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

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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/ethnic groups. 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). Women were administered the Revised Conflict Tactics Scale (R-CTS) survey, 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 community violence exposure. A cumulative stress measure was derived from these instruments. Salivary cortisol samples were collected five times per day over three days 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, while Black participants had intermediate (35%) or high (41%) cumulative stress. 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. The etiology of racial/ethnic differences in stress-induced HPA alterations warrants further research.

*Keywords:* psychological stress, diurnal cortisol, HPA axis, race/ethnicity, pregnancy

Social and psychological stress may disrupt maternal–fetal endocrine dynamics during pregnancy, particularly the hypothalamic–pituitary–adrenal (HPA) axis (Glynn, Schetter, Chicz-DeMet, Hobel, & Sandman, 2007). A wide body of evidence in nonpregnant samples has demonstrated associations between psychological stress and altered HPA axis functioning, which may have broad health implications for a variety of out-

comes, 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 vary with the cumulative nature

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and chronicity of psychological stress experiences. These patterns may best be understood within McEwen's (1998) 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. 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, & Olf, 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 (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 socioeconomic status are more likely to experience multiple stressors (Braveman et al., 2010). Specifically, lower income ethnic minority women are more likely to experience financial hardships (Braveman et al., 2010), exposure to community violence (Clark et al., 2008), racism or discrimination (Nuru-Jeter et al., 2009), and interpersonal violence (IPV; Hien & Bukszpan, 1999; Holman, Silver, & Waitzkin, 2000).

A number of studies have begun to document racial differences in HPA axis regulation. For example, among nonpregnant women, Blacks have been shown to have higher levels of cortisol at the end of the day compared with Whites, resulting in flatter diurnal rhythms, even after accounting for socioeconomic status (Cohen, Schwartz, et al., 2006). Gallagher-Thompson and colleagues (2006) noted that Hispanic women had flatter daytime cortisol slopes compared with non-Hispanic White women. Studies are only beginning to explore differences in HPA axis response during pregnancy across these racial/ethnic groups. Glynn and colleagues (2007) recently reported lower cortisol levels among Black women compared with non-Hispanic White women over pregnancy but no differences in cortisol levels between Hispanic women and non-Hispanic White women. Whether the reported differences are due to variations specifically in morning levels or in levels throughout the day is unknown because of the study's sampling methodology (i.e., one cortisol sample in the afternoon for 1 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, although 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 (Myers, 2009), this is an important area of inquiry.

In this study, we examined 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 considered 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 with White women (Gallagher-Thompson et al., 2006), we explored the effect of cumulative stress on cortisol levels by race/ethnicity. Given a lack of guiding literature, we did not have any a priori hypotheses as to the direction of effects by race/ethnicity.

## Method

### Participants

Participants were from the Asthma Coalition on Community, Environment, and Social Stress project, a prospective cohort originally funded to recruit 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 and Women's Hospital, Boston Medical Center, and three community health centers and their associated Women, Infants and Children 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 because of 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 consider only 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 and 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 Procedure

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 six 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 women 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 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 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 or no) because of their race or ethnicity in any of seven 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 seven situations.

**Other negative life events.** Using the 63-item Crisis in Family Systems—Revised (CRISYS-R), validated in 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, relationship, 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 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 stress domain measures. First, a dichotomous variable was created for each stress 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 min before taking a sample. They provided five samples each day of collection: at awakening ("when your eyes open and you are ready to get up"), 45 min after awakening, 4 hr and 10 hr after awakening, and at bedtime ("right before getting into bed"). They were also instructed to record (in the diary) the time that they woke up 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  $-70^{\circ}\text{C}$  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 min to 1.5 hr after awakening (Time 2), between 3 and 6.5 hr after awakening (Time 3), 7.5 to 11.5 hr after awakening (Time 4), and more than 11.5 hr 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 2,643 saliva samples; 216 samples were excluded from analyses because they did not meet the sampling time windows, leaving 2,427 samples for analyses.

### Covariates

A baseline questionnaire ascertained information on health behaviors and prepregnancy 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 Latina? (yes or 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 Latina/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 article, we choose to use the terms *race* and *ethnicity* interchangeably to refer to groups on the basis of 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, calculated as height/weight<sup>2</sup>, 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 or outside 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 of

collection as well as the area under the curve (AUC), morning (a.m.) change, and diurnal slope over the waking day. Cortisol values were log transformed prior to analyses due to nonnormality. 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 a.m. 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 allowed us to determine whether cortisol varies throughout the day in an unusual manner, and the a.m. change is a general stress marker 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, a.m. change, and diurnal slope measures (one per each day per each participant). In addition, we used mixed models regressions to estimate the effect of cumulative stress on log cortisol at each time 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 nonlinear 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, prepregnancy body mass index, 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. Means and standard deviations for the psychosocial stressors, cortisol levels aggregated across the 3 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-R negative events score compared with Hispanic participants,  $F(2) = 14.7, p = .0002$ . The IPV scale was modestly



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

Variable	Full sample ( $n = 200$ )	Blacks ( $n = 68$ )	Hispanics ( $n = 132$ )	$p^a$
<b>Demographic</b>				
Mean ( <i>SD</i> ) age (years)	26.7 (5.9)	26.4 (5.8)	26.8 (5.9)	.61
Mean ( <i>SD</i> ) prepregnancy BMI ( $\text{kg}/\text{m}^2$ )	28.9 (6.7)	28.7 (6.5)	29 (6.8)	.87
Mean ( <i>SD</i> ) gestational age (weeks) at saliva collection	28.8 (4.8)	28.9 (5.1)	28.7 (4.7)	.79
<b>Education level, <math>n</math> (%)</b>				
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)	
<b>Smoking status, <math>n</math> (%)</b>				
Current smoker	33 (16.5)	19 (27.9)	14 (10.6)	.002
Nonsmoker	167 (83.5)	49 (72.1)	118 (89.4)	
Mean ( <i>SD</i> ) adult R-CTS (range = 0–10) <sup>b</sup>	0.5 (1.3)	0.7 (1.7)	0.4 (1.0)	.07
Mean ( <i>SD</i> ) exposure to community violence (range = 0–4)	0.7 (0.9)	1.1 (1.0)	0.4 (0.7)	<.0001
Mean ( <i>SD</i> ) CRISYS–R negative events (range = 0–16)	2.4 (3.1)	3.6 (3.7)	1.8 (2.6)	.0002
Mean ( <i>SD</i> ) racism (range = 0–6)	1.4 (1.7)	1.5 (1.9)	1.3 (1.7)	.44
<b>Mean (<i>SD</i>) cortisol measures (nmol/l)</b>				
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
Morning change	0.03 (0.3)	0.01 (0.3)	0.03 (0.4)	.47
Diurnal slope	–1.6 (0.8)	–1.43 (0.9)	–1.73 (0.8)	<.0001

Note. BMI = body mass index; R-CTS = Revised Conflict Tactics Scale; CRISYS–R = Crisis in Family Systems—Revised; AUC = area under the curve.

<sup>a</sup> Differences between Black and Hispanic women tested with via chi-square or ANOVA tests. <sup>b</sup> Adult R-CTS assesses interpersonal violence.

correlated with the negative life events and racial discrimination scales ( $r = .24$  and  $r = .15$ , respectively,  $ps < .05$ ) 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 ( $r = .38$ ,  $p < .0001$ ). Although 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), whereas 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 with Black participants with low or medium exposure (see Figure 2a); Hispanic participants with high cumulative stress scores had lower cortisol levels at Time 2 compared with Hispanic participants with low or medium exposure,  $F(2) = 3.2$ ,  $p = .04$  (see Figure 2b).

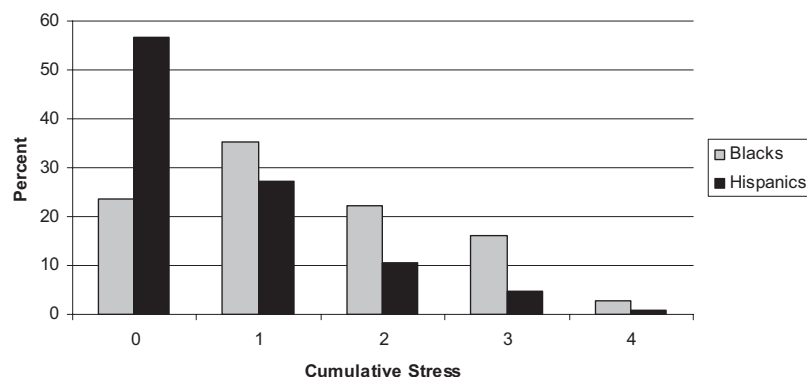


Figure 1. Distribution of cumulative stress scores for Black and Hispanic women.

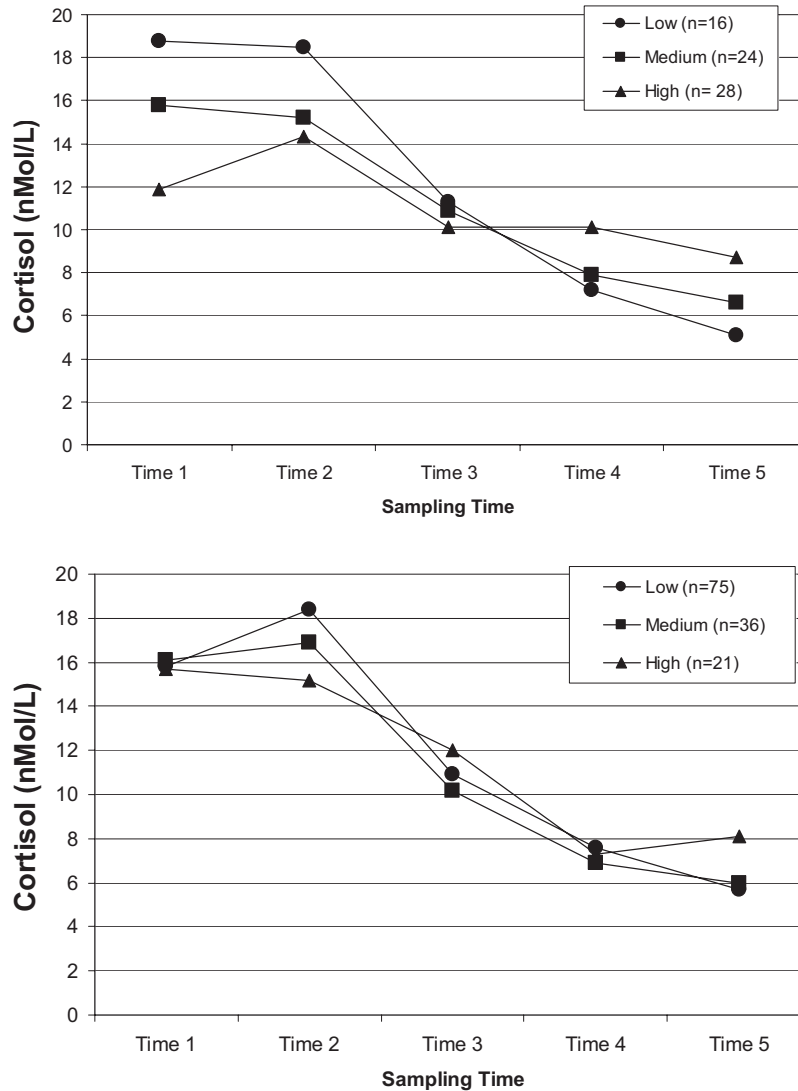


Figure 2. (a) Mean cortisol levels by sampling time for Black women by cumulative stress exposure. (b) Mean cortisol levels by sampling time for Hispanic women by cumulative stress exposure. Low cumulative stress was defined as 0, medium was defined as 1, and high was defined as 2 or more in the 0–4 scale of cumulative stress. Note: Differences were statistically significant ( $p < .05$ ) between the three stress groups at Time 1 and Time 2.

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

Table 2  
Associations Between Cumulative Stress and Cortisol Response (nmol/l) Among Black and Hispanic Women by Time of Collection, Area Under the Curve (AUC), Morning Change, and Diurnal Slope

Cumulative stress	Time 1		Time 2		Time 3		Time 4		Time 5		AUC		Morning change		Diurnal slope	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Full sample <sup>a</sup>	-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 <sup>b</sup>																
Black	-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
Hispanic	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

Note. Change in cortisol parameter (nmol/l) per unit change in cumulative stress measure.

<sup>a</sup> Models are adjusted for maternal race/ethnicity, age, smoking status, education, prenatal body mass index, and gestational age at cortisol collection. <sup>b</sup> Models are adjusted for maternal age, smoking status, education, prenatal body mass index, and gestational age at cortisol collection.

\*  $p < .05$ .

women. In addition, greater cumulative stress was related to a flatter waking to bedtime rhythm among Black women only.

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 findings of other studies of violence exposure or PTSD. For example, Johnson, Delahanty, and Pinna (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 with 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 et al., 2008). Similarly, other studies have noted lower cortisol morning levels among women victims of IPV compared with 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 with 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 8 a.m. and 9 a.m. 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. 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., 2010). Given 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.

## References

- Berry, C. A., Quinn, K. A., Portillo, N., & Shalowitz, M. U. (2006). Reliability and validity of the Spanish version of the Crisis in Family Systems—Revised. *Psychological Reports, 98*, 123–132.
- Bowen, E., Heron, J., Waylen, A., & Wolke, D. (2005). Domestic violence risk during and after pregnancy: Findings from a British longitudinal study. *BJOG, 112*, 1083–1089.
- Braveman, P., Marchi, K., Egarter, S., Kim, S., Metzler, Stancil, T., & Libet, M. (2010). Poverty, near-poverty, and hardship around the time of pregnancy. *Maternal and Child Health Journal, 14*, 20–35.
- Buss, C., Davis, E. P., Class, Q. A., Gierczak, M., Pattillo, C., Glynn, L. M., & Sandman, C. A. (2009). Maturation of the human fetal startle response: Evidence for sex-specific maturation of the human fetus. *Early Human Development, 85*, 633–638.
- Calvete, E., Corral, S., & Estevez, A. (2007). Factor structure and validity of the Revised Conflict Tactics Scales for Spanish women. *Violence Against Women, 13*, 1072–1087.
- Campos, B., Schetter, C. D., Abdou, C. M., Hobel, C. J., Glynn, L. M., & Sandman, C. A. (2008). Familialism, social support, and stress: Positive implications for pregnant Latinas. *Cultural Diversity & Ethnic Minority Psychology, 14*, 155–162.
- Clark, C., Ryan, L., Kawachi, I., Canner, M. J., Berkman, L., & Wright, R. J. (2008). Witnessing community violence in residential neighborhoods: A mental health hazard for urban women. *Journal of Urban Health, 85*, 22–38.
- Cohen, S., Doyle, W. J., & Baum, A. (2006). Socioeconomic status is associated with stress hormones. *Psychosomatic Medicine, 68*, 414–420.
- Cohen, S., Schwartz, J. E., Epel, E., Kirschbaum, C., Sidney, S., & Seeman, T. (2006). Socioeconomic status, race, and diurnal cortisol decline in the Coronary Artery Risk Development in Young Adults (CARDIA) Study. *Psychosomatic Medicine, 68*, 41–50.
- Daniel, M., Moore, D. S., Decker, S., Belton, L., DeVellis, B., Doolen, A., & Campbell, M. K. (2006). Associations among education, cortisol rhythm, and BMI in blue-collar women. *Obesity, 14*, 327–335.
- Federenko, I., Wust, S., Hellhammer, D. H., Dechoux, R., Kumsta, R., & Kirschbaum, C. (2004). Free cortisol awakening responses are influenced by awakening time. *Psychoneuroendocrinology, 29*, 174–184.
- Gallagher-Thompson, D., Shurgot, G. R., Rider, K., Gray, H. L., McKibbin, C. L., Kraemer, H. C., . . . Thompson, L. W. (2006). Ethnicity, stress, and cortisol function in Hispanic and non-Hispanic White women: A preliminary study of family dementia caregivers and noncaregivers. *American Journal of Geriatric Psychiatry, 14*, 334–342.
- Glynn, L. M., Schetter, C. D., Chicz-DeMet, A., Hobel, C. J., & Sandman, C. A. (2007). Ethnic differences in adrenocorticotrophic hormone, cortisol and corticotropin-releasing hormone during pregnancy. *Peptides, 28*, 1155–1161.
- Griffin, M. G., Resick, P. A., & Yehuda, R. (2005). Enhanced cortisol suppression following dexamethasone administration in domestic violence survivors. *American Journal of Psychiatry, 162*, 1192–1199.
- Hien, D., & Bukszpan, C. (1999). Interpersonal violence in a “normal” low-income control group. *Women & Health, 29*(4), 1–16.
- Holman, E. A., Silver, R. C., & Waitzkin, H. (2000). Traumatic life events in primary care patients: A study in an ethnically diverse sample. *Archives of Family Medicine, 9*, 802–810.
- Johnson, D. M., Delahanty, D. L., & Pinna, K. (2008). The cortisol awakening response as a function of PTSD severity and abuse chronicity in sheltered battered women. *Journal of Anxiety Disorders, 22*, 793–800.
- Jun, H. J., Rich-Edwards, J. W., Boynton-Jarrett, R., & Wright, R. J. (2008). Intimate partner violence and cigarette smoking: Association between smoking risk and psychological abuse with and without co-occurrence of physical and sexual abuse. *American Journal of Public Health, 98*, 527–535.
- Kirschbaum, C., & Hellhammer, D. H. (1994). Salivary cortisol in psychoneuroendocrine research: Recent developments and applications. *Psychoneuroendocrinology, 19*, 313–333.
- Kivlighan, K. T., DiPietro, J. A., Costigan, K. A., & Laudenslager, M. L. (2008). Diurnal rhythm of cortisol during late pregnancy: Associations with maternal psychological well-being and fetal growth. *Psychoneuroendocrinology, 33*, 1225–1235.
- Krieger, N., Smith, K., Naishadham, D., Hartman, C., & Barbeau, E. M. (2005). Experiences of discrimination: Validity and reliability of a self-report measure for population health research on racism and health. *Social Science & Medicine, 61*, 1576–1596.
- McEwen, B. S. (1998). Stress, adaptation, and disease. Allostasis and allostatic load. *Annals of the New York Academy of Sciences, 840*, 33–44.
- McEwen, B. S. (2002). The neurobiology and neuroendocrinology of stress. Implications for post-traumatic stress disorder from a basic science perspective. *Psychiatric Clinics of North America, 25*, 469–494, ix.
- Meewisse, M. L., Reitsma, J. B., de Vries, G. J., Gersons, B. P., & Olf, M. (2007). Cortisol and post-traumatic stress disorder in adults: Systematic review and meta-analysis. *British Journal of Psychiatry, 191*, 387–392.
- Miller, G. E., Chen, E., & Zhou, E. S. (2007). If it goes up, must it come down? Chronic stress and the hypothalamic–pituitary–adrenocortical axis in humans. *Psychological Bulletin, 133*, 25–45.
- Mustillo, S., Krieger, N., Gunderson, E. P., Sidney, S., McCreath, H., & Kiefe, C. I. (2004). Self-reported experiences of racial discrimination and Black–White differences in preterm and low-birthweight deliveries: The CARDIA Study. *American Journal of Public Health, 94*, 2125–2131.
- Myers, H. F. (2009). Ethnicity- and socio-economic status-related stresses in context: An integrative review and conceptual model. *Journal of Behavioral Medicine, 32*, 9–19.
- Nuru-Jeter, A., Dominguez, T. P., Hammond, W. P., Leu, J., Skaff, M., Egarter, S., . . . Braveman, P. (2009). “It’s the skin you’re in”: African-American women talk about their experiences of racism. An exploratory study to develop measures of racism for birth outcome studies. *Maternal and Child Health Journal, 13*, 29–39.
- Obel, C., Hedegaard, M., Henriksen, T. B., Secher, N. J., Olsen, J., & Levine, S. (2005). Stress and salivary cortisol during pregnancy. *Psychoneuroendocrinology, 30*, 647–656.
- Pico-Alfonso, M. A., Garcia-Linares, M. I., Celda-Navarro, N., Herbert, J., & Martinez, M. (2004). Changes in cortisol and dehydroepiandrosterone in women victims of physical and psychological intimate partner violence. *Biological Psychiatry, 56*, 233–240.
- Polk, D. E., Cohen, S., Doyle, W. J., Skoner, D. P., & Kirschbaum, C. (2005). State and trait affect as predictors of salivary cortisol in healthy adults. *Psychoneuroendocrinology, 30*, 261–272.
- Rohleder, N., & Kirschbaum, C. (2006). The hypothalamic–pituitary–

- adrenal (HPA) axis in habitual smokers. *International Journal of Psychophysiology*, 59, 236–243.
- Saltzman, L. E., Johnson, C. H., Gilbert, B. C., & Goodwin, M. M. (2003). Physical abuse around the time of pregnancy: An examination of prevalence and risk factors in 16 states. *Maternal and Child Health Journal*, 7, 31–43.
- Seedat, S., Stein, M. B., Kennedy, C. M., & Hauger, R. L. (2003). Plasma cortisol and neuropeptide Y in female victims of intimate partner violence. *Psychoneuroendocrinology*, 28, 796–808.
- Seeman, T. E., Singer, B. H., Rowe, J. W., Horwitz, R. I., & McEwen, B. S. (1997). Price of adaptation—allostatic load and its health consequences. MacArthur studies of successful aging. *Archives of Internal Medicine*, 157, 2259–2268.
- Selner-O'Hagan, M. B., Kindlon, D. J., Buka, S. L., Raudenbush, S. W., & Earls, F. J. (1998). Assessing exposure to violence in urban youth. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 39, 215–224.
- Shalowitz, M. U., Berry, C. A., Rasinski, K. A., & Dannhausen-Brun, C. A. (1998). A new measure of contemporary life stress: Development, validation, and reliability of the CRISYS. *Health Services Research*, 33(Pt. 1), 1381–1402.
- Sherraden, M. S., & Barrera, R. E. (1996). Prenatal care experiences and birth weight among Mexican immigrant women. *Journal of Medical Systems*, 20, 329–350.
- Straus, M. A., & Douglas, E. M. (2004). A short form of the Revised Conflict Tactics Scales, and typologies for severity and mutuality. *Violence and Victims*, 19, 507–520.
- Strazdins, L., Meyerkort, S., Brent, V., D'Souza, R. M., Broom, D. H., & Kyd, J. M. (2005). Impact of saliva collection methods on sIgA and cortisol assays and acceptability to participants. *Journal of Immunology Methods*, 307, 167–171.
- Suglia, S. F., Ryan, L., & Wright, R. J. (2008). Creation of a community violence exposure scale: Accounting for what, who, where, and how often. *Journal of Traumatic Stress*, 21, 479–486.
- Thomson, C. C., Roberts, K., Curran, A., Ryan, L., & Wright, R. J. (2002). Caretaker-child concordance for child's exposure to violence in a pre-adolescent inner-city population. *Archives of Pediatrics and Adolescent Medicine*, 156, 818–823.
- Weigers, M. E., & Sherraden, M. S. (2001). A critical examination of acculturation: The impact of health behaviors, social support and economic resources on birth weight among women of Mexican descent. *International Migration Review*, 34, 804–839.
- Wright, R. J., Suglia, S. F., Levy, J., Fortun, K., Shields, A., Subramanian, S., & Wright, R. (2008). Transdisciplinary research strategies for understanding socially patterned disease: The Asthma Coalition on Community, Environment, and Social Stress (ACCESS) project as a case study. *Ciencia & Saúde Coletiva*, 13, 1729–1742.

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