The influence of structural racism, pandemic stress, and SARS-CoV-2 infection during pregnancy with adverse birth outcomes

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BACKGROUND: Structural racism and pandemic-related stress from the COVID-19 pandemic may increase the risk of adverse birth outcomes.

OBJECTIVE: Our objective was to examine associations between neighborhood measures of structural racism and pandemic stress with 3 outcomes: SARS-CoV-2 infection, preterm birth, and delivering small-for-gestational-age newborns. Our secondary objective was to investigate the joint association of SARS-CoV-2 infection during pregnancy and neighborhood measures with preterm birth and delivering small-for-gestational-age newborns.

STUDY DESIGN: We analyzed data of 967 patients from a prospective cohort of pregnant persons in New York City, comprising 367 White (38%), 169 Black (17%), 293 Latina (30%), and 87 Asian persons (9%), 41 persons of other race or ethnicity (4%), and 10 of unknown race or ethnicity (1%). We evaluated structural racism (social/built structural disadvantage, racial-economic segregation) and pandemic-related stress (community COVID-19 mortality, community unemployment rate increase) in quartiles by zone improvement plan code. SARS-CoV-2 serologic enzyme-linked immunosorbent assay was performed on blood samples from pregnant persons. We obtained data on preterm birth and small-for-gestational-age newborns from an electronic medical record database. We used log-binomial regression with robust standard error for clustering by zone improvement plan code to estimate associations of each neighborhood measure separately with 3 outcomes: SARS-CoV-2 infection, preterm birth, and small-for-gestational-age newborns. Covariates included maternal age, parity, insurance status, and body mass index. Models with preterm birth and small-for-gestational-age newborns as the dependent variables additionally adjusted for SARS-CoV-2 infection.

RESULTS: A total of 193 (20%) persons were SARS-CoV-2−seropositive, and the overall risks of preterm birth and small-for-gestational-age newborns were 8.4% and 9.8%, respectively. Among birthing persons in neighborhoods in the highest quartile of structural disadvantage (n=190), 94% were non-White, 50% had public insurance, 41% were obese, 32% were seropositive, 11% delivered preterm, and 12% delivered a small-for-gestational-age infant. Among birthing persons in neighborhoods in the lowest quartile of structural disadvantage (n=360), 39% were non-White, 17% had public insurance, 15% were obese, 9% were seropositive, 6% delivered preterm, and 10% delivered a small-for-gestational-age infant. In adjusted analyses, structural racism measures and community unemployment were associated with both SARS-CoV-2 infection and preterm birth, but not small-for-gestational-age infants. High vs low structural disadvantage was associated with an adjusted relative risk of 2.6 for infection (95% confidence interval, 1.7−3.9) and 1.7 for preterm birth (95% confidence interval, 1.0−2.9); high vs low racial-economic segregation was associated with adjusted relative risk of 1.9 (95% confidence interval, 1.3−2.8) for infection and 2.0 (95% confidence interval, 1.3−3.2) for preterm birth; high vs low community unemployment increase was associated with adjusted relative risk of 1.7 (95% confidence interval, 1.2−1.5) for infection and 1.6 (95% confidence interval, 1.0−2.8) for preterm birth. COVID-19 mortality rate was associated with SARS-CoV-2 infection but not preterm birth or small-for-gestational-age infants. SARS-CoV-2 infection was not independently associated with birth outcomes. We found no interaction between SARS-CoV-2 infection and neighborhood measures on preterm birth or small-for-gestational-age infants.

CONCLUSION: Neighborhood measures of structural racism were associated with both SARS-CoV-2 infection and preterm birth, but these associations were independent and did not have a synergistic effect. Community unemployment rate increases were also associated with an increased risk of preterm birth independently of SARS-CoV-2 infection. Mitigating these factors might reduce the impact of the pandemic on pregnant people.

Keywords: COVID-19, preterm birth, racism, SARS-CoV-2, small-for-gestational-age, unemployment

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Introduction

The COVID-19 pandemic is exacerbated by preexisting structures of racism and socioeconomic inequity.[1] In March 2020, New York City (NYC) emerged as the first epicenter of the pandemic in the United States and one of the first regions where stark pandemic-related inequities became apparent, including among pregnant people.[2] Black and Latina pregnant persons are more likely to test positive for SARS-CoV-2 at delivery than non-Latina White persons,[3−5] and Black and Latina pregnant persons have increased risks for intensive care unit admission and invasive ventilation compared with nonpregnant Black and Latina persons.[6]

AJOG MFM at a Glance

Why was this study conducted?
To understand how existing structures of racism and socioeconomic inequity, and pandemic-related social and economic stressors, influence SARS-CoV-2 infection during pregnancy and adverse birth outcomes.

Key findings
Structural racism and community unemployment were associated with both SARS-CoV-2 infection and preterm birth. The adjusted relative risk of preterm birth for high vs low structural disadvantage was 1.7 (95% confidence interval [CI], 1.0−2.9), for racial-economic segregation 2.0 (95% CI, 1.3−3.2), and for community unemployment 1.6 (95% CI, 1.0−2.8). No associations were found for small-for-gestational-age infants. We found no interaction between SARS-CoV-2 infection and structural racism or social-economic stress on birth outcomes.

What does this add to what is known?
During the COVID-19 pandemic in New York City, structural racism and community unemployment were associated with increased risk of SARS-CoV-2 infection and preterm birth. SARS-CoV-2 infection did not explain or exacerbate associations between structural racism and community unemployment with preterm birth.

Many studies have found that asymptomatic or mild SARS-CoV-2 infection does not seem to increase the risk of adverse birth outcomes, but moderate to severe COVID-19 is associated with higher rates of adverse birth outcomes, including stillbirth and preterm birth (PTB).[7−10] It is plausible that SARS-CoV-2 infection interacts synergistically with social determinants of health, increasing the risk of adverse birth outcomes, which potentially explains the disparate findings across study populations; however, this hypothesis has not been rigorously tested.

Besides the direct health effects of SARS-CoV-2 infection, persons of color are also more likely to experience pandemic-related psychosocial and economic impacts during and after pregnancy.[11,12] Furthermore, evidence suggests that individuals reporting high levels of perceived prenatal stress during the pandemic have a higher risk of PTB and delivering infants small for gestational age (SGA).[13] Stress might also operate at the community level. Scholars have described COVID-19−related "collective trauma" in communities, particularly communities of color.[14] Understanding the impact of structural and social changes on perinatal outcomes, owing to the pandemic, has been identified as a research priority.[15]

The purpose of this study is to understand how existing structures of racism and socioeconomic inequity, and pandemic-related social and economic stressors, influence SARS-CoV-2 infection during pregnancy and adverse birth outcomes. We analyzed data from a prospective pregnancy cohort of 967 persons from the Generation C Study. Our first objective was to examine associations between neighborhood measures of structural racism and pandemic stress with 3 primary outcomes: SARS-CoV-2 infection, PTB, and delivering a SGA newborn. Our second objective was to investigate the joint association of SARS-CoV-2 infection during pregnancy and neighborhood measures with adverse birth outcomes.

Materials and Methods

Data source and study population

The Generation C Study is a prospective cohort study of SARS-CoV-2 infection during pregnancy, details of which have been previously published.[16] Birthing patients aged 18 years or older receiving obstetrical care at the Mount Sinai Health System (MSHS) were recruited starting in April 2020. We obtained informed consent per study protocol approved by Icahn School of Medicine at Mount Sinai Program for the Protection of Human Subjects. The activity was reviewed by the US Centers for Disease Control and Prevention (CDC) and was conducted in accordance with applicable federal law and CDC policy. Patients were invited by clinical or research staff to participate at either a prenatal care visit or on admission to labor and delivery. We analyzed blood samples collected from 1137 participants expected to deliver in 2020 on the basis of 40-week gestational age. We limited the sample to live births and excluded participants with twin pregnancies and those who did not reside in NYC, resulting in an analytical sample of 967 persons residing in 144 NYC ZIP codes.

Exposures

Structural racism measures. We used an established index to quantify structural disadvantage leading to increased risk of infection.[17] Briefly, the index was created using Bayesian weighted quantile sum regression and 2018 US census data and publicly available NYC SARS-CoV-2 test data as of May 7, 2020 from the NYC Open and New York Open.[18] The index, henceforth referred to as the Covid Disadvantage Index (CDI), is composed of 10 indicators of the built and social environment, weighted for their contribution to variation in the NYC SARS-CoV-2 infection rate, including the number of people in a household, the proportion of the population who are essential workers, proportion of the population who are essential workers who drive to work, the proportion of the population who are essential workers who rely on public transit to commute, the proportion of people without health insurance, median income, percentage of workers working from home, percentage of unemployed population, population density by residential volume, and number of grocers per 1000 residents. The CDI has not previously been tested in association with SARS-CoV-2 seropositivity.

The Index of Concentration at the Extremes (ICE) is a measure of racial and economic segregation that portrays a form of extreme segregation known as spatial polarization.[19] It measures the concentration of Black, low-income households relative to White, high-income households. The ICE has been studied as a proxy for structural racism in association with adverse maternal and infant outcomes.[20−22] We used ICE measures based on 2014−2018 American Community Survey data made available by the Public Health Disparities Geocoding Project.[23]

Pandemic community stress measures. We use the term "community stress" to represent neighborhood-level social and economic impacts of the pandemic. The first measure we used was the COVID-19 mortality rate as a marker of community trauma owing to the death of neighbors, friends, and loved ones. We obtained COVID-19 mortality rates by ZIP code as of December 2020 from the NYC Department of Health and Mental Hygiene website. The second measure of pandemic stress was increased unemployment rate. We obtained monthly unemployment rates from Catalist LLC[24] by census tract and converted them to ZIP codes using the United States Department of Housing and Urban Development crosswalk.[25] We calculated community unemployment rate changes by subtracting December 2020 from January 2020.

Outcomes

Measures of SARS-CoV-2 infection. We obtained blood specimens from pregnant patients during routine prenatal care and/or admission to labor and delivery. We analyzed SARS-CoV-2 antibody titers using serologic enzyme-linked immunosorbent assays (ELISA).[26] The test has high sensitivity (95.0%) and specificity (100%), as determined with an initial validation panel of samples, with a positive predictive value of 100% and a negative predictive value of 97.0%. Although SARS-CoV-2 vaccines became available to healthcare workers in New York in early December 2020, it is unlikely that any participant was vaccinated before serum collection in this analysis.

MSHS conducts universal molecular testing for pregnant people before admission as standard care.[27] A nucleic acid reverse transcription polymerase chain reaction (RT-PCR) test to detect SARS-CoV-2 is performed on a nasopharyngeal RT-PCR swab sample using the cobas 6800 System (Roche Diagnostics, Basel, Switzerland). All patients with a positive RT-PCR result (n=25) also had a positive SARS-CoV-2 antibody result, and were categorized together as "seropositive."

Preterm birth and small-for-gestational-age newborns. We obtained gestational age and birthweight at delivery from the electronic medical record (EMR). PTB was defined as delivery before 37 completed weeks of gestation on the basis of the best clinical estimate of gestational age. SGA was calculated as the 10th sex-specific percentile on the basis of the 2017 US birth standard.[28]

Covariates

Race and ethnicity data were based on participants' self-reports in the EMR and categorized as: White, non-Latina White (henceforth "White"); Black, non-Latina (henceforth "Black"); Latina; Asian, non-Latina; and Other, non-Latina. We further categorized all categories except non-Latina White as Black, Indigenous, and people of color (BIPOC). We extracted covariates from the EMR: maternal age (continuous), insurance type (private/self-pay, public), parity (nulliparous, multiparous), and prepregnancy body mass index (underweight [<18.5 kg/m^2], normal [18.5−24.9], overweight [25.0−29.9], obese [≥30]).

Statistical analysis

We divided neighborhood measures into quartiles based on the distribution in the analytical sample and used choropleth maps to describe the geographic distribution (Supplemental Figure 1). We used log-binomial marginal regression with a robust variance estimator to account for clustering by ZIP code to estimate the relative risk for each outcome (SARS-CoV-2 seropositivity, PTB, SGA) by neighborhood measure quartile. We tested for the presence of spatial autocorrelation using Moran's I and Geary's C and the centroid coordinates for ZIP code tabulation areas.[29,30] The residuals from associations between both CDI and ICE with seropositivity showed spatial correlation using Geary's C (P=.007 for CDI, P=.003 for ICE) but not Moran's I (P=.32 for CDI, P=.74 for ICE). To determine if accounting for this spatial correlation influenced our estimates, we estimated multilevel log-binomial models with a Gaussian covariance structure. Estimates and standard errors were similar within 2 decimal places, thus we elected to use the marginal model with an unstructured covariance matrix across models. Covariates were selected on the basis of pictorially examining in a directed acyclic graph theoretical causal relationships, that is, factors plausibly associated with both neighborhood measures and outcomes, but not on the causal pathway.[31] We did not include race/ethnicity as a covariate in adjusted models because we view race/ethnicity as a social construct, a downstream effect of structural racism,[32] and therefore inclusion in multivariable models would dilute the influence of structural racism. We instead stratified associations by non-Latina White vs BIPOC and tested an interaction term in the total population model. We did not have a sufficient sample size to stratify by BIPOC groups, although we acknowledge that this category might encompass a diverse range of exposure to structural racism and pandemic stress.

To test the joint association of each neighborhood measure and SARS-CoV-2 infection during pregnancy with adverse birth outcomes, we collapsed structural racism and pandemic stress measures into dichotomous categories and then created a 4-level variable to examine each joint association (eg, high stress/seropositive, high stress/seronegative, low stress/

seropositive, low-stress/seronegative). We then tested associations between these joint association terms and adverse birth outcomes.

We performed several sensitivity analyses. For analyses with SGA as the outcome, we excluded preterm infants (n=81) to disentangle preterm birth and SGA so that any observed associations would better reflect intrauterine growth restriction. We also limited analyses to persons for whom measures were collected prospectively, that is, persons enrolled before 37 weeks of gestation.

Results

Participant characteristics

In our analytical sample, 193 (20%) persons tested positive and 774 (80%) tested negative for SARS-CoV-2 antibodies. Participant demographic and obstetrical characteristics are shown overall and by level of structural disadvantage in Table 1. A higher proportion of persons in Q1 (high disadvantage index) self-identified as Black (29%) or Latina (56%), whereas a higher proportion of persons in Q4 (low disadvantage index) self-identified as non-Latina White (61%). The proportion of persons with public health insurance was greater in Q1 (50%) than in Q4 (17%). Compared with persons in Q4, a higher proportion of persons in Q1 were overweight or obese and were nulliparous.

SARS-CoV-2 seropositivity

In unadjusted analyses, across neighborhood measures, higher risk of SARS-CoV-2 seropositivity during pregnancy was seen in Q1 than in Q4 (Table 2). Q1 vs Q4 risk ratios were 3.6 for structural disadvantage (95% confidence interval [CI], 2.5−5.2), 2.7 for racial-economic segregation (95% CI, 1.9−3.8), 2.3 for COVID-19 mortality rate (95% CI, 1.6−3.4), and 2.6 for increased community unemployment (95% CI, 1.8−3.7). Risk ratios were partially attenuated in adjusted analyses (adjusted risk ratio [aRR] for CDI Q1 vs Q4=2.6; 95% CI, 1.7−3.9; aRR for ICE Q1 vs Q4=1.9; 95% CI, 1.3−2.8; aRR for COVID-19 mortality Q1 vs Q4=1.8; 95% CI, 1.2−2.6; and aRR for community unemployment rate increase Q1 vs Q4= 1.7; 95% CI, 1.2−2.5). The Q4 vs Q1 aRRs were of greater magnitude for BIPOC than for non-Latina White

TABLE 1

Characteristics of participating pregnant persons by structural disadvantage in New York City from April 2020 to December 2020 (n=967)

		COVID-19 disadvantage index in quartiles (CDI)				
Participant characteristic	Total n=967	Q1 (high)n (%)	Q2n (%)	Q3n (%)	Q4 (low)n (%)	*P* value
Maternal age in y						<.0001
18−24	74	29 (15)	16 (10)	20 (8)	9 (3)	
25−34	502	108 (57)	88 (55)	126 (49)	180 (50)	
≥35	391	53 (28)	56 (35)	111 (43)	171 (48)	
Race or ethnicity						<.0001
White, non-Latina	367	11 (6)	45 (28)	91 (35)	220 (61)	
Black or African American, non-Latina	169	55 (29)	37 (23)	49 (19)	28 (8)	
Latina	293	107 (56)	60 (38)	85 (33)	41 (11)	
Asian, non-Latina	87	10 (5)	6 (4)	18 (7)	53 (15)	
Other, non-Latina	41	6 (3)	10 (6)	12 (5)	13 (4)	
Unknown race, non-Latina	10	1 (1)	2 (1)	2 (1)	5 (1)	
Insurance						<.0001
Private or self-pay	657	95 (50)	98 (61)	166 (65)	298 (83)	
Public	310	95 (50)	62 (39)	91 (35)	62 (17)	
Prepregnancy BMI						<.0001
Underweight (<18.5)	27	4 (2)	3 (2)	5 (2)	15 (4)	
Normal (18.5−24.9)	380	48 (25)	49 (31)	90 (35)	193 (54)	
Overweight (25.0−29.9)	290	61 (32)	48 (30)	83 (32)	98 (27)	
Obese (>30)	270	77 (41)	60 (38)	79 (31)	54 (15)	
Nulliparous	450	109 (57)	78 (49)	125 (49)	138 (38)	.0002

BMI, body mass index.

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TABLE 2

Associations between neighborhood structural racism and pandemic stress with SARS-CoV-2 seropositivity during pregnancy, overall and by race or ethnicity in New York City from April 2020 to December 2020, n=967

	Overall					BIPOC			Non-Latina White		
Neighborhood Measure	Ab+n (%)	RR	95% CI	aRR[a]	95% CI	Ab+n (%)	aRR[a]	95% CI	Ab+n (%)	aRR[a]	95% CI
Structural racism measures in quartiles											
Structural disadvantage (CDI)											
Q1 (high)	60 (32)	3.6	2.5–5.2	2.6	1.7–3.9	59 (33)	2.2	1.2–3.8	1 (9)	1.4	0.2–10.3
Q2	44 (28)	3.1	2.1–4.5	2.5	1.7–3.7	37 (32)	2.2	1.3–3.9	7 (16)	2.2	1.1–4.6
Q3	57 (22)	2.5	1.7–3.6	2.1	1.4–3.1	41 (25)	1.8	1.0–3.1	16 (18)	2.8	1.6–5.1
Q4 (low)	32 (9)	1.0	ref	1.0	ref	18 (13)	1.0	ref	14 (6)	1.0	ref
Racial-economic segregation (ICE)											
Q1 (Black, low-income)	86 (28)	2.7	1.9–3.8	1.9	1.3–2.8	83 (30)	1.7	0.9–3.1	3 (1)	1.3	0.4–4.4
Q2	46 (24)	2.4	1.6–3.6	1.9	1.2–2.9	40 (30)	1.8	0.9–3.4	6 (11)	1.4	0.6–3.2
Q3	29 (18)	1.7	1.1–2.7	1.5	0.9–2.4	16 (21)	1.4	0.7–2.8	13 (15)	1.9	1.0–3.3
Q4 (White, high-income)	32 (10)	1.0	ref	1.0	ref	16 (14)	1.0	ref	16 (8)	1.0	ref
Pandemic stress measures in quartiles											
COVID-19 mortality rate											
Q1 (high)	68 (26)	2.3	1.6–3.4	1.8	1.2–2.6	65 (30)	1.7	1.0–2.7	3 (7)	0.7	0.2–2.3
Q2	48 (26)	2.3	1.6–3.5	1.8	1.2–2.7	44 (30)	1.7	1.0–2.8	4 (11)	1.2	0.5–3.0
Q3	40 (21)	1.8	1.1–3.0	1.6	1.0–2.5	27 (23)	1.3	0.7–2.4	13 (17)	1.9	1.0–3.4
Q4 (low)	37 (11)	1.0	ref	1.0	ref	19 (16)	1.0	ref	18 (9)	1.0	ref
COVID-19 unemployment rate increase											
Q1 (high)	56 (28)	2.6	1.8–3.7	1.7	1.2–2.5	55 (29)	1.6	0.9–2.6	1 (9)	0.8	0.1–7.2
Q2	29 (26)	2.4	1.5–4.0	2.3	1.5–3.5	25 (37)	2.5	1.5–4.4	4 (9)	1.2	0.4–3.1
Q3	71 (23)	2.1	1.5–3.1	1.7	1.2–2.4	55 (27)	1.6	0.9–2.6	16 (15)	1.9	1.1–3.4
Q4 (low)	37 (1)	1.0	ref	1.0	ref	20 (15)	1.0	ref	17 (8)	1.0	ref

Ab+, SARS-CoV-2-antibody–positive; *aRR*, adjusted risk ratio; *BIPOC*, Black, Indigenous, and people of color; *BMI*, body mass index; *CDI*, COVID-19 Disadvantage Index; *CI*, confidence interval; *ICE*, Index of Concentration at the Extremes; *RR*, risk ratio; *ref*, reference group.

[a] Adjusted for maternal age, insurance type, parity, and prepregnancy BMI.

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persons for all measures (Table 2), but the interaction term was statistically significant only for community COVID-19 mortality rate (*P*<.001).

Preterm birth

Overall, 8.4% of births were preterm. SARS-CoV-2 seropositivity was not associated with PTB (Supplemental Figure 2). Risk ratios for Q1 vs Q4 in association with PTB were 1.8 for structural disadvantage (95% CI, 1.1−3.0), 2.2 for racial-economic segregation ICE (95% CI, 1.4−3.4), 1.7 for COVID-19 mortality rate (95% CI, 1.0−2.8), and 1.8 for community unemployment rate increase (95% CI, 1.1−2.9) (Table 3). Risk ratios were partially attenuated in adjusted analyses. Among persons identifying as BIPOC, the magnitude of Q1 vs Q4 aRRs was diminished and CIs overlapped for all measures, with the exception of racial and economic segregation, for which the aRR remained of the same magnitude as the overall estimate (aRR, 2.0; 95% CI, 1.0−4.0).

Small-for-gestational age infants

SARS-CoV-2 seropositivity was not associated with SGA infants (Supplemental Figure 2). In unadjusted and adjusted analyses, risk ratios for structural racism and pandemic stress measures and SGA (Q1, Q2, and Q3 vs Q4) were null (Table 4).

Joint association analysis

For structural racism measures, pregnant individuals residing in "highly" (Q1) disadvantaged or segregated neighborhoods who were seropositive had the highest risk of PTB (Figure), but the joint association was not greater than the combined risk of each risk individually, thus no evidence of interaction was present. For pandemic stress measures, no clear pattern of risk was found. Joint association risk ratios for SGA were uniformly null.

FIGURE 1

Sensitivity analysis

In the sensitivity analysis restricting SGA models to term infants, associations remained null (Supplemental Table 1). Results were also similar when restricting the sample to prospectively collected serum samples (Supplemental Table 2).

Comment

Principal findings

We found that markers of structural racism and inequities were associated with SARS-CoV-2 infection in pregnant persons in NYC. The same structural inequities were also associated with adverse birth outcomes; however, associations were not explained by SARS-CoV-2 infection. Community unemployment was also modestly associated with both SARS-CoV-2 infection and PTB. We did not find interaction between SARS-CoV-2 infection, structural measures of racism, and pandemic stress on adverse birth outcomes. Overall, a pattern was seen in which non-Latina White pregnant persons in the most privileged neighborhoods had the lowest risk of adverse outcomes.

Results in the context of what is known

We found that neighborhood structural and socioeconomic inequities profoundly influenced the risk of SARS-CoV-2 infection, but that neighborhood inequity and infection did not work synergistically to worsen pregnancy outcomes. This finding adds to the body of evidence on structural racism and the COVID-19 pandemic.[33] Birthing persons in neighborhoods with a higher relative concentration of Black, low-income households and high structural disadvantage were more likely to have SARS-CoV-2 antibodies. This was true regardless of individual patient characteristics, including race and ethnicity. Most notably, our findings regarding community unemployment suggest that the economic crisis accompanying the COVID-19 pandemic was associated with PTB, consistent with existing evidence on the negative impact of unemployment and economic downturns on birth outcomes. Finch et al found exposure to the Great Recession increased the risk of PTB.[34] Similar associations have been reported between macroeconomic conditions and PTB.[35] Notably, pandemic economic stress and PTB in our cohort seemed to be higher for BIPOC persons. Black and Hispanic women were most affected by unemployment during the COVID-19 pandemic.[36] This differential impact of the economic crisis at the individual level could explain our findings.

Clinical implications

Both structural racism and pandemic stress were associated with higher risk of PTB but did not seem to be worsened in combination with SARS-CoV-2 infection. A major goal of our analysis was to test if SARS-CoV-2 infection interacted with social vulnerability on the risk of adverse pregnancy outcomes, which might have in part explained the conflicting findings regarding SARS-CoV-2 infection and PTB.[37] The mechanism supporting a potential synergistic effect is plausible. Both psychosocial stress in highly impacted neighborhoods and SARS-CoV-2 infection might trigger an inflammatory response in both the mother and fetus, which in turn might influence parturition or impaired fetal growth.[38] Our findings do not support this hypothesis. However, clinicians should be aware of the potential negative effects of structural racism and the economic crisis on patients.

Research implications

A major challenge in researching adverse birth outcomes during the COVID-19 pandemic is that etiology is difficult to determine because of the likely cooccurrence of both protective and harmful factors. Protective factors owing to COVID-19−related lockdown measures include, but are not limited to, working from home, limited commuting, reduced physical stress, and wearing of masks, all of which can decrease the risk of infection and environmental pollutants.[39] Others have suggested a potential decrease in iatrogenic PTB owing to reduced antepartum surveillance.[40] In addition, policies to mitigate the economic impact of the pandemic such as enhanced unemployment benefits and the eviction moratorium might also have lessened the stress of these structural factors and therefore buffered the risk of PTB. Future research might test at the individual

TABLE 3

Associations between neighborhood structural racism and pandemic stress with preterm birth (<37 weeks), overall and by race or ethnicity in New York City from April 2020 to December 2020, n=967

	Overall					BIPOC			Non-Latina White		
Neighborhood Measure	Pretermn (%)	RR	95% CI	aRR[a]	95% CI	Pretermn (%)	aRR[a]	95% CI	Pretermn (%)	aRR[a]	95% CI
Structural racism measures in quartiles											
Structural disadvantage (CDI)											
Q1 (high)	21 (11)	1.8	1.1–3.0	1.7	1.0–2.9	21 (12)	1.5	0.8–2.8	0 (0)	Insufficient data	
Q2	18 (11)	1.8	1.2–2.9	1.7	1.1–2.6	16 (14)	1.7	1.0–3.0	2 (4)		
Q3	20 (8)	1.3	0.8–2.1	1.2	0.7–1.9	16 (10)	1.2	0.7–2.1	4 (4)		
Q4 (low)	22 (6)	1.0	ref	1.0	ref	12 (9)	1.0	ref	10 (5)		
Racial-economic segregation (ICE)											
Q1 (Black, low-income)	37 (12)	2.2	1.4–3.4	2.0	1.3–3.2	36 (13)	2.0	1.0–4.0	1 (4)	Insufficient data	
Q2	13 (7)	1.3	0.7–2.2	1.1	0.6–2.0	13 (10)	1.4	0.7–3.0	0 (0)		
Q3	14 (9)	1.6	0.9–2.8	1.5	0.9–2.7	8 (11)	1.7	0.7–3.8	6 (7)		
Q4 (White, high-income)	17 (6)	1.0	ref	1.0	ref	8 (7)	1.0	ref	9 (5)		
Pandemic stress measures in quartiles											
COVID-19 mortality rate											
Q1 (high)	25 (10)	1.7	1.0–2.8	1.6	0.9–2.6	23 (11)	1.4	0.7–2.7	2 (5)	Insufficient data	
Q2	18 (10)	1.7	1.1–2.7	1.6	0.9–2.6	17 (12)	1.5	0.8–2.8	1 (3)		
Q3	19 (10)	1.7	1.0–2.9	1.6	0.9–2.7	15 (13)	1.7	0.8–3.3	4 (5)		
Q4 (low)	19 (6)	1.0	ref	1.0	ref	10 (8)	1.0	ref	9 (4)		
COVID-19 unemployment rate increase											
Q1 (high)	22 (12)	1.8	1.1–2.9	1.6	1.0–2.8	22 (11)	1.5	0.8–2.7	0 (0)	Insufficient data	
Q2	9 (6)	1.3	0.7–2.5	1.2	0.7–2.3	7 (10)	1.3	0.6–2.8	2 (5)		
Q3	29 (11)	1.5	1.0–2.4	1.4	0.9–2.2	24 (12)	1.4	0.8–2.4	5 (5)		
Q4 (low)	35 (10)	1.0	ref	1.0	ref	12 (9)	1.0	ref	9 (4)		

aRR, adjusted risk ratio; *BIPOC*, Black, Indigenous, and people of color; *BMI*, body mass index; *CDI*, COVID-19 Disadvantage Index; *CI*, confidence interval; *ICE*, Index of Concentration at the Extremes; *RR*, risk ratio; *ref*, reference group.

[a] Adjusted for maternal age, insurance type, parity, prepregnancy BMI, and SARS-CoV-2 antibody status..

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TABLE 4

Associations between neighborhood structural racism and pandemic stress with small-for-gestational-age infants, overall and by race or ethnicity, in New York City from April 2020 to December 2020, n=967

	Overall					BIPOC			Non-Latina White		
Neighborhood Measure	SGAn (%)	RR	95% CI	aRR[a]	95% CI	SGAn (%)	aRR[a]	95% CI	SGAn (%)	aRR[a]	95% CI
Structural racism measures in quartiles											
Structural disadvantage (CDI)											
Q1 (high)	22 (12)	1.2	0.8–1.9	1.3	0.8–2.2	21 (12)	1.3	0.6–2.5	1 (9)	1.0	0.1–6.6
Q2	9 (6)	0.6	0.2–1.4	0.6	0.3–1.5	5 (4)	0.5	0.2–1.2	4 (9)	1.1	0.4–3.3
Q3	29 (11)	1.2	0.7–1.8	1.2	0.8–2.0	22 (13)	1.4	0.7–2.6	7 (8)	0.8	0.4–1.9
Q4 (low)	35 (10)	1.0	ref	1.0	ref	15 (11)	1.0	ref	20 (9)	1.0	
Racial-economic segregation (ICE)											
Q1 (Black, low-income)	35 (11)	1.2	0.8–1.8	1.4	0.8–2.3	31 (11)	1.3	0.6–2.8	4 (14)	1.5	0.5–4.1
Q2	17 (9)	1.0	0.5–1.7	1.1	0.6–1.8	15 (11)	1.3	0.6–3.0	2 (4)	0.4	0.1–1.7
Q3	14 (9)	0.9	0.5–1.7	1.0	0.5–1.8	6 (8)	0.9	0.4–2.1	8 (9)	1.0	0.5–2.0
Q4 (White, high-income)	29 (9)	1.0	ref	1.0	ref	11 (10)	1.0	ref	18 (9)	1.0	
Pandemic stress measures in quartiles											
COVID-19 mortality rate											
Q1 (high)	28 (11)	1.0	0.7–1.6	1.1	0.7–1.9	22 (10)	0.8	0.4–1.5	6 (14)	1.8	0.7–4.6
Q2	17 (9)	0.9	0.5–1.6	1.0	0.5–1.9	13 (9)	0.7	0.3–1.4	4 (11)	1.5	0.4–5.0
Q3	16 (8)	0.8	0.5–1.3	0.8	0.5–1.4	11 (9)	0.7	0.3–1.4	5 (6)	0.8	0.4–1.9
Q4 (low)	34 (10)	1.0	ref	1.0	ref	17 (14)	1.0	ref	17 (8)	1.0	
COVID-19 unemployment rate increase											
Q1 (high)	21 (10)	1.0	0.6–1.6	1.1	0.6–2.0	19 (10)	0.9	0.4–1.9	2 (18)	1.8	0.5–6.3
Q2	13 (12)	1.1	0.7–1.8	1.1	0.7–1.9	11 (16)	1.4	0.7–3.0	2 (5)	0.5	0.1–1.9
Q3	25 (8)	0.8	0.5–1.3	0.8	0.5–1.4	16 (8)	0.7	0.3–1.4	9 (9)	0.9	0.4–1.9
Q4 (low)	36 (11)	1.0	ref	1.0	ref	17 (13)	1.0	ref	19 (9)	1.0	

aRR, adjusted risk ratio; *BIPOC*, Black, Indigenous, and people of color; *BMI*, body mass index; *CDI*, COVID-19 Disadvantage Index; *CI*, confidence interval; *ICE*, Index of Concentration at the Extremes; *RR*, risk ratio; *ref*, reference group; *SGA*, small for gestational age.

[a] Adjusted for maternal age, insurance type, parity, prepregnancy BMI, and SARS-CoV-2 antibody status.

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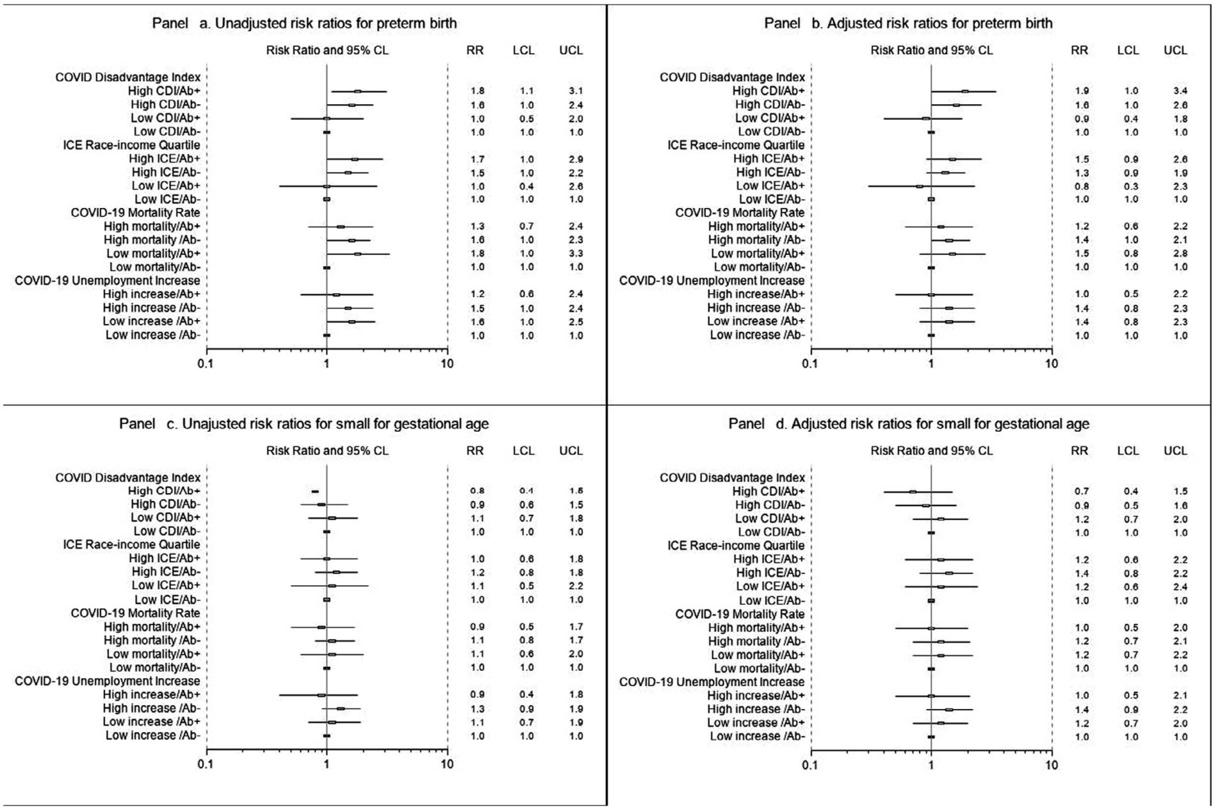
FIGURE 1
Joint effects of structural racism and pandemic stress, SARS-CoV-2 infection, and adverse birth outcomes



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level if pregnant persons experiencing social and economic stressors such as unemployment were at higher risk of PTB.

Strengths and limitations

This analysis had several limitations. First, we did not have information on spontaneous vs medically indicated PTB. However, both PTB subtypes might be elevated by SARS-CoV-2 seropositivity and/or social disadvantage.[41,42] Second, we had no information on the timing of SARS-CoV-2 infection; the antibody assays used did not indicate when an infection occurred. An important limitation is that we did not have information on disease severity; it is possible that a synergistic effect of infection and disadvantage is limited to moderate or severe cases. Furthermore, we were unable to systematically capture PTB or SGA stillbirths because of enrollment after 20 weeks of gestation. Another limitation was the inability to robustly examine associations within all racial-ethnic subgroups, which would have allowed stronger testing of mechanisms. Finally, our prospective cohort was not population-based.

The study does have several strengths. The Generation C Study leverages high numbers of infected patients and can classify patients as ever vs never infected through antibody testing, which allowed us to disentangle community stress exposures from infection. Furthermore, the study population was diverse, with a substantial number of Black and Latina patients across neighborhood types. White patients, however, clustered in the more privileged neighborhoods and had low risk of adverse outcomes. This strong imprint of structural racism on our data created statistical limitations for some analyses, underscoring the need for focusing COVID-19 research within populations of those most affected—Black and Latina—individuals. In addition, NYC might not be representative of other urban populations, and out-migration of pregnant persons from NYC during the pandemic limits generalizability.[43]

Conclusions

In our study of pregnant persons in NYC, the same neighborhoods most affected by structural racism and pandemic stress experienced the highest risk of PTB. However, no evidence was found that SARS-CoV-2 infection and pandemic stress had synergistic effects on adverse birth outcomes. Nonetheless, our study demonstrates that pregnant persons of color are disproportionately impacted by SARS-CoV-2 infection and pandemic-related community stressors. Mitigating structural racism and socioeconomic inequity could reduce the impact of the pandemic on pregnant persons. ■

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.ajogmf.2022.100649.

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Mount Sinai has licensed serologic assays to commercial entities and has filed for patent protection for serologic assays. F.K. is listed among inventors on the pending patent application. The other authors report no conflict of interest.

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