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Cumulative Stress and Cortisol Disruption among Black and Hispanic Pregnant Women in an Urban Cohort

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Abstract

While adult hypothalamic-pituitary-adrenocortical (HPA) axis functioning is thought to be altered by traumatic experiences, little data exist on the effects of cumulative stress on HPA functioning among pregnant women or among specific racial and ethnic groups. Individuals may be increasingly vulnerable to physiological alterations when experiencing cumulative effects of multiple stressors. These effects may be particularly relevant in urban poor communities where exposure to multiple stressors is more prevalent. The goal of this study was to explore the effects of multiple social stressors on HPA axis functioning in a sample of urban Black ($n = 68$) and Hispanic ($n = 132$) pregnant women enrolled in the Asthma Coalition on Community, Environment, and Social Stress (ACCESS). Pregnant women were administered the Revised Conflict Tactics Scale (R-CTS) survey to assess interpersonal violence, the Experiences of Discrimination (EOD) survey, the Crisis in Family Systems-Revised (CRISYS-R) negative life events survey, and the My Exposure to Violence (ETV) survey, which ascertains exposure to community violence. A cumulative stress measure was derived from these instruments. Salivary cortisol samples were collected five times per day over three days to assess area under the curve (AUC), morning change, and basal awakening response in order to characterize diurnal salivary cortisol patterns. Repeated measures mixed models, stratified by race/ethnicity, were performed adjusting for education level, age, smoking status, body mass index and weeks pregnant at time of cortisol sampling. The majority of Hispanic participants (57%) had low cumulative stress

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exposure, while the majority of Black participants had intermediate (35%) or high (41%) cumulative stress exposure. Results showed that among Black but not Hispanic women, cumulative stress was associated with lower morning cortisol levels, including a flatter waking to bedtime rhythm. These analyses suggest that the combined effects of cumulative stressful experiences are associated with disrupted HPA functioning among pregnant women. While the etiology of racial/ethnic differences in stress-induced HPA alterations is not clear, this warrants further research.

Social and psychological stress may disrupt maternal-fetal endocrine dynamics during pregnancy, particularly the hypothalamic-pituitary-adrenal (HPA) axis (Glynn, Schetter, Chiciz-DeMet, Hobel, & Sandman, 2007). A wide body of evidence in non-pregnant samples has demonstrated associations between psychological stress and altered HPA axis functioning, which may have broad health implications for a variety of outcomes, including perinatal health (Glynn, et al., 2007; McEwen, 2002). Disruption of the HPA axis, in particular cortisol production, has been associated with birth weight and gestational length (Buss, et al., 2009; Kivlighan, DiPietro, Costigan, & Laudenslager, 2008).

Evolving research suggests that the pattern of HPA disturbance and the magnitude of the effect varies with the cumulative nature and chronicity of psychological stress experiences. These patterns may best be understood within McEwen's concept of allostasis, which refers to the ability of the body to achieve stability through change such that "the autonomic nervous system, the HPA axis, and cardiovascular, metabolic, and immune systems protect the body by responding to internal and external stress" (McEwen, 1998). Acute stress is generally associated with activation of the HPA axis (i.e., increased cortisol production). Chronic stress however, does not consistently lead to increased cortisol levels; in fact, several studies suggest that people who have experienced chronic stress have lower baseline cortisol levels and a flattening of the typical diurnal cortisol slope. The diurnal rhythm of cortisol typically peaks shortly after awakening and then falls throughout the day. Cortisol levels that are either higher or lower than normal for any given time of day may set the stage for pathogenic processes that predispose to illness (Cohen, Schwartz, et al., 2006). Lower morning cortisol levels as well as flatter diurnal cortisol rhythms have been associated with physical threats and traumatic stress and have been found among women diagnosed with posttraumatic stress disorder (PTSD). (Meewisse, Reitsma, de Vries, Gersons, & Olff, 2007); (Miller, Chen, & Zhou, 2007)

Overlapping stress research suggests that individuals may be increasingly vulnerable to negative health outcomes when exposed to the cumulative effects of multiple stressors (H.F. Myers, 2009). Cumulative and more intense environmental stressors may accelerate bodily wear and tear. (Seeman, Singer, Rowe, Horwitz, & McEwen, 1997) These effects may be particularly relevant in urban poor communities, where exposure to multiple stressors is more prevalent. Particularly during pregnancy, evidence demonstrates that women of lower SES are more likely to experience multiple stressors (Braveman, et al., 2009). Specifically, lower-income ethnic minority women are more likely to experience financial hardships (Braveman, et al., 2009), exposure to community violence (Clark, et al., 2007), racism or discrimination (Nuru-Jeter, et al., 2009), and interpersonal violence (IPV) (Hien & Bukszan, 1999; Holman, Silver, & Waitzkin, 2000).

A number of studies have begun to document racial differences in HPA axis regulation. For example, among non-pregnant women, Blacks have been shown to have higher levels of cortisol at the end of the day compared to Whites, resulting in flatter diurnal rhythms, even after accounting for SES (Cohen, Schwartz, et al., 2006). Gallagher-Thompson and colleagues noted that Hispanic women had flatter daytime cortisol slopes compared to non-Hispanic White women (Gallagher-Thompson, et al., 2006). Studies are only beginning to

explore differences in HPA axis response during pregnancy across these racial/ethnic groups. Glynn and colleagues recently reported lower cortisol levels among Black women compared to non-Hispanic White women over pregnancy but no differences in cortisol levels between Hispanic women and non-Hispanic White women (Glynn, et al., 2007). Whether the reported differences are due to variations specifically in morning levels or in levels throughout the day is unknown due to the study's sampling methodology (i.e., one cortisol sample in the afternoon for one day per trimester).

Studies examining associations between maternal stress and prenatal diurnal cortisol rhythms are sparse and to date have not allowed for an examination of possible differences across racial or ethnic groups in pregnant samples (Kivlighan, et al., 2008; Obel, et al., 2005). Furthermore, while studies have documented associations between specific stressors, and cortisol dysregulation, to our knowledge no study has simultaneously considered the cumulative effects of psychosocial stress domains in pregnant women in relationship to diurnal cortisol expression. Given evidence that low income women experience multiple stressors simultaneously and thus may be increasingly vulnerable to HPA axis dysregulation when exposed to the cumulative effects of multiple stressors (H. F. Myers, 2009), this is an important area of inquiry.

In this study we examine the cumulative effect of multiple stressors, specifically IPV, discrimination, negative life events and community violence, on the diurnal pattern of cortisol among urban pregnant Black and Hispanic women and consider interactions between cumulative stress and race/ethnicity. We hypothesized that experiencing a greater number of stressors would be associated with lower morning cortisol levels and a flatter diurnal pattern of cortisol. Given reports of lower morning cortisol levels among Black women (Glynn, et al., 2007) and flatter diurnal slopes among Hispanic women compared to White women (Gallagher-Thompson, et al., 2006), we explored the effect of cumulative stress on cortisol levels by race/ethnicity. Due to a lack of guiding literature, we did not have any *a priori* hypotheses as to the direction of effects by race/ethnicity.

Methods

Participants

Participants were from the Asthma Coalition on Community, Environment, and Social Stress (ACCESS) project, a prospective cohort originally funded to recruit $N=500$ pregnant women and their children to study the effects of prenatal maternal and early life stress and other environmental risk factors on urban childhood asthma risk, described in detail elsewhere (Wright, et al., 2008). Briefly, English or Spanish-speaking pregnant women who were at least 18 years of age receiving prenatal care at Brigham & Women's Hospital, Boston Medical Center, and three community health centers and their associated Women, Infants and Children (WIC) programs in metropolitan Boston were recruited between August 2002 and January 2007. Research assistants approached women receiving prenatal care on selected clinic days, of whom 78.1% were eligible and agreed to enroll. Those who chose not to participate answered a screener questionnaire including race/ethnicity, education, and annual household income; there were no significant differences in these covariates between those who participated and those who declined. Subsequent funding allowed for the collection of salivary cortisol in a subset of these women. As women were enrolled in the study they were asked to participate in the cortisol protocol. A sample of approximately 375 women was invited to participate in the salivary protocol and 295 were eligible and completed the protocol. Women were excluded due to shift work, exogenous steroid use, and multiples pregnancy as these factors are known to influence cortisol ($n=12$). Women refused participation because they were too busy ($n=35$) or were unable to satisfactorily complete the collection protocol ($n=33$). Those who did not participate in the

cortisol protocol did not differ from those who completed the salivary cortisol protocol on education or smoking status. These analyses only consider racial/ethnic minority participants and include Black ($n = 68$) and Hispanic ($n = 132$) women who completed the salivary cortisol collection protocol and had complete data on the social stressors and covariates of interest. All study activities were approved by the Brigham & Women's Hospital and Boston Medical Center human studies committees. Written informed consent was obtained in the participant's primary language (English or Spanish) prior to beginning any study activities.

Measures and Procedures

Study questionnaires were administered in the participant's primary language in the second or third trimester. Saliva was collected for cortisol assaying as described below at approximately 28 weeks gestation after the ascertainment of questionnaire data.

Psychosocial Stress Domains

Interpersonal Violence: Participants completed the Revised Conflict Tactics Scale (R-CTS) short form, which has previously documented reliability (ranges from $r = .79$ to $.95$) and validity in both English and Spanish speaking subjects (Calvete, Corral, & Estevez, 2007; Straus & Douglas, 2004). IPV was assessed during adulthood, including violence experienced before and during the current pregnancy. Exposure was assessed using 6 items asking participants whether any romantic partner had ever: pushed, grabbed, or shoved them; kicked, bit, or punched them; hit them with something that hurt their body; choked or burned them; forced them to have sexual activities; or physically attacked them in some other way. A scale summing all the items endorsed during adulthood was created, combining adult exposures occurring before and during the index pregnancy. Overall, 38 participants (19%) reported IPV in adulthood. Of the 68 Black women, 18 reported IPV; 20 of the 132 Hispanic women reported IPV exposure. The pregnancy and adulthood periods were combined given the small number reporting abuse during pregnancy ($n=11$). Of note, studies suggest that those abused just prior to pregnancy are likely to experience abuse at a similar frequency and severity during pregnancy (Bowen, Heron, Waylen, & Wolke, 2005; Saltzman, Johnson, Gilbert, & Goodwin, 2003).

Community Violence: Participants were administered a modified version of the *My Exposure to Violence (ETV)* survey (Selner-O'Hagan, Kindlon, Buka, Raudenbush, & Earls, 1998). The ETV measures direct victimization and witnessing violence as well as factors known to influence the impact of violence (e.g. familiarity with the perpetrator or victim, frequency of events and the setting of the exposure such as whether the events occurred at home) (Selner-O'Hagan, et al., 1998). The survey measured exposure to specific violent events in the past year, including hearing gunshots, and witnessing and/or experiencing shoving, hitting or punching, knife attacks and shootings. Because the R-CTS assesses interpersonal items, we considered only items from the ETV that occurred outside of the home, that is, exposure to community violence. Acceptable internal consistency (Cronbach's $\alpha = .92$), test-retest reliability, ($r = .85$), and validity have previously been described for this scale (Selner-O'Hagan, et al., 1998; Thomson, Roberts, Curran, Ryan, & Wright, 2002). We implemented Rasch modeling techniques to summarize responses to the multi-item community ETV questionnaire into a continuous score as previously described (Suglia, Ryan, & Wright, 2008). The Rasch model produces a continuous score based on the participant's responses to the multi-item ETV violence survey, which takes into account the severity and frequency with which each of the violent events was experienced (Suglia, et al., 2008).

Discrimination: Self-reported experiences of racial discrimination were measured by the Experiences of Discrimination (EOD) scale, which has acceptable internal consistency (Cronbach's $\alpha = .74$), test-retest reliability ($r = .70$), and has been validated in working class African Americans and Hispanics (Krieger, Smith, Naishadham, Hartman, & Barbeau, 2005; Mustillo, et al., 2004). Participants were asked whether they had experienced unfair or bad experiences (yes/no) because of their race or ethnicity in any of 7 situations: at school, getting a job, at work, getting a house, getting medical care, on the street or public setting, and from the police or in the courts. Responses were summed to form a scale of racial discrimination across the situations.

Other negative life events: Using the 63-item Crisis in Family Systems-Revised (CRISYS-R), validated in both English and Spanish (Berry, Quinn, Portillo, & Shalowitz, 2006; Shalowitz, Berry, Rasinski, & Dannhausen-Brun, 1998), participants indicated whether they experienced a list of potentially stressful events spanning several domains (legal, relationships, medical and housing issues) during the past 6 months. Items related to interpersonal violence in the home were omitted given that these exposures were assessed using the R-CTS items. Participants rated each experience as positive, negative or neutral. A summary score based on the total number of events rated as negative was calculated. Acceptable test-retest reliability has been demonstrated for the negative life events scale for both English ($r = .93$) and Spanish ($r = .77$) versions (Berry, et al., 2006; Shalowitz, et al., 1998).

Cumulative Stress Measure—A summary scale of cumulative stress was created by combining these four stressor domain measures. First, a dichotomous variable was created for each stressor domain measure: Participants were given a score of 1 if they were in the upper quartile and a score of 0 otherwise for each of the four measures. The cumulative stress score was created by summing over these dichotomous variables and ranged from 0 to 4, with higher scores indicating a higher level of cumulative stress.

Cortisol—Participants provided saliva samples collected around 25 weeks gestation at home via the passive drool technique on 3 consecutive weekdays (Kirschbaum & Hellhammer, 1994; Strazdins, et al., 2005). Participants were given verbal and written instructions by trained research staff when saliva tubes were supplied as well as brief daily diaries that repeated these instructions and recorded adherence to the collection protocol. Participants asked to collect saliva could not be taking exogenous steroids, be nightshift workers, or have a multiple pregnancy, as these circumstances may influence cortisol levels (Federenko, et al., 2004; Kivlighan, et al., 2008). Participants were instructed not to eat, brush their teeth, or drink liquids for at least 15 minutes before taking a sample. They provided 5 samples each day of collection: at awakening (“when your eyes open and you are ready to get up”), 45 minutes after awakening, 4 hours, and 10 hours after awakening, and at bedtime (“right before getting into bed”). They were also instructed to record the time that they woke up (in the diary) and the date and the exact time that each sample was taken (on the tube label and diary). Samples were picked up in person by research staff on the fourth day. Samples were centrifuged, aliquoted and stored at -70° centigrade until assay.

To limit variation between collection times, we restricted our analyses to samples that were taken during the following time windows: at awakening (Time 1), 30 minutes to 1.5 hours after awakening (Time 2), between 3 and 6.5 hours after awakening (Time 3), 7.5 to 11.5 hours after awakening (Time 4) and more than 11.5 hours after awakening (Time 5). These time windows were selected a priori as previously done in other studies (Cohen, Doyle, & Baum, 2006). The 200 participants provided 2643 saliva samples; 216 samples were excluded from analyses because they did not meet the sampling time windows, leaving 2427 samples for analyses.

Covariates—A baseline questionnaire ascertained information on health behaviors and pre-pregnancy height and weight as well as several sociodemographic factors, including race and ethnicity. Race and ethnicity data were obtained by two questions. Participants were first asked, “Are you Hispanic or Latino? (Yes/No)” and then “What is your race? (Black/African-American; Native/Hawaiian; American Indian/Alaskan Native; Asian, White; and Other).” Participants who responded “No” to the first question and selected “Black” to the follow-up question were categorized as non-Hispanic Black. Individuals who responded “Yes” to Latino/Hispanic were categorized as Hispanic, regardless of their response to the follow-up race question with the exception of those who selected Black. Participants who identified as both Black and Hispanic were categorized as Black. Of note, differences of opinion remain about the most appropriate terms to use when referring to different ethnic or racial groups. In this paper, we choose to use the terms *race* and *ethnicity* interchangeably to refer to groups based on notions of race, cultural background, or ethnicity. Analyses were adjusted for maternal education level, categorized as some college education, high school or GED, or less than high school education. Tobacco exposure was also included as a potential confounder, as women who experience IPV and other stressors are more likely to smoke (Jun, Rich-Edwards, Boynton-Jarrett, & Wright, 2008), and tobacco exposure has been shown to alter cortisol secretion (Rohleder & Kirschbaum, 2006). Body mass has also been shown to alter cortisol production (Daniel, et al., 2006); thus we adjusted for body mass index (BMI), calculated as height/weight² in analyses. Because cortisol levels can vary throughout pregnancy (Glynn, et al., 2007), we also adjusted for gestational age at the time of the saliva collection.

Data Analytic Plan

The current analyses consist of 200 Black and Hispanic women who completed the saliva protocol and had complete information for the social stressors and covariates of interest. Cortisol samples that were missing for a particular time point or outside of the sampling windows previously described were excluded from the analyses, but the rest of that participant’s data were still used. Guided by previously described methodologies (Polk, Cohen, Doyle, Skoner, & Kirschbaum, 2005), we examined the relations among the various psychosocial stressors and cortisol levels at each time point of collection as well as the area under the curve (AUC), morning (AM) change, and diurnal slope over the waking day. Cortisol values were log transformed prior to analyses due to non-normality. The AUC, a measure of total daily response, was calculated as the area under a linear interpolation of the log cortisol measures over time for each day of measurement for each participant. The AM change is the difference between the second and first measures of the day, with higher scores reflecting a greater morning cortisol surge. Diurnal slope is the slope of the log cortisol measurements over the course of the day. Slopes were estimated using the best linear unbiased predictor from a hierarchical mixed model that included random effects for subject and day within subject (Cohen, Doyle, et al., 2006). These estimates are “best” estimates in the sense that they are unbiased and less variable than other linear estimators, such as ordinary least squares estimates. All three summary measures are markers of dysregulation and have been associated with poor health outcomes, the AUC is a measure of total daily response, the diurnal slope allows us to determine whether cortisol varies throughout the day in an unusual manner and the AM change is a general stress maker not related to the other measures.

Data analyses proceeded in several steps. Pearson correlation coefficients were performed to assess the associations among the continuous IPV, community violence exposure, racial discrimination and negative life events measures. To model the relation between cumulative stress and cortisol levels, we employed linear mixed models, including both random and fixed effects, allowing for repeated AUC, AM change, and diurnal slope measures (one per

each day per each participant). Additionally, we used mixed models regressions to estimate the effect of cumulative stress on log cortisol at each time point of measurement. We tested interactions between race/ethnicity and cumulative stress in relation to cortisol by creating a multiplicative interaction term between race and cumulative stress. We also examined the cumulative stress models stratified by race/ethnicity and explored a non-linear association between stress and cortisol patterns by modeling cumulative stress as a categorical variable creating three indicator variables: low (score of 0), medium (score of 1) and high (score of 2 or greater). All cortisol analyses were adjusted for maternal age, education, smoking status, pre-pregnancy BMI, and gestational age at saliva sampling. All statistical analyses were done using SAS version 9.0 (SAS Institute, Cary, NC. Statistical significance was assessed at $p < .05$.

Results

Table 1 summarizes the demographic characteristics of the sample and descriptive statistics for all covariates. There were significant differences between Black and Hispanic participants on education level $\chi^2(2) = 15.8, p = .0004$ and smoking status $\chi^2(2) = 9.8, p = .002$. Black participants were more likely to smoke during pregnancy, and a larger percentage of Hispanic participants had less than a high school education as their highest education level attained. Means and standard deviations for the psychosocial stressors, cortisol levels aggregated across the three days for each time interval of collection, and the cortisol summary variables are also depicted. Black participants had a significantly higher average ETV score, $F(2) = 29.2, p < .0001$, as well as a higher CRISYS negative events score compared with Hispanic participants, $F(2) = 14.7, p = .0002$. The IPV scale was modestly correlated with the negative life events and racial discrimination scales ($r = .24$ and $r = .15$, respectively, both $p < .05$) but not with the community violence scale ($r = .14, p = .06$). The racial discrimination scale was moderately correlated with the negative life events scale ($r = .33, p < .0001$) but was not significantly correlated with the community violence scale ($r = .12, p = .10$). Lastly, negative life events were moderately correlated with the community violence scale ($r = .38, p < .0001$). While there is some overlap, the moderate correlation across the stress measures suggests that they are tapping into unique domains.

Figure 1 depicts the distribution of the cumulative stress scale among Black and Hispanic participants. The majority of Hispanic participants (57%) had low cumulative stress exposure (score of 0), while the majority of Black participants had medium (score of 1; 35%) or high (score of 2 or greater 41%) cumulative stress exposure. Unadjusted cortisol levels for each sampling time among Black and Hispanic participants with low, medium and high cumulative stress are presented in Figures 2a and 2b. Black participants with high cumulative stress had lower morning cortisol levels (Time 1, $F(2) = 13.4, p < .0001$ and Time 2, $F(2) = 6.4, p = .002$) compared to Black participants with low or medium exposure (Figure 2a), Hispanic participants with high cumulative stress scores had lower cortisol levels at Time 2 compared to Hispanic participants with low or medium exposure, $F(2) = 3.2, p = .04$ (Figure 2b).

Table 2 displays the adjusted associations between cumulative stress and the cortisol measures. The cumulative stress measure was associated with lower cortisol levels at Time 1 and Time 2 and with a positive diurnal slope. Interactions between cumulative stress and race/ethnicity were significant for Time 1 ($B = -0.25, SE = 0.08, p < .05$) and Time 3 ($B = -0.14, SE = 0.07, p < .05$) and for the diurnal slope ($B = 0.32, SE = 0.12, p < .05$). In stratified analyses, among Black participants, higher cumulative stress was associated with lower cortisol levels at Time 1 and Time 2 and with a positive diurnal slope, indicating that higher cumulative stress scores were associated with cortisol levels that do not decrease as quickly over the course of the day. No significant associations were noted between cumulative stress

and cortisol levels among Hispanic participants. When cumulative stress was examined as a categorical variable (data not shown), we noted a statistically significant effect of high cumulative stress on cortisol levels at Times 1 and 2 and diurnal slope among Black women ($p < .05$). There was no association of medium stress with cortisol patterns, and no association between any category of cumulative stress and cortisol patterns among Hispanic women.

Discussion

The goal of the current study was to examine the role of cumulative psychological stress on cortisol regulation among Black and Hispanic pregnant woman in an urban cohort. Analyses revealed statistically significant interactions between race/ethnicity and cumulative stress on cortisol regulation. Among Black women, cumulative stress was associated with lower morning cortisol levels; this association was not seen among Hispanic women. In addition, among Black women only, greater cumulative stress was related to a flatter waking to bedtime rhythm.

Our findings are similar to other studies that have noted lower morning cortisol levels in response to social stressors (Glynn, et al., 2007; Pico-Alfonso, Garcia-Linares, Celda-Navarro, Herbert, & Martinez, 2004; Seedat, Stein, Kennedy, & Hauger, 2003). Moreover, our finding that high-level cumulative stress exposure, which included traumatic stress measures (e.g., IPV, community violence), was associated with HPA disruption patterns is similar to those found in other studies of violence exposure or posttraumatic stress disorder (PTSD). For example, Johnson et. al. (2008) examined the cortisol awakening response of 52 battered women and found that, overall those diagnosed with PTSD had higher cortisol levels in the morning compared to those without PTSD. However, when chronicity of exposure was accounted for, the authors found that women exposed to more chronic abuse had lower waking cortisol levels than women not chronically abused (Johnson, Delahanty, & Pinna, 2008). Similarly, other studies have noted lower cortisol morning levels among women victims of IPV compared to unexposed women (Griffin, Resick, & Yehuda, 2005; Seedat, et al., 2003). Pico-Alfonso et al. (2004) examined the effects of IPV on women's morning and evening cortisol levels. They noted higher evening cortisol levels among women victims of IPV compared to those not exposed but found no associations with morning levels. Sampling methodology could explain the lack of association in this study, as women provided the morning cortisol sample between 8am and 9am with no regard to the actual awakening time (Pico-Alfonso, et al., 2004).

Our analyses revealed an association between cumulative stress and cortisol levels among Black women but not Hispanic women. We hypothesized that the racial/ethnic difference might be explained by the higher stress levels of Black participants, however in analyses characterizing cumulative stress as a three level categorical variable no effect on cortisol was noted among Hispanics in the high cumulative stress group making it unlikely that the higher range of stress exposures reported by Black women explains the racial/ethnic differences noted. Alternatively, increased social support and coping strategies may account for the lack of association between cumulative stress exposure and cortisol rhythms among Hispanic women in our study. Other studies have documented strong social support in Latino communities (Campos, et al., 2008); (Weigers & Sherraden, 2001), which may have a stress-buffering effect that modifies the impact of cumulative stress on cortisol responses among pregnant Latinas (Sherraden & Barrera, 1996). The potential influence of these factors in explaining differential effects of stress on physiologic disruption (e.g., cortisol) in racial/ethnic minorities should be explored in future research.

Our study has a number of strengths. Unlike much of the prior work, we were able to examine multiple psychosocial stressors rather than one stressor in relation to cortisol dysregulation. The sample included a reasonably large sample of Blacks and Hispanics. We assessed repeated salivary cortisol samples timed to awakening, collected over the entire day over multiple days to take into account situational variance (Kirschbaum & Hellhammer, 1994). We also specifically considered stressors that occur with greater prevalence in ethnic-minority and lower income populations (Braveman, et al., 2009). Due to lack of relevant data, we could not fully account for chronicity or severity of stressors. For example, we do not have information regarding when in the adult period the IPV occurred. As noted previously, prior research suggests that chronicity of stress exposure has a significant impact on cortisol dysregulation. Accounting for these parameters may strengthen associations between cumulative stress and cortisol dysregulation. Lastly, we are limited by the low reports of IPV among Black and Hispanic women.

Future analyses may extend this work by considering mediating or moderating factors, including social supports, coping strategies, psychological functioning (e.g., depression, PTSD) and chronicity of stress. In this study, we noted differences in the effects of multiple psychosocial stressors on cortisol regulation between Black and Hispanic women during pregnancy. Racial and ethnic differences in the physiological stress response may, in part, help explain observed racial/ethnic health disparities.

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Figure 1.
Distribution of cumulative stress scores for Black and Hispanic women.

Figure 2a.

Mean cortisol levels by sampling time for Black women by cumulative stress exposure.

Low cumulative stress defined as 0, medium defined as 1 and high defined as 2 or more in the 0-4 scale of cumulative stress

Note: Differences were statistically significant ($p < .05$) between the three groups at Time 1 and Time 2

Figure 2b.

Mean cortisol levels by sampling time for Hispanic women by cumulative stress exposure. Low cumulative stress defined as 0, medium defined as 1 and high defined as 2 or more in the 0-4 scale of cumulative stress

Note: Differences were statistically significant ($p < .05$) between the three groups at Time 2.

Table 1
Population Characteristics and Descriptive Statistics for Covariates (N=200)

Demographics	Full Sample (n=200)			Blacks (n = 68)			Hispanics (n = 132)			p value ^a
	Mean	SD		Mean	SD		Mean	SD		
Age	26.7	5.9		26.4	5.8		26.8	5.9		.61
Pre-pregnancy BMI (kg/m ²)	28.9	6.7		28.7	6.5		29	6.8		.87
Gestational age (weeks) at saliva collection	28.8	4.8		28.9	5.1		28.7	4.7		.79
Education Level	N	%	N	%	N	%	N	%		
Some college	60	30.0	32	47.0	28	21.2				.0004
High school graduate / Technical school	57	28.5	18	26.5	39	29.6				
Less than high school/ No graduation	83	41.5	18	26.5	65	49.2				
Smoking status										.002
Current smoker	33	16.5	19	27.9	14	10.6				
Non smoker	167	83.5	49	72.1	118	89.4				
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
Adult R-CTS ^b Range (0-10)	0.5	1.3	0.7	1.7	0.4	1.0				.07
Exposure to Community Violence Range (0-4)	0.7	0.9	1.1	1.0	0.4	0.7				<.0001
CRISYS Negative Events Range (0-16)	2.4	3.1	3.6	3.7	1.8	2.6				.0002
Racism Range (0-6)	1.4	1.7	1.5	1.9	1.3	1.7				.44
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		p value ^a
Cortisol Measures (nmol/L)										
Time 1	15.5	8.1	14.9	9.1	15.9	7.8				.11
Time 2	16.8	9.8	15.7	9.8	17.5	9.7				.03
Time 3	10.8	7.0	10.7	6.9	10.9	7.0				.46
Time 4	7.8	7.5	8.7	8.7	7.3	6.8				.11
Time 5	6.5	5.8	7.3	6.9	6.0	5.2				.06
AUC	5.4	3.3	5.44	3.9	5.42	2.9				.92

	Mean	SD	Mean	SD	Mean	SD	Mean	SD	p value ^a
AM change	0.03	0.3	0.01	0.3	0.03	0.4	0.03	0.4	.47
Diurnal slope	-1.6	0.8	-1.43	0.9	-1.73	0.8	-1.73	0.8	<.0001

^a Differences between Black and Hispanic women tested with via chi-square or ANOVA tests.

^b Adult R-CTS assesses interpersonal violence

Associations between Cumulative Stress and Cortisol Response (nMol/L) among Black and Hispanic Women by Time of Collection, AUC, AM Change, and Diurnal Slope

Table 2

	Time 1	Time 2	Time 3	Time 4	Time 5	AUC	AM Change	Diurnal Slope
Cumulative Stress	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)
Full Sample ^a	-0.0801(0.04)*	-0.1355 (0.04)*	-0.0143 (0.03)	0.0368(0.04)	0.0461(0.06)	0.1366 (0.2)	-0.0180 (0.02)	0.1283 (0.06)*
Stratified models ^b								
Blacks	-0.1913 (0.06)*	-0.1999 (0.06)*	-0.0965 (0.05)	0.0066 (0.07)	-0.0093 (0.10)	-0.1109 (0.3)	0.0023 (0.02)	0.2459 (0.09)*
Hispanics	0.0011 (0.05)	-0.0915 (0.05)	0.0392 (0.04)	-0.0041 (0.05)	0.0587 (0.08)	-0.0576 (0.2)	-0.0395 (0.02)	-0.0074 (0.07)

Change in cortisol parameter (nmol/L) per unit change in cumulative stress measure

^aModels are adjusted for maternal race/ethnicity, age, smoking status, education, prenatal BMI, and gestational age at cortisol collection. .

^bModels are adjusted for maternal age, smoking status, education, prenatal BMI, and gestational age at cortisol collection.

* $p < 0.05$