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Am Heart J. Author manuscript; available in PMC 2022 August 01.

Published in final edited form as:

Am Heart J. 2021 August ; 238: 27–32. doi:10.1016/j.ahj.2021.03.015.

Neighborhood education status drives racial disparities in clinical outcomes in PPCM

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Abstract

Background—Peripartum cardiomyopathy (PPCM) disproportionately affects women of African ancestry. Additionally, clinical outcomes are worse in this subpopulation compared to White women with PPCM. The extent to which socioeconomic parameters contribute to these racial disparities is not known.

Methods—We aimed to quantify the association between area-based proxies of socioeconomic status (SES) and clinical outcomes in PPCM, and to determine the potential contribution of these factors to racial disparities in outcomes. A retrospective cohort study was performed at the University of Pennsylvania Health System, a tertiary referral center serving a population with a high proportion of Black individuals. The cohort included 220 women with PPCM, 55% of whom were Black or African American. Available data included clinical and demographic characteristics as well as residential address georeferenced to US Census-derived block group measures of SES. Rates of sustained cardiac dysfunction (defined as persistent LVEF <50%, LVAD placement, transplant, or death) were compared by race and block group-level measures of SES, and a composite neighborhood concentrated disadvantage index (NDI). The contributions of area-based

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Conflict of interest

The authors declare no conflict of interest.

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socioeconomic parameters to the association between race and sustained cardiac dysfunction were quantified.

Results—Black race and higher NDI were both independently associated with sustained cardiac dysfunction (relative risk [RR] 1.63, confidence interval [CI] 1.13–2.36; and RR 1.29, CI 1.08–1.53, respectively). Following multivariable adjustment, effect size for NDI remained statistically significant, but effect size for Black race did not. The impact of low neighborhood education on racial disparities in outcomes was stronger than that of low neighborhood income (explaining 45% and 0% of the association with black race, respectively). After multivariate adjustment, only low area-based education persisted as significantly correlating with sustained cardiac dysfunction (RR 1.49; CI 1.02–2.17).

Conclusions—Both Black race and NDI independently associate with adverse outcomes in women with PPCM in a single center study. Of the specific components of NDI, neighborhood low education was most strongly associated with clinical outcome and partially explained differences in race. These results suggest interventions targeting social determinants of health in disadvantaged communities may help to mitigate outcome disparities.

Peripartum cardiomyopathy (PPCM) is a sometimes severe form of cardiomyopathy occurring toward the end of pregnancy or months postpartum in women with previously normal hearts.[1,2] The estimated incidence of PPCM is 1 in 2,000 pregnant women worldwide, with hotspots such as Haiti and Nigeria.[1,3] In the U.S., the prevalence of PPCM is higher in Black women than White women.[4,5] Clinical outcomes in PPCM vary widely, with most women ultimately recovering cardiac function, but a significant minority of women developing worsening function, need for LVAD or cardiac transplant, or death.[1,3] Again, Black women fare worse than White women: they are generally diagnosed later in the postpartum period and, when diagnosed, are less likely to have recovery of left ventricular (LV) function and more likely to experience adverse events compared to White women.[6,7] We previously described the outcomes of 220 women with PPCM diagnosed and treated within the University of Pennsylvania Health System (Penn) and demonstrated that Black women were half as likely to recover, and took twice as long to do so when they did recover.[6]

The reasons for differences in clinical outcomes between Black and White women with PPCM remain unclear, and may be related to underlying biology, genetics, or a complex interplay of individual and social factors. Social determinants of health impact the development of cardiovascular (CV) risk factors and disease, health behaviors, treatment patterns, and clinical outcomes in complex ways. Neighborhood disadvantage, for example, is associated with incident heart failure and risk of readmission, in addition to individual race/ethnicity and socioeconomic status.[8–10] Neighborhood characteristics and associations with outcomes in PPCM have not previously been examined.

We therefore sought to determine: (1) if neighborhood level social determinants impact clinical outcomes in PPCM; and (2) to what extent the poor outcomes observed in Black women with PPCM may be attributed to neighborhood disadvantage. To do so, we leveraged our large, racially diverse cohort of PPCM patients, the majority of whom live in Philadelphia, a large city with noted differences in access to care and clinical

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outcomes based on race.[11] We further integrated our cohort with a spatially enabled data set to understand how neighborhood disadvantage impacts clinical outcomes in PPCM, and interacts with racial background.

Methods

The University of Pennsylvania Institutional Review Board approved the study and determined that informed consent was not required. We assembled a retrospective cohort of patients at Penn with a diagnosis of PPCM from January 1, 1986, through December 31, 2016 based on diagnostic codes (International Classification of Diseases, Ninth Revision codes 674.50–54) or echocardiographic evaluations obtained within 6 months of delivery.[6] Patients with a history of congenital heart disease, valvular disease predating their PPCM diagnosis, history of radiation or cardiotoxic chemotherapy, or another explanation for their heart failure were excluded.

We abstracted demographic details, residential addresses, diagnosis, and clinical outcome information from the patient electronic medical records. We used ArcGIS Pro (Esri, Redlands, CA) to geocode addresses and identify corresponding Census block groups. A Census block group is the smallest geographic unit (average 1,500 people) in which sample data from decennial census and the American Community Survey are available. Using block groups as a proxy for neighborhoods, we spatiotemporally integrated a select set of variables from the 1990, 2000, and 2010 Census as well as the 2009 through the 2016 American Community Surveys.[12] A composite neighborhood concentrated disadvantage index (NDI) was computed for each patient as the sum of the proportions of unemployment, households receiving public assistance, persons below the federal poverty line, adults without a high school diploma, female-headed households, renter-occupied residences, and residential tenure shorter than 1 year.[13] Each of the components of the NDI were dichotomized at the threshold of their highest quartile for statistical analyses. Sustained cardiac dysfunction was defined as persistent LVEF <50%, cardiac transplant, LVAD placement, or death. Myocardial recovery was defined as at least one occasion of LVEF >50% on echocardiography.

Distributions of patient characteristics were compared by quartiles of block group level factors using χ^2 or Fisher exact tests. We examined the potential for a non-linear association between NDI and persistent cardiomyopathy with restricted cubic splines.[14] We examined the cardiac outcomes (sustained cardiac dysfunction, and myocardial recovery) relative to NDI, and then separately to each component informing the NDI. Crude and multivariate log binomial regression models were used to estimate risk ratios (RR) and corresponding 95% confidence intervals (95% CI). Multivariable models were adjusted first for patient characteristics that were associated with the area-based exposures, or race. The proportional contribution of each area-based socioeconomic parameters to the effect of race on cardiac outcomes was quantified.[15]

The authors are solely responsible for the design and conduct of this study, all study analyses, the drafting and editing of the paper and its final contents. Sources of funding: ZA was supported by the Department of Defense (DOD W81XWH18–1-0503) and NIH

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(HL126797). KG was supported by the NIH (HL143153). JL was supported by the NIH (HL153667).

Results

The cohort of 220 women diagnosed with PPCM consisted of 121 Black women and 99 non-Black women. Demographic and clinical characteristics at presentation and clinical outcomes of this cohort have been described previously.[6] Figures 1 and S1 present the relational geographic distribution of the patients to the greater Philadelphia Metropolitan Area. Neighborhoods with greater disadvantage are concentrated in Philadelphia, Camden, and Trenton.

Table S1 provides the demographics and clinical characteristics for the study population overall, and subdivided by quartiles of NDI, median household income, and proportion of residents with less than high school education, according to block group. Patients in neighborhoods with greater disadvantage were younger (28 years in quartile 4 (Q4) vs. 32 years in quartile 1 (Q1), $P = .002$), and more likely to be Black (89% in Q4 vs 16% in Q1, $P < .001$). Patients from more disadvantaged neighborhoods tended to have a lower nadir LVEF compared to those from less disadvantaged neighborhoods.

Overall, 36.3% ($n = 81$) of patients experienced sustained dysfunction. Both Black race (44% vs 28%; RR 1.63, 95% CI 1.13–2.36) and higher NDI (RR 1.29, 95% CI 1.08–2.53) were independently associated with sustained cardiac dysfunction (Table I). Restricted cubic spline regression revealed that the association between NDI and sustained dysfunction was linear (P value for test for curvature: 0.440; overall significance of linear trend 0.004; Figure 2). Every unit increase in NDI was associated with a 29% higher likelihood of sustained cardiac dysfunction. Effect estimates for both exposures were attenuated following adjustment for age, twin pregnancy, number of children, and timing of diagnosis, but only NDI remained statistically significant (Table I, M1)

Of the individual components of NDI, only area-based low education and high rental occupied housing were significantly associated with sustained cardiac dysfunction (Table I, first column), which persisted after adjusting for race (Table I, M2). Other components of NDI had adjusted risk ratios near null (Table I, M2). The effect estimate for race on sustained dysfunction was largely attenuated upon control for area-based low education: in fact, low education explained approximately 45% of the effect of race on sustained dysfunction (Table I, M3 vs M2). In contrast, control for area-based low income had no impact on the effect estimate for race on sustained dysfunction (Table I, M5 vs M1). Overall comparable results were observed for myocardial recovery (Supplemental Table S2).

Discussion

We find here, in a large racially diverse cohort of women with PPCM, that the markedly worse average clinical outcome of Black women may be explained in large part by greater neighborhood disadvantage, specifically lower educational status at the block group level. The findings underscore the importance of social determinants of health as potential drivers of racial disparities in PPCM. Specifically, lower education status appears to impact PPCM

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outcomes independent of race, and may do so by creating barriers to timely access to high-quality medical care, communication with medical providers, understanding of symptoms, medication adherence, and self-advocacy, especially in the context of structural racism. Race and socioeconomic class are highly correlated in the U.S. Racial disparities in maternal health have been documented independent of education of the individual.[16] The experiences of racism impact the quality of care delivered, patient care engagement, and communication between health care providers and patients. Women from lower SES groups report higher rates of perceived discrimination based on race and insurance status, which may further adversely impact maternal health outcomes.[17, 18]

Despite being the largest mixed-race PPCM cohort reported to date, limitations of our study include being single-center with variable duration of follow-up, which reduces generalizability. Due to relatively small numbers, the analyses do not include Latino or Asian women. Additionally, data were assessed only at the block group level, rather than individual level. Although area-based measures of socioeconomic status may serve as crude proxies to individual SES, they may also have distinct independent and synergistic impacts on PPCM outcomes. Nevertheless, the NDI and component area-based exposures examined do not account for psychological distress, food insecurity, or delays in medical care, all of which may directly impact outcomes for women with PPCM. Data on the use of in vitro fertilization, or on medical treatments for PPCM including type, intensity, or duration were not captured in the manual chart abstractions completed for the cohort and thus are not accounted for in the presented analyses.

In summary, our finding that low area-based education was associated with worse outcomes in women with PPCM suggests a potential role for strategies aimed at improving access to care, patient-provider communication, and in particular health education in mitigating such disparities.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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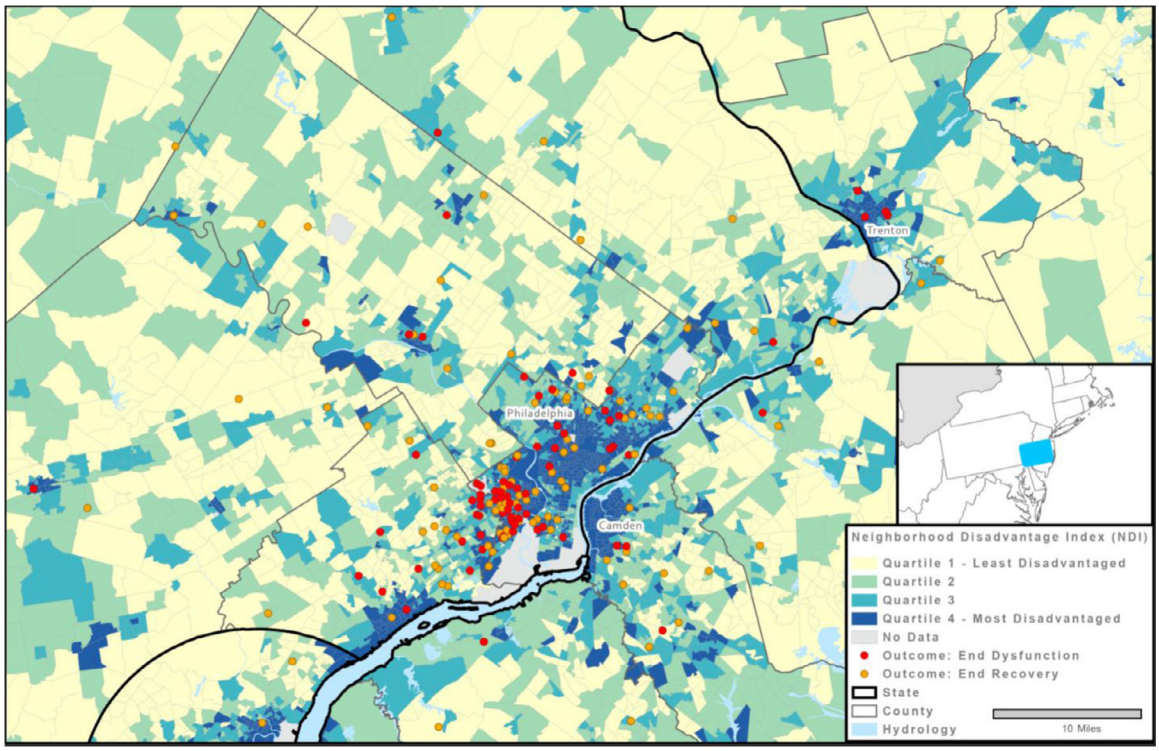

Figure 1.

Relational geographic distribution of PPCM patients to the greater Philadelphia Metropolitan Area, distinguishing between patients who recovered (in yellow) versus those who did not (in red), and stratified by neighborhood disadvantage index (NDI). To protect the privacy of the patients, their locations were spatially anonymized using areal filters and random perturbation.

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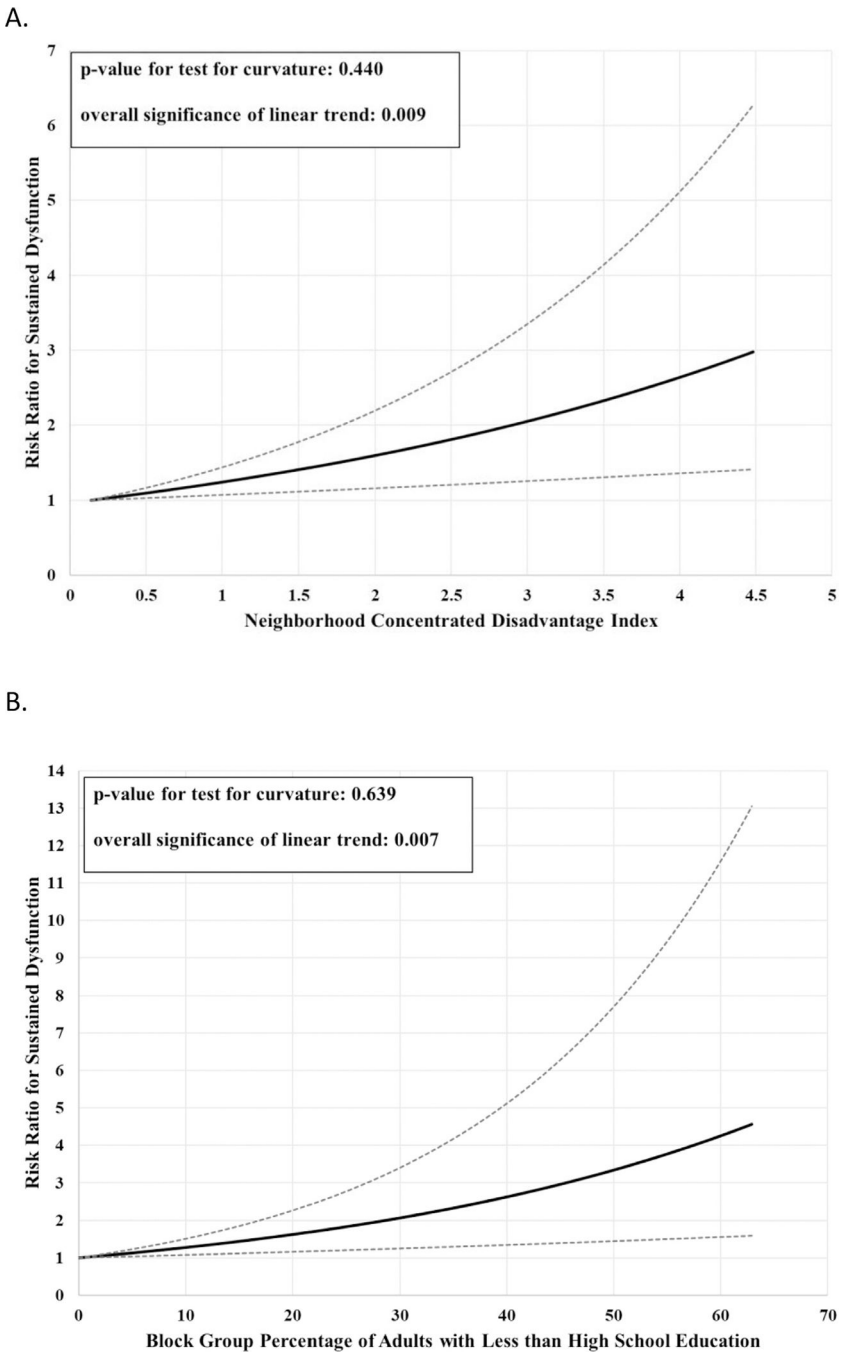

Figure 2.

Linear relationships between (A) neighborhood-concentrated disadvantage index and occurrence of sustained cardiac dysfunction, and (B) proportion of adults in block group with less than a high school education and occurrence of sustained cardiac dysfunction.

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Table I.

	Crude RR (95% CI)	p-value	Adjusted RR (M1)	p-value	Adjusted RR (M2)	p-value	Adjusted RR (M3)	p-value	Adjusted RR (M4)	p-value	Adjusted RR (M5)	p-value
Black race	1.63 (1.13, 2.36)	0.009	1.34 (0.88, 2.03)	0.171	1.19 (0.74,1.92)	0.474	1.17 (0.76, 1.81)	0.419	1.18 (0.74,1.78)	0.527	1.34 (0.87, 2.06)	0.185
Neighborhood concentrated disadvantage index	1.29 (1.08,1.53)	0.004	1.23 (1.00,1.51)	0.021	1.17 (0.91,1.49)	0.217						
Assessments for the Individual Components of the Neighborhood Concentrated Disadvantage Index[a]												
>22.3% adults with less than HS education	1.73 (1.25, 2.39)	<0.001	1.57 (1.10,2.24)	0.014	1.49 (1.02,2.17)	0.040						
>31.8% Renter Occupied Housing	1.70 (1.20, 2.42)	0.003	1.57 (1.07,2.30)	0.020	1.50 (1.00, 2.25)	0.049						
>28.5% HH w. annual income below poverty line	1.23 (0.86,1.77)	0.265	1.09 (0.75,1.60)	0.647	1.00 (0.68,1.46)	0.999						
>31.5% Female Headed Households	1.23 (0.86,1.77)	0.264	1.00 (0.68,1.47)	0.991	0.95 (0.65,1.39)	0.946						
>16.3% adults unemployed	1.14 (0.78,1.67)	0.482	0.98 (0.66,1.45)	0.915	0.90 (0.60,1.33)	0.585						
>10.2% adults on public assistance	1.10 (0.75,1.62)	0.621	0.96 (0.65,1.42)	0.827	0.90 (0.60,1.34)	0.900						
>28.4% with residential tenure less than 1 year	1.11 (0.76,1.63)	0.576	1.08 (0.74,1.59)	0.682	1.10 (0.74,1.64)	0.616						

[a]Each of the block group-level components of the neighborhood disadvantage index were dichotomized at highest quartile for statistical analyses (i.e. Q4 vs Q1-Q3). The numeric thresholds presented for each of the NDI components represent the cutoff value defining the highest quartile.

M1 = adjusted for age, twin pregnancy, number of children, and timing of diagnosis

M2 = race model adjusted for age, twin pregnancy, number of children, timing of diagnosis, and neighborhood concentrated disadvantage index (NDI); Models for individal NDI component area-based exposures adjusted for age, twin pregnancy, number of children, timining of diagnosis, and race

M3 = race model adjusted for age, twin pregnancy, number of children, timing of diagnosis, and neighborhood-based low education

M4 = race model adjusted for age, twin pregnancy, number of children, timing of diagnosis, and neighborhood-based high renter occupied housing

M5 = race model adjusted for age, twin pregnancy, number of children, timing of diagnosis, and neighborhood-based high poverty

Am Heart J. Author manuscript; available in PMC 2022 August 01.