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Maternal Correlates of Children's Stress Functioning Following a Major Natural Disaster

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Concordant assessments of psychological functioning, salivary alpha-amylase (sAA), and cortisol activity were taken for children (n = 28, 6–10 yrs) and their mothers two months after being displaced by Hurricane Katrina and living in a relocation camp. Multilevel regression models revealed that the psychological functioning of the displaced children did not differ from that of demographically matched controls (n = 19 children), but the displaced group had higher sAA activity and lower cortisol levels. Compared to control mothers, displaced mothers showed higher sAA activity; greater symptoms of depression, distress, and anxiety; and lower self-esteem. Maternal psychological functioning was related to children's endocrine activity. The results suggest that pervasive stress exposure may be associated with unique psychobiological distress regulation for mother–child dyads.

Keywords natural disasters, stress functioning, family relations, cortisol, depression

Exposure to psychosocial stressors in adulthood increases risk of depression and anxiety as well as disruption to adrenocortical functioning, depending on the severity and extent of the experiences (e.g., Flinn, Quinlan, Turner, Decker, & England, 1996; Miller, Chen, & Zhou, 2007; Nater & Rohleder, 2009). Short-term adrenocortical responses to *acute* stressors include: (a) increased activation of the hypothalamic–pituitary–adrenal (HPA) axis and release of the stress hormone cortisol; and (b) increased activation of the sympathetic nervous system (SNS) and release of catecholamines (e.g., norepinephrine) into the bloodstream, as well as surrogate biomarkers such as salivary alpha-amylase (sAA) that are released into oral fluids (Chrousos & Gold, 1992; Nater & Rohleder, 2009). Repeated or *chronic* stress exposure (e.g., living under low resource conditions) is associated with low or blunted HPA activity (e.g., low cortisol activity), potentially reflecting habituation to circumstances that cannot be controlled (e.g., Flinn et al., 1996; Miller et al., 2007). For adults, repeated activation of the HPA and SNS is correlated with subsequent trait anxiety, increased susceptibility to viral infection, and onset of many disease-causing factors (e.g.,

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pulmonary constriction; Cohen et al., 1998; Flinn & England, 2003; Kunz-Ebrecht, Mohamed-Ali, Feldman, Kirschbaum, & Steptoe, 2003; Rotton & Dubitsky, 2002; Segerstrom & Miller, 2004; Uchino, Cacioppo, & Kiecolt-Glaser, 1996).

Repeated activation of the HPA and SNS have also been linked to similar health- and mood-related consequences in children, including unhealthy sleeping patterns (El-Sheikh, Buckhalt, Keller, & Granger, 2008), asthma (Wolf, Nicholls, & Chen, 2008), impulsivity (Spinrad et al., 2009), aggression (Gordis, Granger, Susman, & Trickett, 2006), insecure attachment (Hill-Soderlund et al., 2008), and general maladjustment (El-Sheikh, Erath, Buckhalt, Granger, & Mize, 2008). Although it is not fully understood, exposure to traumatic events during childhood may also contribute to permanent alterations in some aspects of stress regulation, including atypical HPA reactivity and mood behaviors in adulthood (Meaney, 2001; Vigil, Brophy, Garrett, & McMurry, 2009). Prospective assessments reveal HPA and SNS activity are predictive of prolonged (i.e., over two years) psychological difficulties, such as externalizing symptoms in children (Keller & El-Sheikh, 2008).

Children's mental and physical (e.g., HPA) responses to traumatic experiences are influenced by genetic factors (Ouellet-Morin et al., 2008), family characteristics (e.g., socioeconomic status), and the availability and extent of reliable emotional support (e.g., Uchino et al., 1996; Vernberg, La Greca, Silverman, & Prinstein, 1996; Wickrama & Kaspar, 2007). Likewise, several studies have highlighted maternal depression, which is associated with elevated risk of child neglect and abuse (e.g., Berger, 2004; Bugental & Happaney, 2004), as a potential predictor of children's HPA regulation. However, the exact nature of this relation is unknown. Some studies found that maternal depression was related to higher cortisol levels in children (e.g., Lupien, King, Meaney, & McEwen, 2000), but others suggested it was related to lower levels (Fernald, Burke, & Gunnar, 2008). The latter findings were from low income families and thus confound maternal depression with broader socioeconomic factors. The combination of maternal and economic factors in these families likely places children at risk for repeated stress exposure that may in turn result in blunted HPA reactivity as found in adults.

To our knowledge, previous studies have not examined the relationship between maternal psychological functioning and hormonal indicators of both SNS and HPA in children who have recently experienced a large-scale disaster. Most previous studies have only measured endocrine markers of these systems using acute stress reactivity paradigms among nontraumatized samples in laboratory settings (but see research on maltreated children; Gordis, Granger, Susman, & Trickett, 2008). Thus, we extended the literature by conducting a preliminary analysis of maternal psychological functioning and children's problem behaviors and their cortisol and sAA reactivity among families that were displaced by Hurricane Katrina and living in a large government relocation camp. The families were assessed two months after the hurricane and were compared to demographically similar, nonexposed control families. Based on previous findings (e.g., Miller et al., 2007), we predicted the hurricane-exposed mothers and their children would show greater symptoms of psychological impairment, and physiological indicators of short-term *and* repeated stress exposure in the form of higher sAA and lower cortisol activity, respectively. Children who exhibit such patterns may be at increased risk for long-term mood and health-related problems (El-Sheikh et al., 2008; Wolf et al., 2008). Further, we expected higher maternal depression to be associated with lower cortisol in their children, and for this relation to be stronger among displaced families than for control families (Fernald et al., 2008).

Methods

Event and Setting

Hurricane Katrina struck the north-central Gulf coast (mostly Louisiana and Mississippi, USA) on August 29, 2005. Structural devastation and displacement was widespread; however, the most populated region affected by the hurricane was New Orleans, due in part to breaches in the levees that protected the city from the surrounding Lake Pontchartrain (Travis, 2005). In addition to the direct loss of life, injury, and structural devastation, hundreds of thousands of people were displaced to government and community shelters across multiple locations throughout the United States. The largest of these camps, located near Baton Rouge, Louisiana, was the site chosen to conduct the present study.

At the time of our data collection, the camp, referred to by the residents and wider community as "Renaissance Village," consisted of approximately 500 travel trailers. Each trailer housed an average of three people (not including infants and young children). The site included a central tent and barracks area, which served as the local post office and cafeteria and where supplies (e.g., clothing) were dispersed. It also included several small laundry houses and a basketball court. Despite the frequent efforts taken to provide the residents with comfortable living conditions, the general mood in the camp at the time of data collection was noticeably low (based on the observations of the first and last authors).

Participants

A convenience sample of 28 children ages 6–10 years (M = 8, SD = 1.5 yrs; 16 females) and their mothers (n = 16; mean age = 34, SD = 8.0 yrs) was recruited from the camp approximately 2 months after the hurricane and 3 weeks after the relocation camp opened (i.e., from October 28 through November 2, 2005). All participants reported having been relocated from the New Orleans region. The control sample consisted of 19 children (mean age = 8, SD = 1.3 yrs; 7 females) and their mothers (n = 12; mean age = 30, SD = 7.6 yrs) recruited from residential neighborhoods in mid-Missouri, USA, who were selected based on parental characteristics (e.g., age, race, socioeconomic status [SES]) matching the Katrina participants (data collected between August 2006 and January 2007).

Comparison of parents' demographic backgrounds confirmed the Katrina and control groups were similar in terms of race (both groups > 93% African American) and SES; mothers did not differ (p's > .10) for years of education (between 11 and 12 years), history of government assistance (e.g., welfare, food stamps; > 67%), or for indicators of wealth. The average yearly income of both samples was between $4,000 and $6,000, with current (post-hurricane) financial assets of less than $200. The child participants from the Katrina and control groups were similar (p's > .31) in age and proportion by sex.

Procedure and Measures

Once written consent and assent were signed by the parents and their children, as outlined by the University of Missouri Institutional Review Board, the mothers completed a survey that consisted of demographic information and items designed to assess psychological wellness. Mothers also completed the Child Behavior Checklist (CBCL/6-18; Achenbach & Rescorla, 2001), which consisted of 118 items designed to measure behavior problems (scored from 0 [*not true*] to 2 [*very true*]). The subscores examined in this study were:

anxious/depressed, withdrawn/depressed, somatic complaints, social problems, thought problems, attention problems, rule-breaking behavior, aggressive behavior, and critical items.

In mothers, depressive symptoms were assessed by the Center for Epidemiologic Studies Depression Scale (Radloff, 1977), which consisted of 20 items scored from 1 (*rarely or less than 1 day a week*) to 4 (*almost always or 5–7 days*; sample α = .90). Anxiety was assessed by the Revised Children's Manifest Anxiety Scale (Reynolds & Richmond, 1978) and consisted of 37 items scored as Yes or No responses (sample α = .92). Global self-esteem was assessed with the Rosenberg Self-Esteem Scale (Rosenberg, 1965) and consisted of 10 items (scored from 1 [*rarely or never*] to 4 [*almost always*]; sample α = .73). Subjective psychological distress was measured with the Impact of Events Scale-Revised (Weiss & Marmar, 1997). The scale consisted of 22 items that measured symptoms of PTSD (e.g., hyperarousal, disassociation, intrusive thoughts, and avoidance behaviors) during the past week; the items were revised to refer specifically to Hurricane Katrina and scored 1 (*rarely or no days during the last week*) to 5 (*almost always or 7 days*); sample α = .96. Completion of the psychological measures and survey items took between 30 and 45 minutes.

Determination of Salivary Biomarkers

Two saliva samples were collected (immediately prior to and subsequent to completion of the survey measures) between the hours of 10:50 a.m. and 6:50 p.m. via a cotton swab version of the Salivette device (Sartstedt, Newton, NC); the samples were collected 60 to 90 minutes apart. Only two saliva samples were collected, due to the impracticality of collecting more samples under field conditions and because they provided a more reliable means of determining cortisol activity than single sample collections (for the implementation of similar techniques, see El-Sheikh et al., 2008). The samples were measured for cortisol by immunoassay and sAA using kinetic reaction assay. Commercially available protocols without modification to the manufacturer's recommendations were used (Salimetrics, State College, PA). Inter- and intra-assay coefficients of variation were less than 10% and 8%, respectively.

Data Analysis

For the missing psychological variables (8%), we created multiple imputed data sets in SAS (SAS Institute, 2004) and used standard Rubin techniques (Rubin, 1987; Schafer, 1997) to conduct the analyses in Mplus, a statistical modeling program (Muthén & Muthén, 1998–2007). The correlations among the two cortisol and the two sAA samples were positive (children's cortisol r = .71, p < .001; mothers' cortisol r = .70, p < .001; children's sAA r = .31, p < .05, mothers' sAA r = .41, p < .05), and thus averaged for subsequent analyses. Missing values for either of the two cortisol or sAA samples (3%) were replaced by the other sample. Children's cortisol levels were negatively related to the amount of time they had been awake prior to time at assessment (children's r = -.49, p < .001; mother' r = -.32, p = .14), but awake time was unrelated to sAA for the children (r = .24, p = .12) or their mothers (r = -.20, p = .35).

Group differences are expressed as effect sizes (*d*'s; mean difference/mean standard deviation). To account for the nested nature of the data (children grouped within families), we used multilevel regression models or hierarchical linear models (HLM) for all analyses that examined differences across the Katrina and control children (Raudenbush & Bryk,

2002). We included sex as a covariate in the multilevel models because previous studies indicate sex differences in cortisol and sAA reactivity to stressors (e.g., Stroud et al., 2009).

Results

Group Differences in Mother–Child Functioning and Salivary Biomarkers

Examination of individual CBCL subscores revealed no significant differences across the Katrina and control children. However, as shown in Table 1, the Katrina children showed higher sAA and lower cortisol levels than controls. These differences were found for participants sampled both earlier and later in the day (split according to mean amount of time awake; *p*'s < .05). The Katrina mothers reported higher symptoms of depression and distress and lower anxiety and self-esteem than the control mothers. The Katrina mothers did not differ in salivary markers of cortisol and sAA activity when time awake was not considered (*p*'s > .10). When time awake was considered, Katrina mothers who had been awake for longer than average and were thus sampled later in the day showed significantly higher sAA than controls, $t(13) = -2.44$, $p < .05$.

Maternal Correlates of Children's Stress Functioning

Bivariate correlations between the maternal variables and children's salivary markers are shown in Table 1. Higher maternal anxiety and higher self-esteem were associated with higher cortisol in children and lower sAA. To examine whether hurricane exposure moderated the relationship between maternal characteristics and children's endocrine activity, we examined a series of HLM equations. For the first set of equations, children's cortisol was entered as the dependent variable for each of maternal depression, anxiety, esteem, and sAA. For these equations, the maternal correlate, hurricane exposure, and the maternal correlate x hurricane exposure interaction terms were entered as predictor variables. The interaction terms for these equations were nonsignificant (*p*'s > .10). For the last equation, children's sAA was entered as the dependent variable, and maternal self-esteem, hurricane exposure, and the self-esteem x exposure interaction terms were entered as predictor variables. The interaction term for this equation was also nonsignificant ($p > .10$), suggesting the relation between maternal psychological functioning and children's endocrine reactivity is not moderated by exposure to the natural disaster.

Discussion

Although displaced children did not demonstrate higher behavioral distress relative to control children, there were substantive (> 1 *SD*) differences in sAA and cortisol levels. Specifically, Katrina children showed higher sAA and lower cortisol levels, suggesting higher SNS reactivity and blunted HPA reactivity in the displaced children. The pattern for these children is consistent with studies of adolescents and adults who have been exposed to acute and chronic stressors, respectively (e.g., Miller et al., 2007; Vigil, Geary, Granger, & Flinn, in press). These findings suggest that under extreme conditions, children may respond to psychosocial stressors with similar neuro-endocrine regulation patterns to adults, although children in more typical circumstances are generally less reactive to stressors. Further, the established severity of the trauma (e.g., homelessness) that was experienced by the hurricane survivors supports the possibility of eventual use of

Table 1

Maternal correlates of children's endocrine activity for hurricane survivors and controls

	Group		Group differences		Bivariate correlations						
	Control	Katrina	*t*	*D*	1	2	3	4	5	6	7
Maternal Depression	2.24 (.37)	2.71 (.74)	−2.55[b]	−.80	—						
Maternal Anxiety	1.69 (.21)	1.31 (.20)	6.20 [b]	1.85	−.41[b]	—					
Maternal Self-Esteem	3.55 (.34)	2.72 (.43)	7.05 [b]	2.14	−.46[b]	.69[b]	—				
Maternal Distress	2.56 (.83)	3.17 (.77)	−2.59[b]	−.76	.75[b]	−.34[a]	−.45[b]	—			
Mothers' Cortisol	.22 (.17)	.20 (.13)	.42	.13	.34[a]	−.30[a]	−.04	.48[b]	—		
Mothers' Amylase	39.63 (41.33)	56.14 (30.86)	−1.57	−.45	.47[b]	−.18	−.10	.12	.22	—	
Children's Cortisol	.21 (.14)	.10 (.04)	−3.97 [b, c]	1.07	−.28	.32[a]	.40[b]	−.13	.16	−.40[b]	
Children's Amylase	26.32 (12.78)	55.41 (24.17)	4.54 [b, c]	−1.50	.06	−.28	−.33[a]	.02	−.15	.18	−.21

Note. Group values indicate variable means; standard deviations are in parentheses. Salivary alpha-amylase is measured in U/mL, and cortisol is measured in ug/dl. OLS examined relationships that included only maternal-level variables or only child-level variables. HLM examined relationships that included child and maternal-level variables. [a]$p < .05$, [b]$p < .01$ [c] HLM *z* values.

practical, noninvasive salivary cortisol and sAA measurements to assess posttraumatic HPA and SNS functioning.

The Katrina mothers reported poorer psychological well-being than control mothers, including increased symptoms of depression and distress and higher sAA levels. The Katrina mothers also reported lower anxiety than the control mothers, which is consistent with the hypothesis that prolonged or recurrent stress exposure is associated with deactivation (e.g., habituation) of certain elements of stress processing. Maternal symptoms of low mood (i.e., low self-esteem) were associated with children's cortisol activity. The findings are therefore consistent with previous studies showing that maternal depression is associated with blunted HPA activity in children of families living under low resource conditions (e.g., Fernald et al., 2008).

The correlations between maternal anxiety and self-esteem and children's cortisol and sAA levels could be due to several factors, including: (a) similar mechanisms for, and patterns of, regulating stress exposure and shared experiences (e.g., hurricane exposure, financial hardships, and access to social support) in children and adults; (b) hereditary factors that result in dyadic similarities in stress regulation; (c) basic learning (e.g., via social modeling, operant/classical conditioning) of stress behaviors and adrenocortical rhythms in children and their mothers; and (d) more direct causality between maternal psychological functioning (e.g., low mood) and children's stress reactivity (e.g., Hibel, Granger, Blair, Cox, & The Family Life Project Key Investigators, in press). Our follow-up analyses using HLM did not find a moderation effect of hurricane exposure on the link between children's endocrine activity and maternal psychological functioning. This finding is consistent with the possibility that mother–child psycho-endocrine synchrony may exist irrespective of acute (shared) trauma experiences, and is more generally related to living in low income communities. Another possibility is that the lack of parent–child intimacy that can result from maternal depression may heighten or reactivate children's endocrine stress reactions, independent of exposure to Hurricane Katrina. The lack of moderation effects might also be due to the small sample sizes.

Additional biological factors, such as sex and age of children and their caregivers, are also associated with psychobiological stress responses (e.g., Swain, in press; Vigil, in press). Sex- and age-typical distress patterns suggest that differential reactivity may be characterized by normative developmental processes. Emotional and endocrine stress responses are moderated by real or imagined interaction with other people (e.g., interpersonal evaluations, comforting, and victimization experiences), but not nonsocial cognitive demands (e.g., adding tasks; Dickerson & Kemeny, 2004; Gordis et al., 2008; Holt-Lunstad, Birmingham, & Light, 2008; Stroud et al., 2009; Sugimoto, Kanai, & Shoji, 2009), which has led some theorists to speculate that stress reactions may ultimately (i.e., evolutionarily) operate in part to serve social, remedial (e.g., solicitous) functions (e.g., Vigil, in press). The possible confluence of hereditary and learning mechanisms makes it difficult, however, to determine when children may begin to regulate psychosocial stressors similar to adults.

Interpretation of the results of the current study need to be made within the limitations that accompany this type of field research. Although the window of time used to collect the saliva samples was reasonable, the use of practical saliva collection techniques that enable researchers to track diurnal fluctuations in hormonal activity under field conditions is needed. This research is particularly complicated when working with transient families and individuals with low education, as was the case in the current study. Likewise, the sample sizes were small, which limited our power to detect some findings (e.g., hurricane-related psychological functioning and mother–child synchronization). However, for the

majority of nonsignificant effects we observed quite small effect sizes, indicating that while differences may exist, they do not appear to be statistically large. Finally, although the hurricane-affected and control groups were demographically similar in terms of race and socio-economic experiences (i.e., low-income, largely government housing recipients), it is possible that our findings were affected by regional experiences of the two groups. Future research will benefit from longitudinal investigations of psychobiological stress recovery of children and families that have experienced severe forms of trauma such as those caused by natural disasters.

Despite these limitations, the current findings add to the scientific literature in several important ways. Children who were affected by pervasive stressors (i.e., causing severe social and material losses) show psychobiological distress patterns similar to adults exposed to repeated stressors. These reactions are correlated with certain aspects of maternal functioning that may alter the ease with which children recover from such events. Maternal symptoms of low mood (e.g., depression) are associated with child neglect, which may perpetuate the perception of lack of reliable social support, thereby perpetuating psychoendocrine stress responses in children. Further investigations should focus on how early childhood trauma affects normative ontological processes and the discrete learning mechanisms (e.g., social modeling, shared experiences) that contribute to intergenerational synchrony of stress regulation in children and their parents.

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