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# Association Between Maternal Stress And Parental Responses To Child Development As Measured By Hpa Axis Biomarkers

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# *Association between Maternal Stress and Parental Responses to Child Development as Measured by HPA Axis Biomarkers*

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## Abstract

***Background.*** This study aims to assess the association between perceived stress and maternal responses to child developmental behavior, utilizing hypothalamic-pituitary-adrenal (HPA) axis biomarkers to measure maternal stress: cortisol, cortisone, DHEA and testosterone.

***Methods.*** This study was conducted using data collected from a randomly selected sample of mother-infant dyads from the Bachpan cohort. This analysis focuses on data collected at baseline and 36 months postpartum. Of the women who screened positive for depressive symptoms at baseline (n=889) and provided responses to the 36-month questionnaire assessing perceived stress, a sub-sample (n=90) provided hair cortisol concentration (HCC) samples and completed a questionnaire concerning parental responses to child misbehavior. A series of bivariate correlations and regression statistics adjusting for the education, socioeconomic status, age and sample clustering were used to assess the relationship between stress and response to child misbehavior.

***Results.*** Mothers utilized negotiation and reason most frequently per week, followed by diversion, scolding, and yelling in response to child misbehavior. Testosterone levels exhibited significantly strong associations with spanking ($\beta = -0.989,\ p < 0.01$) as well as shaming ($\beta = 0.544,\ p < 0.05$) in response to misbehavior. Other associations include cortisol and shaming ($\beta = 0.038,\ p < 0.10$); cortisone and slapping child ($\beta = -0.017,\ p < 0.05$); DHEA and timeouts($\beta = 0.035,\ p < 0.01$).

***Discussion.*** Maternal perception of stress significantly impacts their methods of parenting tactics used in response to child misbehavior. The correlation between parental responses increases the likelihood of engaging in other associated responsive behaviors.

***Conclusion.*** This assessment found biomarkers to be significantly correlated with the expression of parenting tactics. Public health interventions targeting reduction of maternal parenting stress are recommended to lessen the impact of biopsychosocial associations with negative parenting skills in

order to construct supportive developmental environments and improve child health outcomes.

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**Introduction**

Stress response among healthy individuals innately activate biochemical mechanisms that assist with immediate coping and survival. This response is composed of three phases: reaction, recovery and adaptation (Staufenbiel et al., 2012). Dysregulation of this stress response system, such that recovery and adaptation are not achievable under conditions of chronic exposure to stress, results in progressive tissue damage over time thereby disrupting memory storage and problem-solving mechanisms (Oitzel et al., 2009). Chronic stress is defined here as consistent exposure to environmental and social stressors that create overwhelming sensations of pressure over a period of time. Measures of chronic stress are reflected in hair cortisol concentrations (HCC) given the individual has engaged in persistent stress responses. Prior studies have hypothesized that individuals who perceive chronic stress experience higher levels of HCC in comparison to those who are not exposed to periods of stress (Staufenbiel et al., 2012); and subsequently, experience a dysregulated adaptive stress response phase which may alter their reactive behavioral patterns and increase the risk of developing affective disorders (Oitzl et al., 2009). Given the relationship between chronic stress and poor mental health, studies indicate that environmental stressors placed on the maternal figure impact child behavior (Berens et al., 2017). For example, postpartum depression is highlighted as being the most common complication of childbirth and affecting nearly 10-15% of women (Grace et al., 2003) with an overall maternal depression prevalence rate of about 6-17% for women (Callender et al., 2012). Studies indicate that depressed mothers experience heightened cortisol expression through hypothalamic-pituitary-adrenal (HPA) axis activity (Oitzl et al., 2009), disrupted supportive care for their infant (Lupien et al., 2009), and significantly engaged in negative parenting behaviors towards their child that were shown to be less effective (Dougherty et a., 2013, Cuijpers et al., 2015, Heath et al., 2015, and Sieberg et al., 2011). Chronic stress exposure

limits mothers' perceived self-efficacy, thereby negatively impacting the developmental outcomes of their children through negative rearing habits.

Social environments of developing infants are largely constituted by relationships with their mothers and their specific upbringings. The context in which the mother was raised impacts parenting behaviors projected onto the rearing of their infants which in turn greatly influences developmental health trajectory of that child. The mother's behavioral resources stem from her developmental history where personal exposure to adversity and toxic stress shape her idea of appropriate and responsive parenting tactics. The status of maternal mental health influences the developmental environment of the child such that poor mental health, including depression, has been linked consistently with disengaged parenting styles (Husain et al., 2021). Previous research studying the connection between maternal mental health and exposure to adversity via the Adverse Childhood Experience (ACE) questionnaire found ACEs to be related to depressive symptoms at both prenatal and postpartum stages of pregnancy. The Bachpan cohort estimates the prevalence of postpartum depression in Pakistan to be at 28% to 36% where 58% reported exposure to one ACE and 7% experienced at least four, with most common experiences including physical and emotional abuse as well as neglect (LeMasters et al., 2021). Utilization of the ACE questionnaire was culturally modified to account for exposure to collective violence and witnessing community violence, acts which are more common within LMICs. Given the impact of maternal upbringing on child development, children exposed to highly reactive temperaments may be more susceptible to detrimental effects of their parenting environment (Husain et al., 2021). Mothers who experience chronic stressors may face greater difficulty in managing their infant's behaviors (Heath et al., 2015), subsequently reducing the quality of maternal interaction. Early infancy is a critical period for brain development such that environmental stressors experienced by mothers may also interfere with the infant's neurodevelopment. In a study analyzing the biological embodiment of childhood adversity, Berens et al. (2017) found that children who were exposed to low-quality care

by maternal caregivers experiencing mental health concerns globally exhibited decreased cortical thickness. To prevent negative health outcomes associated with exposure to maladaptive maternal responses to stress among infants, it is necessary to mediate perceived stress and cortisol production of supportive caregivers to serve as a buffer to exposure to chronic stress in early infancy (Gerdes et al., 2007, Kamin et al., 2016, Lewinsohn et al., 2005, and Vreeland et al., 2019).

Chronic stress among maternal caregivers was obtained using analysis of HPA axis biomarkers including cortisol, cortisone, dehydroepiandrosterone (DHEA) and testosterone. The HPA axis is the physiological stress response system responsible for the regulation of response, recovery and adaptation to perceived stress. This response system is enabled through stimulation of adrenal release of aforementioned hormones (Hagaman et al., 2020, Lupien et al., 2009, and Steudte et al., 2010). Dysregulation of the HPA system under prolonged periods of stress can lead to alterations in baseline levels and sensitivity of produced hormones (Kamin et al., 2016). In response to stress, an HPA hormone and neurotransmitter, corticotropin-releasing factor (CRF) stimulates the secretion of glucocorticoids including cortisol and cortisone in humans through a series of feedforward mechanisms. (Berens et al., 2017 and Kamin et al., 2016). The release of cortisol and cortisone serve to mediate adaptive responses to environmental stressors for a distinct period of time; however, in cases of exposure to chronic stress, these hormones disrupt regular immune system functioning and the central nervous system (Knight et al., 2017). It is important to note that the levels of cortisol and cortisone circulating in the system are substantially elevated during pregnancy and present higher levels as compared to women who are not pregnant, particularly within the first trimester of pregnancy (Musana et al., 2020). With respect to DHEA, further research is needed to examine its response to stress in infancy and early development. Current research suggests DHEA is negatively correlated with chronic exposure to stress (Qiao et al., 2017), reduces the physiological impacts of cortisol (Hagaman et al., 2020), and alters physiology and function at the cellular level (Kamin et al., 2016). Lastly, testosterone has shown to increase cortisol

concentrations in anticipation of acute stress; however, research studying the relationship between testosterone and mental health disorders or the exposure to ongoing stressors presents U-shaped correspondence where both high and low testosterone levels are associated with psychological concerns (Knight et al., 2017). Further research regarding the relationship between testosterone in response to ongoing stressors is still needed.

Effects of exposure to maternal stress during early childhood development has shown to be associated with the expression of greater behavioral health concerns, lower IQ levels, and higher cortisol levels in their adulthood (Kamin et al., 2016). The impact of stress on mothers and factors associated with mental health disorders such as poverty and poor social support, subsequently influence their responses to child behavior and lead to maladaptive developmental outcomes. This study focuses on a subsample of women enrolled in the Bachpan longitudinal cohort study situated in Pakistan where the rate of depression during pregnancy is estimated to be between 25% to 48% and 28% to 36% during the postnatal period (Husain et al., 2011). This study aims to assess the mediation between maternal stress and maternal responses to child developmental behavior, utilizing hypothalamic-pituitary-adrenal (HPA) axis biomarkers to measure maternal perceived stress: cortisol, cortisone, DHEA and testosterone.

## Methods

*Sample.*

This analysis utilizes data collected from a randomly selected sample of mother-infant dyads (*n=104*) from a study population within the Bachpan cohort, a longitudinal birth cohort of mother-child dyads in rural villages of Pakistan (Turner et al., 2016). This sample originally stems from a perinatal depression cluster randomized controlled trial (cRCT) of which mothers and their children (*n=1,154*) were followed at the start of their final trimester of pregnancy. Full details of the study's procedures are described elsewhere (Turner et al., 2016). Women who screened positive for depression within the study area's 40 village clusters were invited to participate. Each participating

woman with depression was matched with a non-depressed woman from the same village. The original study collected data at baseline (beginning of the final trimester of pregnancy) as well as at five additional time points (3, 6, 12, 24, and 36 months). At the 36 month time point, participating women were asked to complete questionnaires concerning symptoms of anxiety, perceived stress, and exposure to adverse childhood experiences (ACEs). This analysis focuses on data collected at two time points: baseline and 36 months postpartum. Of all women initially included at baseline who screened positive for depression, *n=889* provided responses to the 36-month questionnaire assessing perceived stress level and history of exposure to ACEs. A sub-sample of mothers and infants were then approached for HPA- axis biomarker measures consisting of hair cortisol concentrations (HCC). Finally, *n=90* women provided both hair cortisol samples and mental health questionnaire responses.

*Measures.*

**Behavioral Report.** Baseline parental child-rearing responses were obtained using the Parental Response to Child Misbehavior (PRCM) Scale (Holden et al, 1992). Child misbehavior is defined as misconduct or non-productive habits such as being disruptive or hostile. Participants completed a questionnaire assessing the frequency of which they used each of the 13 different parenting responses to misbehavior over the duration of one week. Such responses included diversion, negotiation, and withdrawing privileges from their child during periods of misbehavior. Response frequency choices are ranked using a Likert-type scale to report average frequency of response type in a week: 1=Never, 2=Rarely, 3=Once or twice, 4-A few times a week, and 5=Everyday or more than once per day.

**HPA Axis Biomarkers.** Hypothalamus-pituitary-adrenal (HPA) axis biomarkers indicate one biological measure of exposure to stress. These outcomes of interest were derived from 1cm segments of human hair, reliably reflecting HPA-axis hormone function within the last thirty days,

and analyzed as a single segment. (Hagaman et al., 2020). In contrast to alternative methods of hormone extraction such as saliva, blood serum, and urine which indicate acute and variable measures of HPA-axis hormones, hair-derived hormone measures provide reliable retrospective values of HPA-axis activity over a longer period of time (Khoury et al., 2019; Qiao et al., 2017). Hair-derived HPA-axis hormones under analysis include cortisol, cortisone, DHEA and testosterone.

**Perceived Stress.** Measure of maternal perceived stress was obtained using the Perceived Stress Scale (PSS), a widely used psychological 10-item assessment tool that has been proven valid for a variety of populations (Qiao et al., 2017). The PSS is used to measure the degree to which a person perceives their life events as being uncontrollable, overwhelming, or overall stressful within the last thirty days (Musana et al., 2020). Each item on the scale is rated using a 5-point system, ranging from "almost never" to "almost always" where the total possible range extends from 0 to 40 with higher scores correlated with higher levels of perceived stress. A total PSS score is calculated by summing all scale items: scores 0 to 13 indicate low stress; sores 14 to 26 indicate moderate stress; and scores 27 to 40 depict high stress.

**Covariates.** Socioeconomic status of participating women was assessed using a composite measure of household assets. This value was obtained using a polychoric correlation principal component analysis of baseline asset data. Age, education, and number of children were assessed.

*Statistical Analysis.*

A Chi-Square Test of Independence was implemented to determine the association between categorical variables in the subsample population of women. The significance of association is determined by a p-value $< 0.05$. An ANOVA was used to assess mean weights and age among the women and number of children birthed. A series of linear regression statistics were used to assess the relationship between multiple variables presented. A final reduced model adjusted for the study arm, a 3-level variable used to differentiate between women and their level of depression and

enrollment in the study, as well as socioeconomic status, education, and sample clustering. Bivariate correlations were also used to assess the association between the study variables including various parental responses and biomarkers.

*Ethical Considerations.*

The study was approved by the institutional review board (IRB) at Duke University. Approval by the IRB at Yale School of Public Health was not required.

**Results**

Baseline and 36-month postnatal demographics of maternal participants ($n = 90$) are included in Table 1. The women included in the final analysis were in their third trimester of pregnancy at baseline, had a mean weight of $61.4 \pm 8.2\ kgs$ and were on average $26.7\ years$of age with a standard deviation of $4.8\ years$. On average, participants reported $6.8 \pm 3.9\ years$ of education, with grades ranging from primary to higher secondary courses passed. Women included in the study had approximately 2 to 3 children they were directly caring for in their home. Postnatal interviews conducted at 36 months indicated an average Cohen's perceived stress score (PSS) of $13.9 \pm 9.1$, indicating low to moderate stress among mothers. Mean scores of the Parental Response to Child Misbehavior (PRCM) scale, $3 \pm 0.6$, indicate that mothers employ PRCM responses at least once or more per day on average. Additionally, objective measures of maternal stress may be interpreted via identified HPA axis biomarkers. Refer to Table 2 for full mean responses implemented by mothers as categorized by parenting strategy .

A full breakdown of prevalence for each item on the Parental Response Child Misbehavior (PRCM) scale is provided in Table 2. Maternal participants completed the PRCM scale, a 13-item Likert-type questionnaire, during a 36-month postnatal interview to assess parenting techniques in response to their children's misbehavior. The range of responses varied from 1 "Never" up to 5 "Everyday or more than once per day" on the scale. Mothers reported their frequency of each

response item over the course of one week. Techniques included items such as utilizing reason, scolding, expressing disappointment in their child's actions, and implementing corporal punishment such as spanking and slapping. Mean scores among participants indicated they utilized all responses at least once or twice during the week,$PRCM = 3 \pm 0.6$; however, itemized mean scores indicate mothers often negotiated with their child ($4.9 \pm 0.4$) and utilized reason ( $4.4 \pm 1.2$) a few times per week up to everyday or more than once per day in response to the child's behavior. The prevalence of harsh parenting practices among mothers in the study included spanking their child with their hand or an object ($2.9 \pm 1.4$), suggesting moms used this parenting tactic about once per week with a range of never to everyday or more than once per day; yelling in anger in response to misbehavior ($3.2 \pm 1.3$) about once or twice per week, with a range from never to everyday; and lastly, slapping their child rarely to once or twice per week on the child's face or hand ($2.5 \pm 1.3$), with a range from never to everyday.

Bivariate correlations between multiple exposure and outcome variables are presented in Table 3. Full results of Table 3 present strong, moderate, and low associations between biomarkers and various parental responses to child misbehavior among mothers perceiving low to moderate levels of stress. Several low but significant associations are found between two biomarkers: DHEA and testosterone. DHEA levels were significantly correlated with implementing timeouts (0.268, $p<0.01$) and withdrawing privileges (0.230, $p<0.05$) in response to child misbehavior. Testosterone levels were significantly correlated with scolding (-0.252, $p<0.05$) and shaming (0.211, $p<0.10$) in response to a child misbehaving. No significant associations were found between cortisol or cortisone levels and parental responses to misbehavior; however, strong significant associations are found between cortisol and cortisone levels (0.814, $p<0.001$). Although there lacks further evidence associating biomarkers with parental responses, various parenting tactics were correlated with one another: scolding and threatening (0.495, $p<0.001$); scolding and spanking (0.543, $p<0.001$); and choosing to slap and spank child in response to misbehavior (0.528, $p<0.010$). There are also

significant associations found between yelling and multiple other responses such as spanking (9.493, p<0.001), scolding (0.484, p<0.001), and verbally threatening their child (0.627, p<0.001). Other moderate, significant associations are found between utilizing reasoning and diversion tactics (0.353, p<0.001) as well as with negotiation (0.400, p<0.001).

Lastly, Table 4 depicts full and reduced linear regression models of maternal responses to child misbehavior collected utilizing the PRCM questionnaire associated with HPA axis biomarkers: cortisol, cortisone, DHEA, and testosterone. The full model accounts for the study arm: depressed mothers enrolled in the intervention, depressed controls, and non-depressed mothers enrolled in the intervention. The full model ($N = 90$) shows the overall degree of association between the predictor and outcome variables via beta coefficient values, presented in Table 4, along with robust standard error in parentheses. The beta coefficient is the degree of change in the outcome variable for every 1-unit of change in the predictor variable where positive coefficient values indicate positive increases for outcome variables by the absolute beta value and negative coefficient values indicate an inverse relationship between predictor and outcome variables. The reduced model controls for several characteristic confounders including study arm, clustered sampling, socioeconomic status, age, and education. The reduced model indicates that there exist significant associations between the biomarkers and maternal responses to child's misbehavior. Data shows that cortisol levels are significantly associated with ignoring($\beta = 0.017,\ p < 0.10$), shaming ( $\beta = 0.038,\ p < 0.10$), and slapping their child on the face ($\beta = 0.033,\ p < 0.10$) in response to misbehavior. The association between cortisone and various parenting tactics indicated a significant and inverse correlation with mothers implementing shame ($\beta = -0.015,\ p < 0.10$) and slapping their child's face($\beta = -0.017,\ p < 0.05$) in response to child misbehavior. Additionally, DHEA levels were found to be significantly, positively associated with utilizing timeouts ($\beta = 0.035,\ p < 0.01$) and withdrawing privileges ($\beta = 0.031,\ p < 0.05$) to redirect child behavior. Lastly, testosterone levels indicated significant associations with spanking their child

($\beta = -0.989,\ p < 0.01$), scolding their child($\beta = -0.695,\ p < 0.10$), and shaming ($\beta = 0.544,\ p < 0.05$) in response to misbehavior.

**Discussion**

The manner in which mothers respond to their child's development is in part determined by their personal development and environmental exposures. This study asked mothers to respond to a questionnaire in order to assess the association between a selection of parenting styles and their perception of stress as measured by biochemical expression of biomarkers collected through hair cortisol concentrations. The completion of bivariate correlations and reduced linear regression models indicate significant associations between these study variables.

Maternal perception of stress significantly impacts their employed methods of parenting tactics in response to misbehavior of children. Their chosen response to misbehavior is associated with other related methods of parental response thereby increasing the likelihood of engaging in other correlated responsive behaviors. For example, given the strong and positive correlation between scolding and other factors such as spanking and threatening, mothers who utilize scolding as a way of responding to their child's disruptive behavior may also then employ spanking and verbal threats. Behaviors associated with one another may escalate to amplify other negative or less constructive parental responses to child misbehavior whereas mothers who employ reasoning may be less likely to express disappointment in their child, threaten, or yell at them thereby engaging in more constructive parenting efforts which have shown to yield greater positive environments and healthy behavioral development.

The prevalence of perceived stress in this population ranged from low to moderate stress (4.8-23.0), with the measure of stress further reflected by low to normal ranges of biomarkers released during stress responses: cortisol, cortisone, DHEA, and testosterone. Given chronic exposure to environmental stressors, we expect to see increased levels of baseline biomarkers due

to dysregulation of the adaptive stress response phase. Despite the absence of biomarkers indicating high levels of continuous stress exposure, this study did find meaningful correlations between biomarkers and parenting techniques that align with other research findings. In agreement with external findings, cortisol and cortisone levels increased in response to stress and were correlated with negative rearing tactics such as ignoring, shaming, and even slapping their child in response to misbehavior. Other research suggests DHEA may be negatively correlated with stress such that it reduces physiological impacts of cortisol but that was out of this study's focus. Additionally, research has indicated that testosterone levels present U-shaped responses to stress. Low levels of testosterone in this study were correlated with exposure to low and moderate stress values, presenting with aggressive rearing behaviors such as spanking, scolding, and shaming.

This study expected to find chronic exposure to stress to be correlated with more aggressive parenting behaviors; however, increased exposure to stress did not produce significantly greater cortisol expression nor more aggressive parenting tactics. Surprisingly, moms included in the study largely implemented engaging tactics such as negotiation, reason as well as diversion in response to child misbehavior. Exposure to stress may not have been severe enough with this population to produce any observable impact of exposure to moderate to high levels of stress on maladaptive parenting behaviors.

This study presents limitations with regards to cross-cultural implications of findings and the final sample size of participants included in the analysis. This study focused specifically on mothers situated within a rural village in Pakistan, presenting with baseline rates of depression among women and stress exposures, such as natural disaster, war and terrorism, as well as witnessing or experiencing traumatic situations, may be more specific to the region and thus may not be representative of the impact of stressors present in different cultural settings. Additionally, the final sub-sample of women included in the analysis (n=90) may not be entirely representative of

the original cohort (n=889) given the substantially smaller proportion of women who were able to complete the final questionnaire in addition to the baseline demographic information.

**Conclusion**

Given the influence of chronic exposure to environmental stressors on child development and behavioral outcomes, this study sought to assess the association between mothers' perception of stress as measured by HPA axis biomarkers and various parental responses to child misbehavior. Several studies have already linked chronic stress and heightened HPA axis activity with disengaged parenting styles and disruptive supportive care towards their child. This assessment found stress response biomarkers to be significantly correlated with the presentation of specific parenting tactics aforementioned above. Recognizing the impact of exposure to chronic stress on child rearing habits, it is necessary to mediate perceived stress and the production of HPA axis biomarkers among mothers during the early infancy period of their children. Public health interventions targeting potential risk factors for persistent symptoms of stress and maternal parenting groups targeting stress reduction are recommended to increase maternal self-efficacy, construct supportive developmental environments, and thereby improve child health outcomes.

## Tables

Table 1. Demographics of Maternal Participants in Bachpan Cohort Study

| Descriptor | | N =90 |
|---|---|---|
| Baseline Characteristics | Mean | SD |
| Age (Years) | 26.7 | 4.8 |
| Education (Years) | 6.8 | 3.9 |
| Number of Children | 2.8 | 2.7 |
| Maternal Weight (kg) | 61.4 | 8.2 |
| Socioeconomic Status Quintiles | n | % |
| Lowest | 18 | 19.9 |
| Lower Middle | 18 | 19.9 |
| Middle | 18 | 19.5 |
| Upper Middle | 19 | 20.6 |
| Highest | 17 | 20.0 |
| 36-month Postpartum Characteristics | Mean (Min, Max) | SD |
| HPA Axis Biomarkers (pg/mg) | | |
| Cortisol | 22.8 (4.4, 62.6) | 11.2 |
| Cortisone | 50.0 (8.6, 153.9) | 28.9 |
| DHEA | 5.4 (0.2, 58.9) | 8.3 |
| Testosterone | 0.2 (0.0, 2.0) | 0.4 |
| PSS Total Score | 13.9 (0.0, 36.0) | 9.1 |

Table 1 provides demographic characteristics for women included in the study at the baseline of their third trimester of pregnancy and at 36-months postpartum, n=90 participants.

Abbreviations: *PSS, Perceived Stress Scale; SD, standard deviation*

Table 2. Parental Response to Child Misbehavior (PRCM) Scale

| | | PSS, N = 90 |
|---|---|---|
| Description of Response | Mean (Min, Max) | SD |
| Overall Response to Child Misbehavior | 3.0 (1.0, 5.0) | 0.6 |
| Reason | 4.4 (1.0, 5.0) | 1.2 |
| Diversion | 3.9 (1.0, 5.0) | 1.5 |
| Negotiate | 4.9 (2.0, 5.0) | 0.4 |
| Scold | 3.6 (1.0, 5.0) | 1.3 |
| Express Disappointment | 1.9 (1.0, 5.0) | 0.9 |
| Threaten | 2.6 (1.0, 5.0) | 1.4 |
| Time Out | 1.9 (1.0, 5.0) | 1.4 |
| Spank with hand or object | 2.9 (1.0, 5.0) | 1.3 |
| Ignore | 2.1 (1.0, 4.0) | 1.0 |
| Withdraw Privileges | 2.1 (1.0, 5.0) | 1.2 |
| Shame | 2.0 (1.0, 5.0) | 1.0 |
| Yell in Anger | 3.2 (1.0, 5.0) | 1.3 |
| Slap on face or hand | 2.5 (1.0, 5.0) | 1.3 |

Table 2 is a 13-item Likert-type questionnaire designed to determine parental techniques implemented in response to their children's misbehaviors. Mothers report the number of times they use one of the listed responses to child misbehavior over the course of one week. Range measured as 1=Never, 2=Rarely, 3=Once or twice, 4-A few times a week, and 5=Everyday or more than once per day.

Table 3. Bivariate correlations between study variables

| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Cortisol | 1.000 | | | | | | | | | | | | | | | | |
| (2) Cortisone | 0.814*** | 1.000 | | | | | | | | | | | | | | | |
| (3) DHEA | -0.068 | -0.074 | 1.000 | | | | | | | | | | | | | | |
| (4) Testosterone | 0.054 | -0.095 | 0.051 | 1.000 | | | | | | | | | | | | | |
| (5) Reason | 0.075 | 0.016 | 0.013 | -0.080 | 1.000 | | | | | | | | | | | | |
| (6) Diversion | -0.058 | -0.032 | -0.016 | -0.082 | 0.353*** | 1.000 | | | | | | | | | | | |
| (7) Negotiate | 0.106 | 0.101 | 0.014 | -0.087 | 0.400*** | 0.153*** | 1.000 | | | | | | | | | | |
| (8) Scold | 0.031 | 0.046 | 0.041 | -0.252** | -0.015 | 0.276*** | 0.069 | 1.000 | | | | | | | | | |
| (9) Express Disappointment | 0.015 | 0.026 | -0.025 | 0.005 | -0.247*** | -0.028 | -0.246*** | 0.204 | 1.000 | | | | | | | | |
| (10) Threaten | -0.067 | -0.018 | -0.018 | -0.109 | -0.284*** | 0.044 | -0.153 | 0.495*** | 0.414 | 1.000 | | | | | | | |
| (11) Timeout | -0.023 | -0.036 | 0.268** | 0.048 | -0.228*** | 0.053 | -0.219*** | 0.243 | 0.448 | 0.419 | 1.000 | | | | | | |
| (12) Spank | -0.040 | -0.088 | 0.019 | -0.145 | -0.016 | 0.265*** | -0.001 | 0.543*** | 0.230 | 0.413 | 0.274 | 1.000 | | | | | |
| (13 )Ignore | 0.191 | 0.135 | 0.107 | 0.002 | 0.044 | 0.044 | -0.089 | 0.180 | 0.249 | 0.315 | 0.311 | 0.163 | 1.000 | | | | |
| (14) Withdraw Privileges | 0.190 | 0.161 | 0.230* | 0.093 | -0.088 | 0.046 | -0.159 | 0.203 | 0.355 | 0.336 | 0.432 | 0.261 | 0.335 | 1.000 | | | |
| (15) Shame | 0.071 | -0.111 | 0.124 | 0.211* | -0.079 | 0.143 | -0.159 | 0.297 | 0.364 | 0.393 | 0.365 | 0.359 | 0.342 | 0.378 | 1.000 | | |
| (16) Yell | -0.118 | -0.137 | 0.064 | -0.028 | -0.227*** | 0.034 | -0.102 | 0.484*** | 0.359 | 0.627*** | 0.343 | 0.493*** | 0.220 | 0.320 | 0.445 | 1.000 | |
| (17) Slap | -0.041 | -0.152 | 0.108 | 0.001 | -0.091 | 0.090 | -0.076 | 0.326 | 0.231 | 0.294 | 0.259 | 0.528*** | 0.094 | 0.289 | 0.332 | 0.432 | 1.000 |

Table 3 depicts bivariate correlations between the parental response variables and biomarkers. Coefficient values between $\pm$ 0. 2 *to* 0. 5indicate low correlations, values between $\pm$ 0. 5 *to* 1. 0indicate strong correlation, and coefficient values near $\pm$ 1. 0 indicating perfect correlation.

*Notes:* p<.10 *p < .05, **p<.01, ***p<.001

Table 4. Linear regression model of factors associated with maternal responses to child behavior among mothers with perceived stress as measured by HPA axis biomarkers

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Biomarkers* | Full Model (N=90) | | | | | | | | | | | | |
| Cortisol | 0.023 (0.020) | -0.007 (0.025) | 0.004 (0.008) | 0.011 (0.021) | 0.000 (0.016) | -0.014 (0.024) | 0.005 (0.018) | 0.020 (0.023) | 0.023 (0.016) | 0.017 (0.019) | 0.042 (0.016) | 0.002 (0.022) | 0.034 (0.021) |
| Cortisone | -0.007 (0.008) | 0.000 (0.000) | 0.000 (0.003) | -0.003 (0.008) | 0.000 (0.006) | 0.003 (0.009) | -0.003 (0.007) | -0.011 (0.009) | -0.002 (0.006) | 0.002 (0.007) | -0.017 (0.006) | -0.007 (0.008) | -0.018 (0.008) |
| DHEA | 0.003 (0.015) | -0.004 (.019) | 0.002 (0.001) | 0.008 (0.016) | -0.004 (0.012) | -0.004 (0.018) | 0.033 (0.014) | 0.003 (0.017) | 0.014 (0.013) | 0.032 (0.014) | 0.012 (0.012) | 0.007 (0.017) | 0.014 (0.016) |
| Testosterone | -0.364 (0.367) | -0.320 (0.462) | -0.115 (0.137) | -0.945 (0.387)* | 0.029 (0.292) | -0.375 (0.439) | 0.093 (0.322) | -0.663 (0.412) | -0.068 (0.300) | 0.251 (0.342) | 0.396 (0.292) | -0.160 (0.395) | -0.196 (0.379) |
| *Biomarkers* | Reduced Model (N=90) | | | | | | | | | | | | |
| Cortisol | 0.020 (0.021) | -0.004 (0.026) | 0.005 (0.008) | 0.009 (0.021) | 0.003 (0.017) | -0.012 (0.025) | 0.014 (0.018) | 0.019 (0.023) | 0.024* (0.017) | 0.014 (0.019) | 0.038* (0.016) | 0.004 (0.022) | 0.033* (0.022) |
| Cortisone | -0.008 (0.008) | -0.001 (0.010) | 0.000 (0.003) | -0.001 (0.008) | 0.000 (0.006) | 0.002 (0.010) | -0.005 (0.007) | -0.010 (0.009) | -0.003 (0.007) | 0.002 (0.007) | -0.015* (0.006) | -0.007 (0.009) | -0.017** (0.008) |
| DHEA | 0.000 (0.016) | -0.002 (0.020) | 0.003 (0.006) | 0.012 (0.016) | -0.004 (0.013) | -0.003 (0.019) | 0.035*** (0.014) | 0.007 (0.018) | 0.013 (0.013) | 0.031** (0.015) | 0.012 (0.012) | 0.007 (0.017) | 0.014 (0.016) |
| Testosterone | -0.568 (0.373) | -0.349 (0.484) | -0.116 (0.142) | -0.989 *** (0.397) | 0.058 (0.305) | -0.452 (0.458) | 0.054 (0.327) | -0.695* (0.426) | -0.010 (0.313) | 0.238 (0.356) | 0.544** (0.295) | -0.092 (0.412) | -0.187 (0.397) |

Table 4 depicts variance for maternal responses to child behavior associated with HPA axis biomarkers via linear regression models. Full model controls for study arm among maternal participants with perceived stress. Reduced model controls for study arm, sample clustering, age, education, and socioeconomic status among participants in the study, (N=90). Beta values are presented along with robust standard error in parentheses.

*Notes:* *p<.10,**p < .05, ***p<.01, ****p<.001
*PRCM Responses:* (1) Reason; (2) Diversion; (3) Negotiate; (4) Scold; (5) Express Disappointment; (6) Threaten; (7) TIme Out; (8) Spanking with Hand or Object; (9) Ignore; (10) Withdraw Privileges; (11) Shame; (12) Yell in Anger; (13) Slap on face

*Abbreviations:*
PRCM - Parental Responses to Child Misbehavior

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