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The Relationship Between Race, Inflammation and Psychosocial Factors Among Pregnant Women

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Abstract

African American women have higher rates of preterm birth (PTB) than women from other racial or ethnic backgrounds. We explored the possibility that African American women experience higher anxiety/lower optimism levels, leading to excess inflammation, a possible pathway leading to PTB. In a cohort of 434 nulliparous women (African American, $n = 119$; Caucasian, $n = 315$), standardized measures of anxiety and optimism were completed at 20 weeks' gestation. C-reactive protein (CRP) was measured in serum collected at the same time, and interleukin-6 (IL-6) was additionally measured in African American women. African American women tended to have higher rates of anxiety ([75th percentile) compared to Caucasian women (27.3 vs. 19.2 %, $p = 0.08$), but rates of low optimism (<25th percentile) did not vary by race. Contrary to our hypothesis, higher concentrations of CRP among African American women were associated with lower risk of anxiety in the highest quartile, adjusted for covariates (OR 0.65, 95 % CI 0.44, 0.98).

Low optimism in African American women was also associated with lower IL-6, but results were only marginally significant (OR 0.43, 95 % CI 0.17, 1.10). CRP, anxiety, and optimism were not correlated among Caucasian women. African American women with high anxiety or low optimism had lower concentrations of pro-inflammatory markers at mid-gestation compared to those without these characteristics. Our results suggest that chronic anxiety among African American women may contribute to intractable race disparities in pregnancy outcomes via an impaired inflammatory response.

Keywords

Anxiety; Inflammation; Pregnancy; Psychosocial factors; Race disparity

Introduction

Profound race disparities in preterm birth (PTB, delivery before 37 weeks gestation) persist in the United States, with African American women having rates on average 1.6 times higher than Caucasian women [1]. Additionally, the preterm-related infant mortality rate in 2007 was 1.8 for Caucasian women and 6.0 for African American women [2]. Though reasons for this disparity are multifactorial, chronic stress and anxiety, perhaps by altering cellular immunity and immune control of the inflammatory response, may contribute [3].

Accumulating evidence links psychosocial factors such as stress and anxiety to PTB. Stress during pregnancy has been well studied, and many forms of stress, including catastrophic events, poverty, and crime, have been associated with the risk of PTB [4]. Anxiety is the most common psychiatric disorder among women, affecting 40 % of women at some point in their lives [5, 6]. Anxiety is characterized by feelings of tension, apprehension, nervousness, and worry and by arousal of the autonomic nervous system [7]. Pregnancy-related anxiety is associated with a 1.5 to twofold increased risk of PTB, and is a construct that includes dispositional traits and conditions specific to pregnancy [8]. Optimism reflects the tendency to view the future positively, expecting in general that good things will happen. Optimism has been linked to lower rates of disease [9], perhaps due to adaptive coping and buffering of difficulties, increased likelihood to engage in health promoting behaviors, and via biological mechanisms such as down-regulation of the autonomic nervous system and inflammation [10–12.] One study has linked optimism during pregnancy to healthy infant birth weight [13].

A proposed model linking pregnancy-related anxiety to PTB suggests that pre-pregnancy factors, such as dispositional anxiety may be moderated by resilience factors such as optimism and may be mediated by health behaviors such as tobacco use and weight gain. Immune changes and inflammation are biological pathways through which these factors are hypothesized to converge, leading to PTB [4]. We have previously reported that African American women, but not Caucasian women, with higher trait anxiety assessed in the first half of pregnancy had shorter gestations and excess risk of PTB [14]. We used this cohort to further test a portion of the hypothesized model linking anxiety to PTB. We considered that high trait anxiety or low optimism may induce pro-inflammatory cytokines that affect

immune responses during pregnancy and that African American women may be particularly susceptible to these effects (Fig. 1). This hypothesis is an important first step in determining whether inflammation may be a mediating mechanism linking psychosocial health with adverse pregnancy outcomes such as PTB, and whether the immune response contributes to racial disparities [15].

Several lines of evidence support this possibility. Inflammatory markers such as CRP and IL-6 have been associated with excess anxiety in non-pregnant adults [16], and anxiety can enhance the production of pro-inflammatory cytokines [17–19]. Socioeconomic gradients in concentrations of these inflammatory markers have been detected in multi-ethnic populations [20], and African American women tend to have a poorer pre-conception health status than Caucasian women [21]. Thus, African American women may also have excess inflammation, explained at least in part by excess disadvantage and its resulting psychosocial consequences, such as high anxiety and low optimism.

Inflammation is a central component of many human reproductive processes, and excess inflammation has been proposed as a cause of PTB [22]. CRP is a marker of both acute and chronic inflammation, and when measured in early and late gestation, CRP has been associated with excess PTB risk [23–25]. We measured CRP in women from our earlier study who had serum collected at the same time as the assessment of anxiety and optimism. Considering the increased risk of PTB in African American women, the evidence that biomarkers of PTB may vary according to maternal race [26], and the importance of the inflammatory pathway in PTB risk in African American women [27, 28], we focused further on this group. In the 119 African American women in our cohort, we also assessed IL-6, which is a pro-inflammatory cytokine that is a primary mediator of host response to inflammation [29, 30]. IL-6 is the most studied biomarker of PTB, with consistent evidence associating elevated concentrations in the amniotic fluid of women who deliver preterm. Evidence associating IL-6 measured in maternal serum with PTB is conflicting, perhaps due to heterogeneity of the populations studied [31]. In addition, higher IL-6 concentrations have been detected in pregnant African American women with depressive symptoms [32, 33.]

We hypothesized that women with high anxiety or low optimism in the first half of pregnancy would have elevated CRP concentrations measured at the same time. We also hypothesized that CRP and IL-6 would be particularly elevated in African American women with high anxiety or low optimism. In exploratory analysis we examined the concomitant associations between anxiety, optimism, and inflammatory biomarkers with shortened gestation.

Materials and Methods

The Pregnancy Exposures and Preeclampsia Prevention study is a prospective study of women enrolled at <21 weeks and followed through the postpartum visit at Magee-Womens Hospital of Pittsburgh, PA. A total of 2,812 women were recruited from clinics and private practices from 1997 to 2006. The study was approved by the University of Pittsburgh Institutional Review Board, and all participants provided written informed consent. Beginning in 2002, a psychosocial component was added to the structured interview, and

enrollment was limited to nulliparous women. Of 942 women eligible for the study after 2002, 795 (84.4 %) agreed to participate. The current study includes women who delivered at our hospital (n = 702) without chronic hypertension (n = 695) who completed the psychosocial instruments (n = 667, 95.0 %). Of these women, 434 (65.1 %) had serum samples collected between 17 and 24 weeks gestation, and they comprise our final study population. African American women were less likely to be included in the current study (27 vs. 35 %, $p = 0.02$), but anxiety, optimism and pre-pregnancy BMI did not differ among those included compared to those without serum, (all $p < 0.15$).

The enrollment interview was conducted, on average, at 20.2 weeks of gestation by trained research staff with extensive experience in pregnancy studies at our hospital. As part of this interview, women were asked to complete the Spielberger Trait Anxiety Inventory (STAI), a standard 10-item self-report tool used to assess relatively stable individual differences in anxiety proneness [34, 35]. Women also completed the revised Life Orientation Test (LOT-R), which is a standard 10-item tool for the assessment of dispositional optimism that has been used extensively in studies of stress and health [36]. The STAI and the LOT-R have been shown to have adequate internal consistency (Cronbach's $\alpha = 0.91$ and 0.76 , respectively) [7, 12] In our sample, Cronbach's $\alpha = 0.84$ for the STAI and 0.63 for the LOT-R.

Maternal non-fasting serum samples were collected at this same visit, and frozen at -80°C . We measured CRP protein concentrations with a high-sensitivity enzyme-linked immunosorbent assay (ELISA) on the SpectraMax ME analyzer (Molecular Devices, Sunnyvale, CA). The detection limit of the assay was 0.03 ng/mL , with an intra-assay variability of 7 %. IL-6 was measured using a high-sensitivity sandwich ELISA (Quantikine HS ELISA Kit, R&D Systems, Minneapolis, MN). The coefficient of variation for test samples in the study was $<5\%$.

Covariates

Maternal race was self-reported as Caucasian or African American; 10 women reported another race/ethnicity, and these women were excluded from the current analysis. Covariates considered were gestational age at blood draw; maternal age at delivery; education (less than high school for women older than 19 who did not complete high school, high school, or >high school); smoking during pregnancy (none, <10 cigarettes per day, ≥ 10 cigarettes per day); and marital status. Receipt of public assistance was reported as yes if anyone in the household currently received Medicaid, food stamps, cash assistance, or public housing. Measured height and reported pre-pregnancy weight at the intake visit were used to calculate pre-pregnancy body mass index (BMI, kg/m^2), and women were classified as normal weight ($<25\text{ kg/m}^2$) or overweight ($\geq 25\text{ kg/m}^2$) [37]. Gestational age was abstracted from the medical record and was based on early pregnancy ultrasounds. PTBs were those delivered <37 completed weeks; term births were ≥ 37 weeks' gestation. Neighborhood factors (percent of families below the poverty level, percent of individuals below the poverty level, and median home value in dollars) were assessed according to zip code of residence of mothers at the time of delivery and were based on 1999 census data.

Statistical analysis

Given our previous work that detected an association between high anxiety and PTB [14], we compared maternal characteristics using t tests or Chi square according to whether anxiety scores were above or below the 75th percentile (STAI > 20 vs. ≤ 20) and optimism scores below or above the 25th percentile (LOT-R < 12 vs. ≥ 12). This approach is consistent with that suggested by the STAI instrument and has been used in other studies [38].

CRP and IL-6 were evaluated as medians (interquartile range, IQR) and were compared using Wilcoxon rank sum tests. Values were log transformed for parametric analyses. Spearman correlations were used to evaluate the relation between anxiety, optimism, CRP, and IL-6, stratified by race. Multivariable logistic regression models were built to assess the independent association between CRP and IL-6 and high anxiety or low optimism, stratified by race. We fit parsimonious regression models by specifying full models with potential confounding variables (all covariates were considered), and confounders were included if they changed the coefficient associated with either CRP or IL-6 by >10 %. All models were also adjusted for pre-pregnancy BMI given the strong associations between adiposity and inflammatory markers. Results were replicated, with anxiety and optimism scores evaluated as continuous outcomes, using linear regression and, again, after removing values of CRP or IL-6 more than 3 standard deviations above the mean as potential outliers. A *p* value of <0.05 defined statistical significance.

Given the well-established relation between BMI, CRP, and IL-6, we also looked for evidence of effect measure modification by pre-pregnancy overweight status and pre-pregnancy BMI as a continuous variable, using the likelihood ratio test (*p* < 0.10). Because our study was nested within an existing prospective cohort, we were unable to enroll more women. Based on women available for this study, we had 77–83 % power to detect a one mg/L difference in CRP and one pg/ml difference in IL-6 in African American women with high anxiety or low optimism compared to African American women without these characteristics. This magnitude of difference has been reported in another study of maternal stress and inflammatory markers assessed during pregnancy [39]. Power was much higher (>95 %) for the same comparisons among Caucasian women, due to larger numbers. Data were analyzed using SAS software version 9.2 [40].

Results

Maternal Characteristics

Thirty-two African American women in the study (27.3 %) reported trait anxiety in the highest quartile (STAI > 20), and 60 Caucasian women (19.2 %) reported anxiety above this threshold ($\chi^2 = 3.11$, *p* = 0.08). Optimism in the lowest quartile (LOT-R < 12) was reported in 30 African American women (25.6 %) and 77 Caucasian women (24.6 %; $\chi^2 = 0.01$, *p* = 0.91). Overall, 18.0 % of African American women and 13.8 % of Caucasian women reported both high anxiety and low optimism. Among both African American and Caucasian women (Tables 1 and 2), those with anxiety in the highest quartile were less likely to have education beyond high school and were more likely to smoke. Other characteristics revealed race differences according anxiety/optimism scores. African American women had high

rates of disadvantage that did not vary according to anxiety and optimism, whereas Caucasian women who were more disadvantaged had high anxiety/ low optimism.

Inflammatory Markers

CRP, anxiety and optimism were modestly correlated among African American women ($r = 0.16$, $p = 0.09$ for anxiety; $r = 0.12$, $p = 0.18$ for optimism). Median concentrations of CRP tended to be lower in African American women with high anxiety compared to low anxiety, but differences were not significant (3.72 vs. 5.11 mg/L, $p = 0.07$; Table 1). In addition, increasing concentrations of CRP were significantly associated with reduced risk of anxiety above the 75th percentile after accounting for gestational age at sampling, education and smoking status, (OR 0.65, 95 % CI 0.44, 0.98; Table 3). Results were similar among African American women who reported both high anxiety and low optimism ($n = 21$; OR 0.57 [0.35, 0.92) and were unaffected after removing women with CRP more than 3 SD above the mean ($n = 4$). CRP, anxiety and optimism were unrelated among Caucasian women.

African American women with high anxiety were somewhat less likely to be overweight, while Caucasian women with high anxiety were more likely to be overweight. The relation between anxiety and inflammatory measures did not differ, however, according to overweight status. For example, among both African American overweight (≥ 25 kg/m²) and normal weight women (BMI < 25 kg/m²), increasing CRP was associated with lower risk of high anxiety (OR 0.69 [0.42, 1.14] for normal weight women; OR 0.68 [0.34, 1.36] for overweight women). Again, anxiety, optimism, and CRP were unrelated in Caucasian women after stratifying by pre-pregnancy BMI.

Given the racial disparity in PTB and in markers of inflammation, we also measured IL-6 in African American women. CRP and IL-6 were modestly correlated among these women ($r = 0.48$). In contrast to our findings for CRP, IL-6 concentrations were not different among African American women with high anxiety (1.03 vs. 1.15 pg/ml, $p = 0.16$), but concentrations were significantly lower in those with low optimism compared to their counterparts above the 25th percentile (1.03 vs. 1.34 pg/ml, $p = 0.04$, Table 1). Higher concentrations of IL-6 tended to be associated with reduced odds of low optimism among African American women (OR 0.43, 95 % CI 0.17, 1.10) after accounting for covariates, although this comparison was not statistically significant (Table 3). Thus, the associations between IL-6 and anxiety/optimism among pregnant African American women in our study appeared to be different than for CRP.

Exploratory analysis of the concomitant associations between anxiety, optimism, inflammatory markers and gestational length in weeks also revealed patterns that varied by race. Among African American women, high anxiety was associated with gestations that were, on average one week shorter than their counterparts with anxiety below this threshold although this difference was not statistically significant (beta = -1.17 weeks [SE 0.67], $p = 0.08$), perhaps due to small numbers. LogCRP and logIL-6 were non-significant when added to these models ($p = 0.45$ and 0.98 , respectively). In contrast, logCRP was associated with a modest but significant reduction in gestational weeks among Caucasian women (beta = -0.34 [SE 0.12], $p < 0.01$), while high anxiety was unrelated ($p = 0.44$).

Discussion

There was a trend for African American women in our study to have higher levels of anxiety assessed at mid-pregnancy compared to Caucasian women, although rates of low optimism did not vary according to maternal race. Contrary to our hypothesis, African American women with anxiety in the highest quartile or optimism in the lowest quartile had lower circulating concentrations of proinflammatory markers compared to African American women without these characteristics. These differences persisted after accounting for covariates, including pre-pregnancy BMI and smoking. Interestingly, in our data, African American women with lower anxiety had concentrations of CRP similar to that among Caucasian women with either high or low anxiety.

While accumulating evidence indicates that pregnancy-related anxiety may have the most consistent associations with PTB, we did not have this measure in our study. A proposed conceptual model, however, recognizes that a predisposition to anxiety, in our study characterized by trait anxiety, is a key determinant of pregnancy-related anxiety [4]. Similarly, the stronger the anxiety trait, the more likely an individual will experience anxiety in a fearful situation [7]. In addition, anxiety that persists postpartum, that may affect parenting or future pregnancies, may be best characterized by trait anxiety [41], and thus, trait anxiety may be a key precursor to the cascade that triggers pregnancy-related anxiety, its accompanying immune responses, and associations with adverse pregnancy outcomes. This trajectory warrants further study.

Our results of lower circulating inflammatory markers among African American women with high anxiety or low optimism were unexpected, and we can only speculate as to possible reasons. Chronic stress—and thus, the related emotional state of anxiety—has been associated with immunosuppression, as characterized by decreased natural killer cell activity, and suppressed lymphocyte or humoral responses [42]. A healthy immune system is flexible and redundant, and therefore, even large stress-induced immune changes may have only small clinical consequences. However, a dysregulated immune system that is less flexible and more senescent, as seen with aging, may have clinical consequences [43]. Another possibility is that some individuals are particularly sensitive to psychosocial distress or react with more or less amplified immune activation [44]. Lower CRP and IL-6 concentrations among African American women in our study with higher chronic anxiety or lower dispositional optimism may be markers of a less adaptive immune system but this speculation warrants direct study.

In large population-based cohorts of men and women, increasing anxiety has been associated with increasing CRP and IL-6 concentrations after accounting for BMI and other factors, although these studies were limited to Caucasian participants [45–47]. In another large population study of younger adults (mean age 31), increasing anxiety was associated with higher concentrations of CRP in men, but not in women [48]. In studies during pregnancy, Coussons-Read demonstrated that stress assessed in the first trimester was associated with increased CRP measured at the same time, although there was only one African American woman in this study [49]. Consistent with our current results, a recent study comprised largely of Hispanic women (and no African American women)

demonstrated that excess stress, assessed in early and late gestation, was associated with lower concentrations of IL-6 [39]. Also consistent with our findings, Menon and colleagues have reported that IL-6, measured in the amniotic fluid of women with PTB, was higher in Caucasian women, but lower in African American women, compared to those with term births [50].

In contrast to our results, two recent studies comprised largely of African American women have reported that depressive symptoms assessed during pregnancy were related to elevated IL-6 but not CRP at mid-gestation [32, 33]. Although depression and anxiety overlap, the associations between each state and PTB appear to be distinct [8]. Future studies that assess both depression and anxiety among diverse groups of women during pregnancy are needed to disentangle these remaining questions.

African American and Caucasian women with high anxiety and low optimism in our study tended to differ from one another in body size, an important consideration given that inflammatory markers are known to vary according to body composition [51]. These data raise the possibility that behaviors such as diet, physical activity, and smoking, that are importantly related to pregnancy, may also vary by anxiety and race [52]. Although we were able to account for some of these characteristics in our study, this possibility warrants additional investigation.

Among African American women in our study, high anxiety, but not low optimism, was associated with lower CRP. IL-6 revealed a different pattern such that optimism, but not anxiety, was associated with IL-6. This pattern was evident in the logistic and the linear models of IL-6, suggesting that, although CRP was modestly correlated, in our data, with IL-6, these biomarkers may be related to different processes and pathways. Multiplex technology has been used to measure a large array of cytokines, and this approach may help to more robustly characterize of the complex biology of immune function and its relation to psychosocial factors.

Other approaches, such as evaluation of interventions designed to influence the biologic response to anxiety may provide additional insight into how inflammation may be influenced by emotions. One pilot study of non-pregnant adults demonstrated that mindfulness-based stress reduction was associated with reductions in CRP concentrations and natural killer cell activity [53]. Another study demonstrated a decline in depression, stress, and anxiety among pregnant participants in a mindfulness-based stress reduction group [54]. Whether such interventions may improve immune function among African American women with high anxiety is not known.

Our results are preliminary and need to be considered in the context of our study's limitations. Although our study was nested within a larger prospective cohort, our race-specific analyses were limited by small numbers of African American women with high anxiety and low optimism, and thus, our results are exploratory and may be due to chance. Our power calculations suggested we may have adequate numbers to evaluate within-race differences, however, because our results were contrary to our hypotheses larger studies designed to examine the race-specific inflammatory response to anxiety, stress and optimism

are warranted. We measured CRP and IL-6 at one time point, which are only two markers of a complex immune system that changes across gestation. Future studies in a contemporary cohort should characterize how immune markers and emotions may change together across gestation.

In addition, we did not have access to clinical diagnoses or symptoms of depression, nor did we have diagnostic information regarding generalized anxiety disorder. Given the overlap between depressive symptoms and anxiety, it will be important to include these assessments in future pregnancy studies. We also did not assess pregnancy-related anxiety or information regarding the underlying cause of the anxiety assessed. A recent report demonstrated that exposure to racial discrimination explained 24 % of the variance in psychological distress among a cohort of African Americans with high rates of poverty, suggesting some race-specific causes that warrant additional study [55]. Future studies in this area should also ensure that research staff reflects the race/ethnicity diversity of the population.

Strengths of our study were the relatively large cohort of pregnant women enrolled during the first half of pregnancy, inclusion of both Caucasian and African American women and utilization of validated psychosocial instruments. Future studies of other ethnic groups are also needed, as are larger studies that can evaluate how these processes may affect pregnancy outcomes such as PTB risk and its clinical subtypes. In addition, intervention studies designed to improve the psychosocial health of women during pregnancy are needed.

Our data suggest that, contrary to what has been reported in non-pregnant adults, African American women with high anxiety or low optimism in the first half of pregnancy had lower circulating concentrations of proinflammatory markers compared to African American women without these characteristics. These differences persisted after accounting for covariates, including pre-pregnancy BMI. We detected no associations between anxiety, optimism, and inflammatory markers in Caucasian women. Our results suggest that chronic anxiety among African American women may contribute to intractable race disparities in pregnancy outcomes via an impaired inflammatory response. Additional understanding of these pathways and interventions to improve the psychosocial health of minority women during pregnancy are needed.

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Fig. 1.
Conceptual model relating dispositional optimism, trait anxiety and proinflammatory markers during pregnancy

Table 1Maternal characteristics according to anxiety, mean (SD) or *n* (%)

	Black women			White women		
	Low (n = 85)	High (n = 32)	<i>p</i>	Low (n = 252)	High (n = 60)	<i>p</i>
Age (years)	21.72 (3.58)	20.79 (1.99)	0.30	26.19 (5.40)	23.38 (4.44)	0.00
Education (<i>n</i> , %)						
Less than high school	14 (16.0)	11 (34.4)	0.04	19 (7.5)	12 (19.7)	<0.01
High school	37 (43.5)	15 (46.9)		58 (23.0)	22 (36.1)	
Greater than high school	34 (29.1)	6 (18.8)		175 (69.4)	27 (44.3)	
Married or marriage-like (<i>n</i> , %) ^a	11 (12.94)	2 (11.11)	0.51	157 (62.30)	17 (27.87)	<0.01
Public Assistance (<i>n</i> , %)	67 (78.82)	28 (87.50)	0.28	101 (40.08)	45 (73.77)	<0.01
Cigarette smoking (<i>n</i> , %)	17 (20.0)	15 (46.9)	<0.01	42 (18.2)	19 (23.2)	0.33
Prepregnancy BMI (kg/m ²)	26.46 (6.76)	25.63 (6.68)	0.57	24.83 (5.90)	24.92 (5.25)	0.51
Prepregnancy overweight (<i>n</i> , %)	44 (51.8)	12 (37.5)	0.17	93 (36.9)	30 (49.2)	0.08
Preterm (< 37 weeks'), (<i>n</i> , %)	10 (11.76)	5 (15.63)	0.58	28 (11.11)	10 (16.39)	0.26
Families below poverty (%)	20.56 (13.83)	23.52 (15.66)	0.41	8.48 (5.89)	10.66 (7.12)	0.06
Individuals below poverty (%)	24.15 (14.05)	27.28 (16.21)	0.41	11.57 (6.70)	13.86 (8.21)	0.11
Median home value (%)	51,716 (23,058)	49,305 (23,050)	0.60	86,088 (49,398)	75,518 (45,059)	0.02
Gestational weeks at sampling	20.92 (2.02)	21.44 (2.01)	0.16	20.40 (1.96)	20.72 (2.02)	0.28
CRP, median (IQR)	5.11 (2.25, 11.40)	3.72 (1.98, 6.11)	0.07	5.68 (1.89, 10.01)	5.19 (2.21, 12.85)	0.85
IL6, median (IQR)	1.15 (0.79, 1.79)	1.03 (0.72, 1.36)	0.16	–	–	–

n = 429 women with complete anxiety assessments^aFishers exact test

Table 2Maternal characteristics according to optimism, mean (SD) or *n* (percent)

	Black women			White women		
	Low (<i>n</i> = 30)	High (<i>n</i> = 89)	<i>p</i>	Low (<i>n</i> = 77)	High (<i>n</i> = 238)	<i>p</i>
Age (years)	21.02 (1.96)	21.59 (3.55)	0.84	23.27 (4.31)	26.32 (5.41)	<0.01
Education (<i>n</i> , %)						
Less than high school	10 (33.3)	16 (18.0)	0.20	13 (16.7)	19 (8.0)	<0.001
High school	12 (40.01)	40 (44.9)		30 (38.5)	49 (20.6)	
Greater than high school	8 (26.7)	33 (37.1)		35 (44.9)	170 (71.4)	
Married or marriage-like (<i>n</i> , %) ^a	3 (10.00)	10 (11.24)	0.99	24 (30.77)	154 (64.71)	<0.01
Public assistance (<i>n</i> , %)	27 (90.00)	69 (77.53)	0.13	56 (71.29)	91 (38.24)	<0.01
Cigarette smoking (<i>n</i> , %)	13 (43.3)	19 (21.4)	0.03	28 (35.9)	53 (22.3)	0.02
Prepregnancy BMI (kg/m ²)	24.64 (6.14)	26.74 (6.83)	0.13	24.57 (5.77)	24.94 (5.79)	0.64
Prepregnancy overweight (<i>n</i> , %)	12 (40.0)	45 (37.8)	0.32	31 (39.7)	93 (39.1)	0.92
Preterm (< 37 weeks'), (<i>n</i> , %)	4 (13.33)	11 (12.36)	0.89	12 (15.38)	26 (10.92)	0.29
Families below poverty (%)	23.82 (14.68)	20.41 (14.03)	0.27	9.92 (6.31)	8.74 (6.41)	0.11
Individuals below poverty (%)	27.23 (15.87)	24.13 (14.09)	0.37	12.83 (7.26)	11.92 (7.23)	0.33
Median home value (%)	47,554 (15,210)	51,858 (24,927)	0.97	72,868 (40,742)	87,404 (50,881)	0.01
Gestational weeks at sampling	21.33 (1.96)	20.96 (2.02)	0.33	20.74 (1.98)	20.35 (1.96)	0.12
CRP, median (IQR)	3.86 (2.31, 6.42)	5.11 (2.25, 11.40)	0.13	6.32 (2.35, 11.85)	5.10 (1.87, 10.29)	0.34
IL6, median (IQR)	1.03 (0.72, 1.24)	1.34 (0.82, 1.96)	0.04	–	–	

n = 434 women with complete optimism assessments^aFishers exact test

Table 3

Logistic regression relating high anxiety and low optimism (outcome variables) to maternal concentrations of logCRP and log IL-6 (dependent variables)

Outcome		Black				White			
		Unadjusted		Adjusted		Unadjusted		Adjusted	
		OR (95 % CI)	p	OR (95 % CI)	p	OR (95 % CI)	p	OR (95 % CI)	p
Anxiety High ^a	logCRP ^c	0.71 (0.50, 1.02)	0.06	0.65 (0.44, 0.98)	0.04	1.02 (0.79, 1.31)	0.91	0.94 (0.707, 1.249)	0.67
	logIL-6 ^d	0.59 (0.26, 1.34)	0.21	0.75 (0.30, 1.88)	0.53				
Optimism Low ^b	logCRP ^e	0.79 (0.55, 1.12)	0.18	0.84 (0.56, 1.25)	0.38	1.11 (0.88, 1.40)	0.39	1.14 (0.87, 1.48)	0.35
	logIL-6 ^f	0.38 (0.15, 0.94)	0.04	0.43 (0.17, 1.10)	0.08				

^a Anxiety High, anxiety in highest quartile compared to those with anxiety score below this threshold

^b Optimism Low, optimism in lowest quartile compared to those with optimism score above this threshold

^c Model estimating odds of high anxiety associated with each logCRP unit increase in Black women adjusted for gestational age at sampling and BMI(continuous); Model with logCRP in White women adjusted for education, BMI(continuous) and marital status

^d Model estimating odds of high anxiety with each logIL-6 unit increase in Black women adjusted for education, BMI(continuous) and smoking

^e Model estimating odds of low optimism associated with each logCRP unit increase in Black women adjusted for gestational age at sampling, BMI(continuous) and smoking; Model with logCRP in White women adjusted for age, smoking, marital status, BMI(continuous) and public assistance

^f Model estimating odds of low anxiety associated with each logIL-6 unit increase in Black women adjusted for BMI(continuous)