Testing the Association Between Traditional and Novel Indicators of County-Level Structural Racism and Birth Outcomes among Black and White Women

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Abstract:

Despite decreases in infants born premature and at low birth weight in the United States (U.S.), racial disparities between Black and White women continue. In response, the purpose of this analysis was to examine associations between both traditional and novel indicators of county-level structural racism and birth outcomes among Black and White women. We merged individual-level data from the California Birth Statistical Master Files 2009–2013 with county-level data from the United States (U.S.) Census American Community Survey. We used hierarchical linear modeling to examine Black-White differences among 531,170 primiparous women across 33California counties. Traditional (e.g., dissimilarity index) and novel indicators (e.g., Black to White ratio in elected office) were associated with earlier gestational age and lower birth weight among Black and White women. A traditional indicator was more strongly associated with earlier gestational age for Black women than f or White women. This was the first study to empirically demonstrate that structural racism, measured by both traditional and novel indicators, is associated with poor health and wellbeing of infants born to Black and White women. However , finding s indicate traditional indicators of structural racism, rather than novel indicators, better explain racial disparities in birth outcomes. Results also suggest the need to develop more innovative approaches to: (1) measure structural racism at the county-level and (2) reform public policies to increase integration and access to resources.

Keywords: Structural racism | Gestational age | Low birth-weight | Racial disparities

Article:

Introduction

Despite decreases in infants born premature and at low birth weight in the United States (U.S.) during 2007–2014, racial disparities continue [1]. Black women are two to three times as likely to have an infant born premature or at low birth weight compared to White women [2]. This is problematic since preterm birth and low birthweight are the top two leading causes of infant mortality[3]. Researchers often attribute racial disparities in adverse birth outcomes

between Black and White women to individual-level factors such as mothers ' socioeconomic status [4, 5], health risks behaviors (e.g., smoking during pregnancy) [6, 7], experiences of stress [8, 9], health com-plications during pregnancy [10, 11], and prenatal care utilization [12, 13]. Emerging research has explored expo-sure to structural racism during pregnancy and across the life course as a f actor associated with racial disparities in adverse birth outcomes, rendering promising results [14–21]. Nonetheless, racial disparities in adverse birth outcomes persist [14, 15, 19, 21–23], warranting further investigation of the potential association of novel indicators of structural racism in understanding racial disparities in adverse birth outcomes.

Structural racism is defined as systemic laws and processes used to allocate resources and opportunities to ad-vantage one racial group over another in society [24, 25]. Theoretical literature on structural racism is replete with examples of how racism is embedded within institutions (e.g., policy, healthcare facilities, schools) and its negative impacts on health outcomes [26]. Recently, scholars have used the ecosocial theory to account for the complexity of structural racism and its potential effects on birth outcomes [21, 27]. The ecosocial theory posits that societal and eco-logical context exposures (e.g., social and economic deprivation, inadequate medical care, exogenous hazards, and social traumas) are biologically embodied by individuals, thus resulting in health disparities [28–32]. Embodiment acknowledges that people are biologically integrated in their societal and ecological context, as well as the social and material worlds in which they live. In this view, expo-sure, susceptibility, and resistance interplay cumulatively across the life-course. From a population perspective, the accumulated effects of embodied exposures are apparent in gene expression (rather than gene frequency), and accounts for timing and response to embodied exposures. Although theoretical underpinnings of structural racism have advanced in practice, much of the empirical research examining measures of structural racism has focused on social segregation, and in particular, measures of residential segregation. Residential segregation is traditionally measured by spatial distributions between social groups across geo-graphic regions using five indices: dissimilarity index (evenness of two social groups), isolation index (expo-sure/interaction between two social groups), concentration index (concentration of one social group across a geographic region), centralization index (centralization of one social group to the center of a geographic region), and clustering index (the extent to which people from on social group reside in adjoining geographic regions) [24]. Residential segregation indices aim to capture the aftermaths of enslavement of Africans through the use of collective action racism (i.e., institutionalized laws and legislation to separate Blacks from Whites) and centralized racism (i.e., an operative process used to maintain separation between Blacks and whites) to geographically separate Blacks from Whites and allocate resources accordingly [27]. Furthermore, structural racism is a fundamental cause of health disparities.

The relationship between structural racism and disparities in birth outcomes varies across studies. At the community level, isolation, dissimilarity, deprivation, and crime rates are positively associated with adverse birth outcomes among Black women, after controlling for community poverty [14–17, 22, 33–35]. Regardless of geographic scale used to represent "community" (e.g., census tracts, census block groups, or metropolitan areas) research consistently shows structural racism has negative impacts on Black women's birth outcomes, providing evidence that racism produces stress-induced living conditions [32, 36]. In contrast, residential segregation measured by racial clustering is associated with more optimal birth outcomes among Black women, specifically fewer incidents of low-birth weight and premature infants, after controlling for community poverty [14, 16]. There are inconsistent results about the

association of residential segregation with adverse birth outcomes for White women [15–19,33–35]. For example, some studies have found that White women living in highly isolated neighborhoods are at de-creased odds of adverse birth outcomes compared to Black women [18, 27], while other studies found White and Black women living in highly segregated communities have similar birth outcome [15, 16, 19, 26, 28]. Findings from these studies provide evidence that residential segregation may explain racial disparities in adverse birth outcomes beyond community poverty.

Although there is a strong relationship between residential segregation and adverse birth outcomes, racial disparities continue. This can be due to residential segregation indices only measuring one dimension of structural racism (e.g., institutional policies used to prevent Blacks from living in predominately White neighborhoods), and does not capture the way in which racism operates through state and local laws, and political infrastructures that differentially affect people of color [37]. For example, Blacks, in comparison to Whites, have significant disadvantages in incarceration and becoming elected officials [38–40]. This historic pattern of disadvantage is a reflection, and potentially cause, of the aftermath of enslavement and op-pression systems in the U.S. society used to continually advantage one racial group over another [37]. Lukachko and colleagues [37] were the first to use novel state-level indicators of structural racism across four domains (i.e. political participation, judicial treatment, educational attainment, and employment and job status) and assessed their association with myocardial infarction among Black and White persons. Indeed, state-level indicators of racism (i.e., employment and job status, educational attainment, and judicial treatment) have been shown to be associated with higher odds of infants being born small for gestational age [21]. However, it is currently unknown whether this novel approach to measuring structural racism, when scaled at the county level, is associated with indicators of preterm birth and l ow birth weight, the two leading causes of infant mortality.

Exposures to racism may operate differently by geographic scale (e.g., metropolitan statistical areas, census tracts, and county- and state-level), representing distinct patterns in the spatial distribution of racial groups including social context and health policies [41, 42], and may offer unique opportunities to dismantle racial disparities through community-level interventions. In some U.S. states, county is a more accurate geographic unit to measure structural racism due to the uneven distribution of resources across counties (e.g., access to and availability of health care) and governance power to allocate resources (e.g., social and political context) [43–47]. For ex-ample, in California, 24% of counties have the power to adopt and amend laws and regulations affecting the flow of re-sources and the diversity of county governance [48]. Only one study has assessed the association between county-level residential segregation (i.e., isolation and dissimilarity indices) and county distributions of preterm births and infants born at lo w birth weight among Black women across the U.S. [49]. Nyarko and Wehby [49] used quantile regression grouping counties average percentage of preterm birth and infants born at low birth weight among Black women in the following quantiles 0.1, 0.25, 0.5, 0.75, and 0.9 [49]. Findings showed as county-level dissimilarity and isolation increased, there was about a 10% increase in preterm births and infants born at low birth weight to Black women among counties with the lowest prevalence of adverse birth outcomes (i.e., quantile0.1) compared to counties with higher prevalence of adverse birth outcomes (i.e., quantiles 0.75 and 0.9) [49]. There are currently no studies focused on the relationship between county-level residential segregation and women's individual adverse birth outcomes.

This study aimed to merge identified gaps in the literature, by assessing the extent to which residential segregation indices (traditional indicators of structural racism) and Black and White ratios in incarceration and elected officials (novel indicators of structural racism) are associated with birth outcomes. To our knowledge, this will also be the first study to measure structural racism at the county level and model its association with women's individual birth outcomes. We used Krieger's [28, 32] conceptualization of ecosocial theory to frame these analyses and acknowledge that race and race relations systematically advantage Whites over Blacks in the U.S. American society, generating B inequitable living and working conditions that, via embodiment, result in the biological expression of racism—and hence racial/ethnic health inequities^ [32]. This study centered on Black and White women's exposures to structural racism at the county level to better understand longstanding-embodied racial disparities in adverse birth out-comes. We hypothesized that county-level indicators of structural racism would be significantly associated with adverse birth outcomes, and at a higher magnitude for Black women compared to White women.

Methods

Data

We analyzed data from the California Birth Statistical Master Files for years 2009–2013. These data are cross-sectional re-cords for the corresponding years, with information obtained from birth certificates. This dataset represents the most comprehensive and largest available birth data nationwide and includes maternal, parental, and infant characteristics, as well as medical information (e.g., preeclampsia, STI infections) pertaining to the birth. Geographic information related to the mother's place of residence during birth including census tract, state, county, and zip code level are provided. This allowed us to link the birth record data to contextual information from the U.S. Census American Community Survey (2009–2013) and to conduct multilevel analyses to better understand associations of individual- and county-level factors with racial disparities in birth outcomes.

Study sample

This study focused on non-Hispanic Black and White women who gave birth during 2009–2013 and reported California as their place of residence. This study excluded Hispanic women due to research supporting that structural racism operates differently to impact the health of Hispanic women in comparison to non-Hispanic Black women [22]. Individual-level exclusion criteria included women who had previous births or pregnancy terminations, multiples (e.g., twins and triplets), gave birth to infants less 500 or greater than 6000 g, pregnancies ended before 21 weeks, pregnancies extended post43 weeks due to their association with adverse birth outcomes [14]. Additionally, 664,830 women were excluded due missing covariate data. Women included in this study were less likely to identify as White, be of an older age, use public insurance, have pregnancy complications, and have adverse birth outcomes compared to women excluded from the study (data not provided).

County-level inclusion criteria included population size100,000 or greater and at least 50 live births to Black women in the county for the study time period to reduce estimation biases among counties with low populations of Blacks [49].Therefore, this study was limited to 33 of

the 58 counties within California, resulting in a final sample size of 531,170 non-Hispanic Black and White women.

Measures

The two outcome variables were gestational age and birthweight. Gestational age was measured in weeks ranging from21 to 42 weeks, and birth weight was measured in grams ranging from 501 to 5993 g.

Individual-level predictor variables included mother's race, age, complications during pregnancy, insurance, cigarette use during pregnancy, and prenatal care utilization. Mother's race was denoted by non-Hispanic Black or White only. Age was a continuous variable. Complications during pregnancy were measured by two dichotomous variables: diabetes (i.e., before and/or during pregnancy) and hypertension (i.e., before and/or during pregnancy). Insurance used during pregnancy was measured by three dichotomous variables: private, public, or self-pay. Cigarette use during pregnancy was measured by any cigarette used across the three trimesters versus no cigarette use during pregnancy. Prenatal care utilization was measured by Adequacy of Prenatal Care Utilization Index (APCU Index), [50] classifying care as Adequate (Adequate/Adequate Plus) versus Less than Adequate (Intermediate/Inadequate). Mother's age, pregnancy complications, insurance status, cigarette use, and prenatal care utilization served as control variables due to their association with adverse birth outcomes [4, 6, 11, 12].

County-level predictor variables were traditional and novel approaches to measure structural racism. Table 1provides a description of county-level indicators of structural racism used in this study. Traditional approaches to measuring indicators of structural racism are residential segregation indices; this study focused on evenness, expo-sure, and concentration indices (described above). Given the tremendous racial disparities between Black and White people in positions of power and rates of incarceration, this study measured novel county-level indicators of structural racism (Black to White ratios) across two domains: political participation (i.e., elected officials) and judicial treatment (i.e., incarcerated). Information on elected officials was collected during 2016, and the time each board of supervision served in their position ranged from 1 to 22 years.

County-level poverty served as a control variable due to community-level poverty's association with adverse birth out-comes, [51, 52], and evidence supporting indicators of structural racism are associated with adverse birth outcomes, even after accounting for community poverty [14, 16]. County-level poverty was measured by the proportion of all persons living below the federal poverty line.

Statistical method

Descriptive statistics and bivariate analyses (i.e., t tests and chi-square tests) were conducted for all individual- and county-level variables. Hierarchical linear modeling was used to assess whether county-level indicators of structural racism were associated with women's adverse birth outcomes. Random slopes hierarchical linear modeling was used to allow the exploration of cross-level interactions, testing whether the association between county-level structural racism and birth outcomes varied by individual women 's race (Black or White).

Preliminary analyses revealed that infant birth weight (intra-class correlation = 0.007; $p < 0.001$) and gestational age (intra-class correlation = 0.008; $p < 0.001$) significantly varied across

counties, providing justification for the use of hierarchical linear modeling. We used a step-wise approach to assess if indicators of structural racism explained additional variation in racial disparities seen in adverse birth outcomes between Black and White women, thus accounting for both county-level poverty and individual-level maternal characteristics and behaviors, insurance, pregnancy complications, and prenatal care utilization. First, we assessed if racial status was associated with gestational age and birth weight accounting for individual-level control variables and county variability (via random intercept). Second, we added county-level poverty as the only level-2 predictor. Third, we ran a series of models in which each indicator of structural racism was added (one in each model, as a level-2 predictor) to prior models. Finally, we used random slope modeling to assess cross-level interactions between individual-level race and county-level indicators of structural racism in predicting adverse birth out-comes. All models were adjusted for maternal characteristics and behaviors, insurance, pregnancy complications, prenatal care utilization, and county variability. All statistical analyses were conducted in HLM version 7. Intra-class correlations and proportion of variance explained were calculated in Microsoft Excel 2010.

Results

Maternal and County-Level Characteristics

Among the 531,170 women included in this study, about 17% (n = 88,815) identified as Black and 83% as White (n = 442,355). On average women birthed infants at 38.9gestational weeks 3382.6 g (g). Approximately 6% of women had preterm births, and 4.5% had infants born at low birthweight (less than 2500 g or 5.5 lbs). See Table 2.

There were statistically significant differences by racial group in individual characteristics, health behaviors, complications during pregnancy, prenatal care utilization, and birth outcomes (see Table 2). On average, Black women were younger than White women (M = 26.3 vs. 29.6). Black women were also more likely to use public insurance during pregnancy (20.3 vs. 11.0%) and to receive less than adequate pre-natal care (36.0 vs. 26.2%) compared to White women. Higher proportions of White women reported cigarette use (3.8 vs. 3.6%) and diabetes complications (3.4 vs. 3.1%) be-fore and/or during pregnancy. Black women were more likely to be hypertensive before and/or during pregnancy compared to White women (4.4 vs. 3.3%). On average, Black women's infants had earlier gestational ages (M = 38.6 vs. 39.0 weeks) and lower birth weights (M = 3190.3 vs. 3421.2 g) compared to White women.

Table 3 displays descriptive statistics for county-level variables. Approximately, 17% of per sons living in counties across California lived below the federal poverty line. Overall, counties reported low isolation (M =0.25), moderated is similarity (M = 0.49), and high concentration (M =0.80). The mean for elected officials was under 1, suggesting Blacks are underrepresented in board of supervisor positions. For example, on average, there was one Black person to 11White persons who served in board of supervisor positions per 100 Blacks and Whites across counties. In contrast, Blacks were over represented in prisons across counties in California at 1.09 times that of Whites per 100 Blacks and Whites across counties.

Table 1 Description of measurement of indicators of structural racism items

Indicators of structural racism	Measure	Description	Data source (date)
Traditional			
Evenness	Dissimilarity Index	$D - \frac{1}{2}\sum_{i=1}^{n}\left[\frac{x_i}{X} - \frac{w_i}{W}\right]$, the proportion of African Americans that would have to change their place of residence to achieve an even distribution of Whites and African Americans in the county. Scores range from 0 (complete integration) to 1 (complete segregation).	American Community Survey. U.S. Census (2009–2013)
Exposure	Isolation Index	$xPx^{*} - \sum_{i=1}^{n}\left[\left(\frac{x_i}{X}\right)\left(\frac{x_i}{t_i}\right)\right]$, the probability that an African American will reside in the same sub-area within a county as another African American. Scores range from 0 (complete integration) to 1 (complete segregation).	American Community Survey. U.S. Census (2009–2013)
Concentration	Delta Index	$Del - \frac{1}{2}\sum_{i=1}^{n}\left[\frac{x_i}{X} - \frac{a_i}{A}\right]$, the proportion of African Americans that would have to change their place of residence to achieve uniform density of African Americans across a county. Scores range from 0 (complete integration) to 1 (complete segregation).	American Community Survey. U.S. Census (2009–2013)
Novel			
Judicial treatment	Felony incarcerations	Ratio of Blacks/Whites at the county-level who are incarcerated for a felony.	Center on Juvenile and Criminal Justice (2012)
Political participation: elected office	Racial composition of county board of supervisors	Ratio of Blacks/Whites who were elected to county board of supervisors.	County board of supervisors websites (2016)

x_i= total African Americans in a census tract
w_i= total Whites in a census tract
t_i= total population (African Americans + Whites) in a census tract
a_i= total land area in a census tract
X = total African Americans in a county
W = total Whites in a county
A = total land area in a county

Bivariate results: the association between county-level characteristics and birth outcomes

County-level poverty as well as traditional and novel indicators of structural racism were statistically associated with adverse birth outcomes (data not available). County-level poverty was significantly associated with infants 'birth weight (β = − 380.97 g, 95% CI = − 647.71–− 114.28) and gestational age (β = − 1.76 g, 95% CI = − 2.53– − 0.99). County-level isolation was significantly associated with birth weight (β = − 157.81 g, 95% CI = − 258.83–− 92.81), while concentration was related to gestational age (β = − 0.66 g, 95% CI = − 1.29–− 0.02). County-le vel racial disparities in incarceration were significantly associated with infants' birth weight (β = − 12.15 g, 95% CI = − 23.41–− 0.88), while disparities in board of supervisors were not related to birth out-comes. County-level dissimilarity was not significantly associated with infants' birth weight (β = − 142.27 g, 95% CI = − 362. 38–− 77.84, p = 0.23) or gestational age (β =0.02g, 95% CI=− 0.73–− 0.77).

Multivariate Results: the Association of Individual-and County-Level Characteristics with Infant Birth Weight

Table 4 shows results of hierarchical linear models predicting infant birth weight. Model 1 reveals that racial status is negatively associated with infant birth weight, when controlling for maternal characteristics and behaviors, insurance, pregnancy complications, prenatal care utilization, and county variability (Model 1; β =− 207.36 g, 95% CI = − 222.82–− 191.90). The addition of county-level poverty in Model 2 shows a statistically significant relationship between county-level poverty and infant birth weight. As county-level poverty increases, infants' weight decreases by 209.03 g (95% CI = − 359.45– − 58.71). However, racial status remains a significant contributor (Model 2; β = − 209.03 g, 95% CI = − 224.30–− 193.76). The addition of county-level poverty slightly reduced the intra-class correlation and proportion of variance explained than the model accounting f or individual-level factors alone.

Table 3 Characteristics of California counties in Study, U.S. Census American Community Survey 2009–2013 (N =33)

County-level variables	Mean	Std. deviation	Range
Poverty			
Proportion of residents living below the federal poverty level	0.17	0.06	0.08–0.27
Indicators of structural racism			
Residential segregation			
Dissimilarity	0.49	0.07	0.35–0.68
Isolation	0.25	0.16	0.02–0.64
Concentration	0.80	0.08	0.56–0.93
Political participation: elected office			
Racial composition of board of supervisors	0.09	0.22	0.00–1.00
Judicial treatment			
Incarceration	1.09	1.39	0.09–7.10

Table 4 Estimates of associations between race, and county-level poverty and indicators for structural racism with birth weight

	Model 1 Est. (95% CI)	Model 2 Est. (95% CI)	Model 3 Est. (95% CI)	Model 4 Est. (95% CI)	Model 5 Est. (95% CI)	Model 6 Est. (95% CI)	Model 7 Est. (95% CI)
Fixed effect							
Intercept	3312.45 (3287.91, 3336.99)	3348.12 (3318.41, 3377.83)	3455.15 (3386.04, 3524.26)	3386.78 (3361.63, 3411.93)	3356.75 (3251.13, 3462.37)	3369.23 (3340.75, 3397.71)	3361.28 (3332.37, 3390.19)
Individual factors							
Race (White as referent)							
Black	− 207.36 (− 222.82, − 191.90)	− 209.03 (− 224.30, − 193.76)	− 209.27 (− 224.42, − 194.12)	− 208.70 (− 224.05, − 193.35)	− 208.98 (− 224.31, − 193.65)	− 208.49 (− 223.82, − 193.16)	− 208.81 (− 224.06, − 193.56)
County factors							
Poverty	–	− 209.08 (− 359.45, − 58.71)	− 294.35 (− 415.28, − 173.42)	− 277.64 (− 415.86, − 139.70)	− 202.40 (− 372.94, − 31.86)	− 247.95 (− 390.66, − 105.24)	− 261.05 (− 412.15, − 109.95)
Structural racism							
Traditional							
Dissimilarity	–	–	− 187.31 (− 328.195, − 46.43)	–	–	–	–
Isolation	–	–	–	− 110.20 (− 157.69, − 62.71)	–	–	–
Concentration	–	–	–	–	− 12.15 (− 162.05, 137.75)	–	–
Novel							
Incarceration	–	–	–	–	–	− 7.80 (− 14.91, − 0.69)	–
Board of supervisors	–	–	–	–	–	–	− 42.10 (− 66.97, − 17.23)
Random effect							
Residual	266,917.07	266,917.30	266,917.48	266,917.55	266,917.30	266,917.20	266,917.35
Intercept	1056.12	1041.61	909.82	878.61	1075.57	959.91	974.39
Black, slope	1684.84	1660.58	1651.47	1629.05	1659.87	1668.84	1672.11
Model statistics							
Chi-square statistic	–	535.92	535.91	535.91	535.92	535.92	1620.98
Degrees of freedom	–	32	32	32	32	32	30
Intra-class correlation	0.0041	0.0040	0.0035	0.0033	0.0042	0.0037	0.0037
Proportion or variance explained	0.4809	0.4835	0.5530	0.5754	0.4668	0.5247	0.5247

All models were controlled for age, insurance, and complications during pregnancy, cigarette use, and prenatal care utilization. EST esti ma te, CI confidence interval.* ≤ 0.05

Among traditional county-level indicators of structural racism, dissimilarity and isolation were associated with birthweight, controlling for maternal characteristics and behaviors, insurance, pregnancy complications, prenatal care utilization, and county-level poverty (see Table 4). Higher levels of county-level dissimilarity (Model 3; β = − 187.31 g, 95%CI = (− 328.195– − 46.43) and isolation (Model 4;β = − 110.20 g, 95% CI = − 157.69–− 62.71) were each associated with Black and White women having infants of lower birth weight. The addition of the dissimilarity and isolation indices reduced the intra-class correlation and explained an additional 7 and 10% of the variation in birth weight, respectively, compared to models accounting for individual-level characteristics and county-level poverty alone.

Novel approaches to measuring structural racism were only associated with birth weight (see Table 4). As the Black to White ratio in county-level incarceration increased, infants' birth weight decreased by 7.80 g among both Black and White women (95% CI = − 14.91–− 0.69). Yet, as county-level board of supervisor positions reached racial equity, infants' birth weight decreased by 42.10 g among both Black and White women (95% CI = − 66.97–− 17.23). The addition of novel approaches to measuring county-level structural racism reduced the intra-class correlation and explained about3% more variation in birth weight compared to models only accounting for individual-level factors and county-level poverty. There were no statistically significant interactions be-tween traditional or novel indicators of structural racism and race with infants' birth weight (data not provided).

Multivariate Results: the Association of Individual-and County-Level Characteristics with Gestational Age

Table 5 displays the results of hierarchical linear models predicting gestational age. Model 1 shows that being a Black woman, in comparison to a White woman, is significantly associated with an earlier gestational age (Model 1;β = − 0.35 weeks, 95% CI = − 0.39–− 0.31), accounting for maternal characteristics and behaviors, insurance, pregnancy complications, prenatal care utilization, and county variability. The addition of county-level poverty in Model 2 shows that county-level poverty is significantly associated with gestation-al age, reducing the intra-class correlation explaining 22%more variation in gestational age than Model 1. County-level poverty magnified a suppressed relationship between racial status and gestational age, where being a Black woman was associated with birthing infants nearly 2 weeks earlier than White women, compared to about 3 days earlier in Model 1(Model 2; β = − 1.98 weeks, 95% CI = − 2.53–− 1.43).

County-level isolation was the only traditional indicator of structural racism associated with gestational age among Black and White women, after controlling for maternal characteristics and behaviors, insurance, pregnancy complications, pre-natal care utilization, and county-level poverty and variability(Model 4; β = − 0.37 weeks, 95% CI = − 0.61–− 0.11). The addition of the isolation index did not explain more variation in gestational age; yet, racial status and county-level poverty remained significant predictors of gestational age. The inter-action between race and county-level isolation was significantly associated with gestational age (β = − 0.35 weeks,95% CI = − 0.60–− 1.53). Black women who lived in counties with higher isolation birthed infants at earlier gestational ages, in comparison to White women who lived in counties with higher isolation. Accounting for the interaction effect between racial status and county-level isolation reduced the intra-class correlation and explained 2% more variation in gestational age

compared to the model testing the association of main effects of racial status and county-level isolation and individual- and community level control variables (data not provided)

Discussion

To our knowledge, this was the first study to assess the association of both traditional and novel indicators of structural racism measured at the county-level with women's birth outcomes. The significant association between county-level racial concentration and gestational age became non-significant after accounting for individual characteristics and county-level poverty. This may be due to high-levels of areal concentration (the measurement of the proportion of Blacks that would have to change their place of residence to achieve uniform density of Blacks across a county).However , given that other residential segregation indices (e.g., county-level dissimilarity and isolation) were significantly associated with women's adverse birth outcomes, while accounting for individual characteristics and county-level poverty, our findings support the importance of traditional approaches to measuring county-level indicators of structural racism to understand adverse birth outcomes experienced by both Black and White women.

Our findings also support traditional indicators utility in explaining racial disparities in adverse birth outcomes. For ex-ample, the results indicate Black women who live in counties with high isolation (the measurement of the probability that a Black person will reside in the same sub-area within a county as another Black person) birth infants at earlier gestation ages, which suggest declines in community isolation can have positive impacts on birth outcomes [14, 15, 18, 19, 22, 49, 53]. Even though the interaction of race and county-level isolation explained more variation of racial disparities in gestational age than individual-level factors and county poverty alone, race remained a significant predictor. This finding can be due to historical exposures to high levels of persistent race-related stress reactivity during childhood, adolescence, and pregnancy [54–57]. It is well documented that exposures to interpersonal racism across the life [36, 58–60] span is associated with adverse birth outcomes among Black women. Therefore, findings from this analysis suggest a need for research that utilizes cumulative pathway models to account for exposures to trauma across the life course, such as structural racism and its association with adverse birth outcomes.

Novel approaches to measuring county-level indicators of structural racism increased our understanding of how different domains of structural racism are associated with birth out-comes. Our findings support that Blacks, in comparison to Whites, are overrepresented in the prison system, while being underrepresented in local elected official positions. Racial disparities in county-level boards of supervisors and incarceration were significantly associated with birth weight among women [21], suggesting county-level structural racism is detrimental to the health and well-being of Black and White women and infants. Although novel approaches to measuring indicators of structural racism at the county-level are important to Black and White women's infant health, these novel approaches were not related to gestational age.

Novel measures of county-level indicators of structural racism did not explain variation in racial disparities in infants born to Black and White women for either birth weight or gestational age. In fact, in comparison to traditional indicators of structural racism, novel indicators explained less variation in adverse birth outcomes experienced by Black and White women. Future studies should explore different approaches to measuring indicators of structural racism at the county-level. This is particularly true for counties in California as some have the

ability to regulate the flow of resources as well as the diversity of county governance, thereby affecting the accessibility of resources and health of county constituents.

Given the profound effect of county-level poverty on ad-verse birth outcomes, we believe poverty and indicators of structural racism may be measuring overlapping forms of op-pression [21, 61]. Although most studies examine the independent effect of racism and poverty, there is a growing body of literature assessing the interactional effect of race and in-come segregation [61]. For example, research suggests in-creases in community poverty can be attributed to high racial segregation [61]. Studies consistently show that racial segregation is a stronger predictor of health inequities than income segregation, with the interaction between racial and income segregation exhibiting strong effects on spatial isolation among people living in poverty [62–64]. Future studies should examine the collective impact poverty, and indicators of strutural racism may have on adverse birth outcomes among Black and White women.

Limitations

Although lower percentages of Black women in this study reported preterm births and low birth weight infants compared to the U.S. and California as a whole, there were similar inequity gaps between Black and White women. The lower per-centages of adverse birth outcomes found among women in this study were expected due to the study's exclusion criteria procedures (e.g., previous births or pregnancy terminations, pregnancies ended before 21 weeks). Thus, women in the study represented those who were at lowest risk for having adverse birth outcomes. Second, this study used cross-sectional data and as a result, cannot assess life-course expo-sure to racism or causality. Nonetheless, findings from this study provided a snapshot of the impact of exposure to racism on adverse birth outcomes and can be used to inform future research using longitudinal datasets to assess the cumulative effect of exposures to structural racism across the life course. Further, in our analyses, we used novel approaches to measure structural racism initially proposed by Lukachko and colleagues [37] to be used at the state level. This study differed from Lukachko et al. 2014 [37] in that it measured novel indicators at structural racism at the county level. Candidacy and voting would be potentially better measures of political participation; however, due to the change from states to counties within California, racial stratifications for these variables were not readily available. For this study, we measured racial disparities in board of supervisors and had an imperfect match of years for these data; despite the mismatch, these were the only racial disparity data related to political participation available at the county-level. Similarly, we were unable to measure all constructs of judicial treatment (i.e., disenfranchised and death row). These factors should be considered in future work.

Conclusion

This was the first study to test the relationship between traditional and novel county-level indicators of structural racism and birth outcomes among Black and White women in California. Findings from our analysis highlight the importance of traditional app roaches to measuring indicators of structural racism, compared to novel approaches, at the county level in understanding racial disparities in adverse birth out-comes between Black and White women residing in California. Traditional indicators of structural racism, particularly the isolation index, are association with earlier gestation age for infants born to Black women. County-level novel approaches to measure indicators of structural racism were associated with birth weight for both

Black and White women. This suggests that exposures to residential segregation (traditional indicators) become embodied and contribute to racial disparities in gestational age between Black and White women. Given the social stratification of Black and White people in the U.S. is situated within historical and contemporary racism, generations of Black women embody exposures and ac-cumulated effects of social, economic, and political disparities, which negatively impacts Black women's health[32].Findings from this study also suggest the need to develop more innovative approaches to measure county-level indicators of structural racism such as racial disparities in policing(American Public Health Association [APHA], 2016).

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