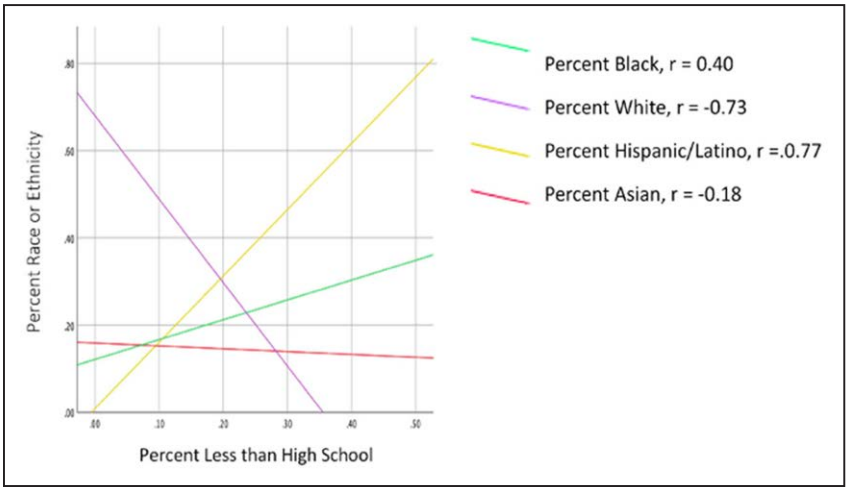
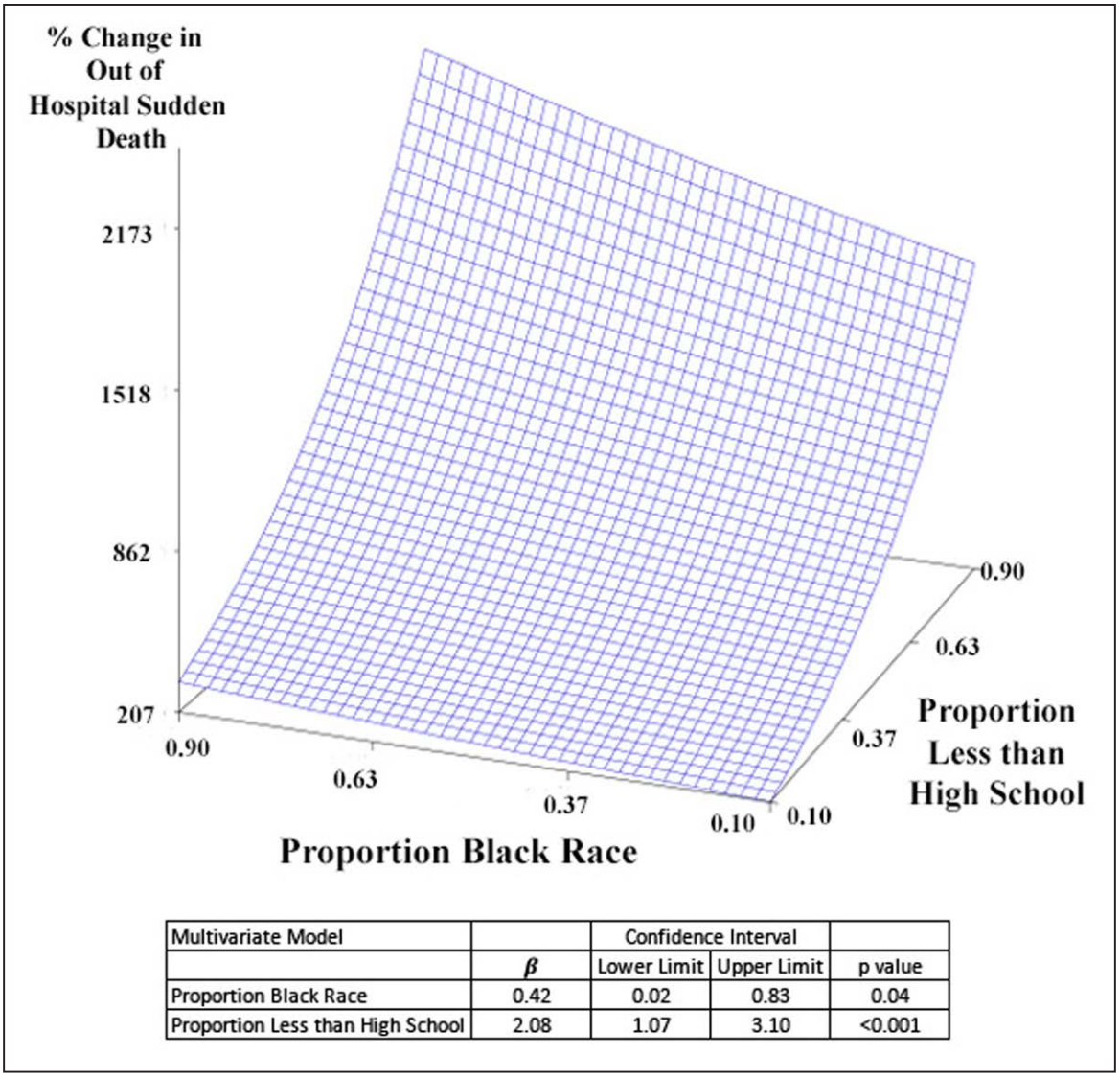


Figure 2. Correlation analysis between percentage of race/ethnicity and percentage less than high school education in ZIP codes.
Spearman correlation coefficient, *r*, is reported.



Multivariate Model		Confidence Interval		
	β	Lower Limit	Upper Limit	p value
Proportion Black Race	0.42	0.02	0.83	0.04
Proportion Less than High School	2.08	1.07	3.10	<0.001

Figure 3. Displays the lower predicted rate of increase (effect of β) in ZIP code level out of hospital sudden death (OHSD) with higher proportion of (10%–90%) Black population (angle with *x* axis) compared with the higher predicted rate of increase in OHSD with higher (10%–90%) of people with less than high school in a ZIP code (angle with *y* axis).
Rate of increase in ZIP code ratio of OHSD with increasing % of both Black and less than high school (angle with xy surface) in a ZIP code.

were less affected by the endemic surge. That coupled with the fact that elderly patients were more likely to be hospitalized might explain the paradox of a lower increase of OHSD in ZIP codes with a higher percentage of population >65 years of age. It is possible not all OHSDs may have resulted in an emergency medical service response and are therefore not reflected in this dataset. Finally, the cause of sudden death is unknown as it was not reported by the Fire Department of New York. However, this does not invalidate the findings of increased OHSD and the social factors impacting death during the pandemic.

Conclusions

The proportion of people with less than a high school education and the proportion of Black residents in NYC ZIP codes were significantly associated with increased rates of OHSD during the COVID-19 NYC pandemic. Addressing components of structural inequities, including low health literacy among those with less than high school education, may positively impact survival. Results from future research must continue to inform leaders in health care and public policy. This should encourage the creation of equitable laws, policies, and practices that can dismantle structural inequities, which in turn, can save lives. Further studies are needed to identify the mechanism of increased OHSD during a pandemic which are not reported in this study.

ARTICLE INFORMATION

Received November 30, 2020; accepted March 14, 2021.

Affiliations

Zucker School of Medicine at Hofstra/Northwell, Northwell Health, Hempstead (S.E.M., L.M.E., J.M., C.K., R.-M.B., J.K., S.R., P.M., J.H.M., K.W.D., R.O.R.). Department of Cardiology, Northwell Health, New York (S.E.M., L.M.E., K.C., M.S., R.-M.B., J.K., P.M., J.H.M., R.O.R.). Division of Pediatric Surgery, Cohen's Children's Hospital, Northwell Health, New Hyde Park (C.K.). Center for Equity of Care, Northwell Health, Lake Success (J.M., E.M., J.H.M., R.O.R.). Feinstein Institute for Medical Research, Northwell Health, Manhasset, NY (M.L.).

Sources of Funding

This work was supported by the grant R24AG064191 from the National Institute of Aging of the National Institutes of Health.

Disclosures

None.

REFERENCES

1. Braveman P, Gottlieb L. The social determinants of health: it's time to consider the causes of the causes. *Public Health Rep*. 2014;129(suppl 2):19–31. doi: 10.1177/00333549141291S206
2. Stecker EC, Reinier K, Rusinaru C, Uy-Evanado A, Jui J, Chugh SS. Health Insurance Expansion and Incidence of out-of-hospital cardiac arrest: a pilot study in a US Metropolitan Community. *J Am Heart Assoc*. 2017;6:e005667. doi: 10.1161/JAHA.117.005667
3. Huikuri HV, Castellanos A, Myerburg RJ. Sudden death due to cardiac arrhythmias. *N Engl J Med*. 2001;345:1473–1482. doi: 10.1056/NEJMra000650
4. Baldi E, Sechi GM, Mare C, Canevari F, Brancaglione A, Primi R, Klersy C, Palo A, Contri E, Ronchi V, et al; Lombardia CARe Researchers. Out-of-hospital cardiac arrest during the Covid-19 outbreak in Italy. *N Engl J Med*. 2020;383:496–498. doi: 10.1056/NEJMc2010418
5. Mountantonakis SE, Saleh M, Coleman K, Kuvin J, Singh V, Jauhar R, Ong L, Qiu M, Epstein LM. Out-of-hospital cardiac arrest and acute coronary syndrome hospitalizations during the COVID-19 surge. *J Am Coll Cardiol*. 2020;76:1271–1273. doi: 10.1016/j.jacc.2020.07.021
6. Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, Wang B, Xiang H, Cheng Z, Xiong Y, et al. Clinical Characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. *JAMA*. 2020;323:1061–1069. doi: 10.1001/jama.2020.1585
7. Guo T, Fan Y, Chen M, Wu X, Zhang L, He T, Wang H, Wan J, Wang X, Lu Z. Cardiovascular implications of fatal outcomes of patients with coronavirus disease 2019 (COVID-19). *JAMA Cardiol*. 2020;5:811–818. doi: 10.1001/jamacardio.2020.1017
8. Wiersinga WJ, Rhodes A, Cheng AC, Peacock SJ, Prescott HC. Pathophysiology, transmission, diagnosis, and treatment of coronavirus disease 2019 (COVID-19): a review. *JAMA*. 2020;324:782–793. doi: 10.1001/jama.2020.12839
9. Douglas JA, Subica AM. COVID-19 treatment resource disparities and social disadvantage in New York City. *Prev Med*. 2020;141:106282. doi: 10.1016/j.ypmed.2020.106282
10. New York City Department of Health and Mental Hygiene. COVID-19 Data. 2020; Accessed May 1, 2020. https://www1.nyc.gov/site/doh/covid/covid-19-data.page
11. Arasteh K. Prevalence of comorbidities and risks associated with COVID-19 among black and hispanic populations in New York City: an examination of the 2018 New York City Community Health Survey. *J Racial Ethn Health Disparities*. 2020;13:1–7.
12. Price-Haywood EG, Burton J, Fort D, Seoane L. Hospitalization and mortality among black patients and white patients with Covid-19. *N Engl J Med*. 2020;382:2534–2543. doi: 10.1056/NEJMsa2011686
13. Webb Hooper M, Nápoles AM, Pérez-Stable EJ. COVID-19 and racial/ethnic disparities. *JAMA*. 2020;323:2466–2467. doi: 10.1001/jama.2020.8598
14. Lai PH, Lancet EA, Weiden MD, Webber MP, Zeig-Owens R, Hall CB, Prezant DJ. Characteristics associated with out-of-hospital cardiac arrests and resuscitations during the novel coronavirus disease 2019 pandemic in New York City. *JAMA Cardiol*. 2020;5:1154–1163.
15. Cogburn CD. Culture, Race, and Health: Implications for Racial Inequities and Population Health. *Milbank Q*. 2019;97:736–761. doi: 10.1111/1468-0009.12411
16. NYC Crime Statistics Historical New York City Crime Data. Accessed April 23, 2020. https://www1.nyc.gov/site/nypd/stats/crime-statis-tics/historical.page
17. UDS Mapper. "HealthLandscape. ZIP Code to ZCTA Crosswalk". Accessed May 02, 2020. https://udsmapper.org/zip-code-to-zcta-crosswalk/
18. Thomas AJ, Eberly LE, Davey Smith G, Neaton JD; Multiple Risk Factor Intervention Trial (MRFIT) Research Group. ZIP-code-based versus tract-based income measures as long-term risk-adjusted mortality predictors. *Am J Epidemiol*. 2006;164:586–590. doi: 10.1093/aje/kwj234
19. Berkowitz SA, Traore CY, Singer DE, Atlas SJ. Evaluating area-based socioeconomic status indicators for monitoring disparities within health care systems: results from a primary care network. *Health Serv Res*. 2015;50:398–417. doi: 10.1111/1475-6773.12229
20. Luy M, Zannella M, Wegner-Siegmundt C, Minagawa Y, Lutz W, Caselli G. The impact of increasing education levels on rising life expectancy: a decomposition analysis for Italy, Denmark, and the USA. *Genus*. 2019;75:11.
21. Schultz WM, Kelli HM, Lisko JC, Varghese T, Shen J, Sandesara P, Quyyumi AA, Taylor HA, Gulati M, Harold JG, et al. Socioeconomic status and cardiovascular outcomes: challenges and interventions. *Circulation*. 2018;137:2166–2178. doi: 10.1161/CIRCULATIONAHA.117.029652
22. Woodward M, Peters SA, Batty GD, Ueshima H, Woo J, Giles GG, Barzi F, Ho SC, Huxley RR, Arima H, et al; Asia Pacific Cohort Studies Collaboration. Socioeconomic status in relation to cardiovascular disease and cause-specific mortality: a comparison of Asian and Australasian populations in a pooled analysis. *BMJ Open*. 2015;5:e006408. doi: 10.1136/bmjopen-2014-006408
23. Rosengren A, Subramanian SV, Islam S, Chow CK, Avezum A, Kazmi K, Sliwa K, Zubaid M, Rangarajan S, Yusuf S; INTERHEART Investigators. Education and risk for acute myocardial infarction in 52 high, middle and low-income countries: INTERHEART case-control study. *Heart*. 2009;95:2014–2022. doi: 10.1136/hrt.2009.182436
24. Kelly MJ, Weitzen S. The association of lifetime education with the prevalence of myocardial infarction: an analysis of the 2006 Behavioral Risk Factor Surveillance System. *J Community Health*. 2010;35:76–80. doi: 10.1007/s10900-009-9189-x
25. Hu B, Li W, Wang X, Liu L, Teo K, Yusuf S; INTER-HEART Investigators. Marital status, education, and risk of acute myocardial infarction in Mainland China: the INTER-HEART study. *J Epidemiol*. 2012;22:123–129. doi: 10.2188/jea.je20100175
26. Gerber Y, Goldbourt U, Drory Y; Israel Study Group on First Acute Myocardial Infarction. Interaction between income and education in predicting long-term survival after acute myocardial infarction. *Eur J Cardiovasc Prev Rehabil*. 2008;15:526–532. doi: 10.1097/HJR.0b013e328304feac
27. Kershaw KN, Droomers M, Robinson WR, Carnethon MR, Daviglus ML, Monique Verschuren WM. Quantifying the contributions of behavioral and biological risk factors to socioeconomic disparities in coronary heart disease incidence: the MORGEN study. *Eur J Epidemiol*. 2013;28:807–814. doi: 10.1007/s10654-013-9847-2
28. Baker DW, Wolf MS, Feinglass J, Thompson JA, Gazmararian JA, Huang J. Health literacy and mortality among elderly persons. *Arch Intern Med*. 2007;167:1503–1509. doi: 10.1001/archinte.167.14.1503
29. Mantwill S, Monestel-Umaña S, Schulz PJ. The relationship between health literacy and health disparities: a systematic review. *PLoS One*. 2015;10:e0145455. doi: 10.1371/journal.pone.0145455
30. Institute of Medicine (US) Committee on Health Literacy. *Health Literacy: a Prescription to End Confusion*. Nielsen-Bohlman L, Panzer AM, Kindig DA, eds. National Academies Press (US); 2004.
31. Lange SJ, Ritchey MD, Goodman AB, Dias T, Twentyman E, Fuld J, Schieve LA, Imperatore G, Benoit SR, Kite-Powell A, et al. Potential indirect effects of the COVID-19 pandemic on use of emergency departments for acute life-threatening conditions - United States, January-May 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69:795–800. doi: 10.15585/mmwr.mm6925e2
32. Garcia S, Albaghdadi MS, Meraj PM, Schmidt C, Garberich R, Jaffer FA, Dixon S, Rade JJ, Tannenbaum M, Chambers J, et al. Reduction in ST-segment elevation cardiac catheterization laboratory activations in the United States During COVID-19 pandemic. *J Am Coll Cardiol*. 2020;75:2871–2872. doi: 10.1016/j.jacc.2020.04.011
33. Solomon MD, McNulty EJ, Rana JS, Leong TK, Lee C, Sung SH, Ambrosy AP, Sidney S, Go AS. The Covid-19 pandemic and the incidence of acute myocardial infarction. *N Engl J Med*. 2020;383:691–693. doi: 10.1056/NEJMc2015630
34. Bhatt AS, Moscone A, McElrath EE, Varshney AS, Claggett BL, Bhatt DL, Januzzi JL, Butler J, Adler DS, Solomon SD, et al. Fewer hospitalizations for acute cardiovascular conditions during the COVID-19 pandemic. *J Am Coll Cardiol*. 2020;76:280–288. doi: 10.1016/j.jacc.2020.05.038
35. Gogia S, Newton-Dame R, Boudourakis L, Uppal A, Tatem K, Gupta R, Langston MD, Astua A, Kapinos G, Sokol SI, et al. COVID-19 X-curves: illness

hidden, illness deferred. *NEJM Catalyst*. 2020. https://catalyst.nejm.org/doi/full/10.1056/CAT.20.0231
36. Metzler B, Siostrzonek P, Binder RK, Bauer A, Reinstadler SJ. Decline of acute coronary syndrome admissions in Austria since the outbreak of COVID-19: the pandemic response causes cardiac collateral damage. *Eur Heart J*. 2020;41:1852–1853. doi: 10.1093/eurheartj/ehaa314
37. Kansagra AP, Goyal MS, Hamilton S, Albers GW. Collateral effect of Covid-19 on stroke evaluation in the United States. *N Engl J Med*. 2020;383:400–401. doi: 10.1056/NEJMc2014816
38. Deo R, Safford MM, Khodneva YA, Jannat-Khah DP, Brown TM, Judd SE, McClellan WM, Rhodes JD, Shlipak MG, Soliman EZ, et al. Differences in risk of sudden cardiac death between blacks and whites. *J Am Coll Cardiol*. 2018;72:2431–2439. doi: 10.1016/j.jacc.2018.08.2173
39. Zhao D, Post WS, Blasco-Colmenares E, Cheng A, Zhang Y, Deo R, Pastor-Barriuso R, Michos ED, Sotoodehnia N, Guallar E. Racial differences in sudden cardiac death. *Circulation*. 2019;139:1688–1697. doi: 10.1161/CIRCULATIONAHA.118.036553
40. Lewis TT, Williams DR, Tamene M, Clark CR. Self-reported experiences of discrimination and cardiovascular disease. *Curr Cardiovasc Risk Rep*. 2014;8:365. doi: 10.1007/s12170-013-0365-2
41. Brody GH, Lei MK, Chae DH, Yu T, Kogan SM, Beach SRH. Perceived discrimination among African American adolescents and allostatic load: a longitudinal analysis with buffering effects. *Child Dev*. 2014;85:989–1002. doi: 10.1111/cdev.12213
42. Williams DR, Lawrence JA, Davis BA, Vu C. Understanding how discrimination can affect health. *Health Serv Res*. 2019;54 Suppl 2:1374–1388. doi: 10.1111/1475-6773.13222
43. Williams DR, Lawrence JA, Davis BA. Racism and health: evidence and needed research. *Annu Rev Public Health*. 2019;40:105–125. doi: 10.1146/annurev-publhealth-040218-043750
44. Geronimus AT, Hicken M, Keene D, Bound J. "Weathering" and age patterns of allostatic load scores among blacks and whites in the United States. *Am J Public Health*. 2006;96:826–833. doi: 10.2105/AJPH.2004.060749
45. Churchwell K, Elkind MSV, Benjamin RM, Carson AP, Chang EK, Lawrence W, Mills A, Odom TM, Rodriguez CJ, Rodriguez F, et al; American Heart Association. Call to action: structural racism as a fundamental driver of health disparities: a presidential advisory from the American Heart Association. *Circulation*. 2020;142:e454–e468. doi: 10.1161/CIR.0000000000000936
46. Ogedegbe G. Responsibility of medical journals in addressing racism in health care. *JAMA Netw Open*. 2020;3:e2016531. doi: 10.1001/jamanetworkopen.2020.16531
47. Colantonio LD, Gamboa CM, Richman JS, Levitan EB, Soliman EZ, Howard G, Safford MM. Black-white differences in incident fatal, nonfatal, and total coronary heart disease. *Circulation*. 2017;136:152–166. doi: 10.1161/CIRCULATIONAHA.116.025848
48. Powell W, Richmond J, Mohottige D, Yen I, Joslyn A, Corbie-Smith G. Medical mistrust, racism, and delays in preventive health screening among African-American Men. *Behav Med*. 2019;45:102–117. doi: 10.1080/08964289.2019.1585327
49. Kirby JB, Kaneda T. Neighborhood socioeconomic disadvantage and access to health care. *J Health Soc Behav*. 2005;46:15–31. doi: 10.1177/002214650504600103
50. Phelan JC, Link BG, Tehranifar P. Social conditions as fundamental causes of health inequalities: theory, evidence, and policy implications. *J Health Soc Behav*. 2010;51(suppl):S28–S40. doi: 10.1177/0022146510383498
51. Becker LB, Han BH, Meyer PM, Wright FA, Rhodes KV, Smith DW, Barrett J. Racial differences in the incidence of cardiac arrest and subsequent survival. The CPR Chicago Project. *N Engl J Med*. 1993;329:600–606. doi: 10.1056/NEJM199308263290902
52. Wilde ET, Robbins LS, Pressley JC. Racial differences in out-of-hospital cardiac arrest survival and treatment. *Emerg Med J*. 2012;29:415–419. doi: 10.1136/emj.2010.109736
53. Edelson DP, Sasson C, Chan PS, Atkins DL, Aziz K, Becker LB, Berg RA, Bradley SM, Brooks SC, Cheng A, et al; American Heart Association ECC Interim COVID Guidance Authors. Interim guidance for basic and advanced life support in adults, children, and neonates with suspected or confirmed COVID-19: from the emergency cardiovascular care committee and get with the guidelines-resuscitation adult and pediatric task forces of the American Heart Association. *Circulation*. 2020;141:e933–e943. doi: 10.1161/CIRCULATIONAHA.120.047463
54. Sasson C, Magid DJ, Chan P, Root ED, McNally BF, Kellermann AL, Haukoos JS; CARES Surveillance Group. Association of neighborhood characteristics with bystander-initiated CPR. *N Engl J Med*. 2012;367:1607–1615. doi: 10.1056/NEJMoa1110700
55. Bailey ZD, Krieger N, Agénor M, Graves J, Linos N, Bassett MT. Structural racism and health inequities in the USA: evidence and interventions. *Lancet*. 2017;389:1453–1463. doi: 10.1016/S0140-6736(17)30569-X