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An assessment of hair cortisol among postpartum Brazilian mothers and infants from a high-risk community in São Paulo: Intra-individual stability and association in mother–infant dyads

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Abstract

This study examined maternal–infant synchrony of hair cortisol at 12 months after birth and the intra-individual stability of maternal hair cortisol in the postpartum period. Participants were selected from an ongoing São Paulo birth cohort project, where families are considered to be “high-risk” due to their chronic stress experiences, with the majority living in slums (favelas). Cortisol was collected through 3-cm segments of hair samples, with values representing approximate levels of cortisol from 9 to 12 months for mothers and children and 6 to 12 months for mothers. Maternal and infant cortisol values reflecting chronic stress 9–12 months after birth were highly correlated ($r = .61, p < .001$); earlier maternal cortisol levels (6–9 months) and child cortisol levels at 9–12 months ($r = .51, p < .001$) were also correlated. Maternal cortisol values showed stability over time ($r = .79, p < .001$). These maternal–infant correlations are high compared to the existing literature on hair cortisol in other mother–child dyads, suggesting stronger synchrony under high-risk contexts where families are faced with challenging circumstances.

Keywords

hair cortisol; high-risk; infant; postpartum; stress

1 | INTRODUCTION

In recent years, hair cortisol has been utilized as a biomarker of chronic stress among humans and animals, with emerging data on its use with children (Karlén, Frostell, Theodorsson, Faresjö, & Ludvigsson, 2013) and infants (Yamada et al., 2007). Hair cortisol

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CONFLICTS OF INTEREST

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appears to capture cumulative cortisol output over a longer period of time (months) relative to other cortisol indices, such as those obtained from saliva, urine, or blood. As an integrated measure, hair cortisol may reflect prolonged stress exposures, making it an ideal measure for assessing vulnerable populations such as children in high-risk neighborhoods.

Given the documented positive associations between adversity, often measured by socioeconomic status (SES), psychosocial stress, and hair cortisol (Wosu, Valdimarsdóttir, Shields, Williams, & Williams, 2013), a major question is whether adversity and/or SES in the family have an impact on hair cortisol in both mothers and children. Since SES may reflect chronic stress due to the exposure of adversity that, in turn, leads to an activation of the HPA axis, it is important to consider children's HPA response within adverse conditions. Such factors have been examined in salivary cortisol across development, which have showed that children with lower SES have higher basal salivary cortisol levels (Clearfield, Carter-Rodriguez, Merali, & Shober, 2014; Lupien, King, Meaney, & McEwen, 2000), and that maternal depression is associated with higher cortisol levels among children (Ashman, Dawson, Panagiotides, Yamada, & Wilkinson, 2002; Brennan et al., 2008; Lupien et al., 2000). A general pattern has emerged suggesting greater cortisol dysregulation as a function of an adverse environment (Tarullo & Gunnar, 2006).

Extant studies on either family adversity or SES, and hair cortisol in children (Karlén et al., 2013; Liu, Snidman, Leonard, Meyer, & Tronick, 2016; Palmer et al., 2013), have showed either no correlations or small negative correlations with neighborhood-level SES and hair cortisol in 4–18-year-old children from the Netherlands (Vliegenthart et al., 2016) or with parent education and hair cortisol among a heterogeneous SES sample of preschool children (Vaghri et al., 2013). Lower family income was associated with higher levels of hair cortisol in 6-year-old children from a large and ethnically diverse sample from the Netherlands (Rippe et al., 2016). While hair cortisol studies on children do not necessarily include direct measures of psychosocial stress (Liu et al., 2016; Ouellette et al., 2015), direct measures of psychosocial stress within the family have been associated with hair cortisol across populations (Palmer et al., 2013). For instance, parenting stress and maternal depression were positively correlated with hair cortisol among 1-year-old Black and White urban children from Tennessee (Palmer et al., 2013). Potential methodological issues that might explain the mixed findings include differences in the developmental periods of assessment and the homogeneity of populations within and across studies. Studies on hair cortisol from adverse environments are scarce as well (Flom, St John, Meyer, & Tarullo, 2016; Liu et al., 2016; Wosu et al., 2013).

Cortisol, when captured by hair, may help to clarify possible physiological synchrony between mothers and infants. It is hypothesized that dyadic synchrony may be a “salient physiological manifestation of the dyad's ‘shared’ emotional and behavioral experiences” (Atkinson, Jamieson, Khoury, Ludmer, & Gonzalez, 2016), as children depend on their caregivers for regulation. There is consistent evidence to suggest cortisol secretion might be synchronized among mothers and infants in both field and laboratory studies from measures of salivary cortisol (Atkinson et al., 2016). However, the small literature examining the association of parent and child hair cortisol has been mixed. For example, maternal and infant hair cortisol was not correlated at 9 or 12 months of age in a low-risk sample of

Boston mothers (Liu et al., 2016), nor was it correlated in a Colorado sample of mothers and newborns (with values reflecting fetal hair cortisol) (Hoffman, D'Anna-Hernandez, Benitez, Ross, & Laudenslager, 2017). On the other hand, maternal hair cortisol at 6 and 12 months was positively correlated with infants at 12 months in another sample of Boston mothers (Flom et al., 2016). Given the small number of studies, it remains unknown whether stronger maternal–infant synchrony in hair cortisol might be observed across contexts. Sampling hair cortisol from an adverse environment provides an opportunity to examine the possible synchrony in the mother–child dyad.

2 | PRESENT STUDY

The aim of this study was to examine maternal–infant synchrony in hair cortisol at 12 months after birth, as well as the stability of hair cortisol level over time for mothers. We focused on a “high-risk sample” given that the few studies on maternal and infant hair cortisol have been on relatively low-risk populations. Our hypothesis was that hair cortisol levels would be correlated between “high-risk” mothers and infants and that cortisol levels in mothers would be stable over time. Sociodemographic correlates and pregnancy behaviors were also examined in relation to hair cortisol values in mothers and infants.

To accomplish this, data were collected from mothers and infants participating in the Western Region Birth Cohort project. All study subjects resided in the Butantã-Jaguarié region within Western São Paulo, Brazil, a region representing 3% of the São Paulo municipality (approximately 380,000 people) (Brentani et al., 2016). A large share of these families live in favelas or “slums” within the city (Jacobi, 1994). Major environmental and social risks and poor health outcomes often occur within these communities, which include substance use, criminality, interpersonal violence, and poor nutrition (Ferri et al., 2007; Perseu Abramo Foundation Economic and Social Council, 2008). As such, these adversities have led the Brazilian government to adopt the Millennium Development Goals to improve the maternal and child health of Brazilians (Barros et al., 2010; Brentani, Fink, Bourroul, & Grisi, 2015). We characterize the mothers and infants in these communities as “high-risk” given the chronic stress experiences among these families.

3 | METHODS

3.1 | Participants

Between April 2012 and March 2014, a total of 6,207 children born at the University Hospital of São Paulo as well as their caregivers were enrolled in the Western Region Birth Cohort Project. The University Hospital delivers approximately 40% of births from the region overall and approximately 80% of all births covered by public health insurance. From this group, 129 children who were on average 12 months old during the present data collection were randomly selected to participate. For analysis, we relied on a sample size of 69 observations with available hair cortisol samples and hospital information. We also analyzed a subsample of 56 cases where more detailed socio-economic information was available. Due to the availability of data (hair samples and questionnaire measures on SES), our analyses relied on different sample sizes. Appendix Table A1 displays the rates of

reasons for unavailable samples and the sample sizes of those available. Appendix Table A2 compares the selected sample with the broader cohort on demographic characteristics.

3.2 | Procedures

Data collection took place through a home visit. The procedures were explained and consent was obtained prior to the hair sampling.

3.3 | Measures

We linked hair cortisol measures to two sets of variables: birth-related variables collected within the University Hospital of São Paulo's routine electronic data system, and socioeconomic variables collected through an in-person interview with mothers prior to hospital discharge. The hospital electronic records provided data on the maternal age at birth (in years), maternal race (as reported by the provider who delivered the baby), delivery modality (vaginal, Caesarean section, or forceps), and Apgar score immediately after birth (minute 0, 1–10 scale). With the Apgar, a score of 7 or higher refers to a good to excellent condition of the baby with respect to heart rate, respiratory effort, muscle tone, reflex irritability, and color. As well, gestational duration (normal, preterm: <37 weeks of gestation, late term: >40 weeks of gestation), birth weight category (appropriate for gestational age, small for gestational age, large for gestational age coded according to Fenton's [2003] revised growth charts for premature births) (Alexander, Himes, Kaufman, Mor, & Kogan, 1996), child gender, an indicator for twin status (0 = single birth, 1 = twin), and the child's race as reported by the provider who delivered the baby were obtained.

From the postpartum interview (available for 56 mother–child dyads who agreed to participate prior to hospital release), we obtained additional information on health behaviors during pregnancy, as well as maternal socioeconomic status. Specifically, we have maternal self-report on alcohol and cigarette use during pregnancy, maternal marital status (single, married, living with partner, or widowed), maternal educational attainment (highest level attained), and monthly family income. Within Brazil, at the time of the data collection, the monthly minimum wage was R\$622 (~300 USD). In Brazil, income classifications are based on minimum wage increments, with low income being 2 minimum wages, average income being 2–4 minimum wages, and high income >4 minimum wages. These designations are also noted in the Tables.

3.4 | Hair sampling

Following the signed consent of mothers, hair was sampled from the vertex posterior of the head from mothers and infants. Using sterile scissors, approximately a strip of 1.5 inches of hair was cut at the scalp from mothers and infants that had at least a hair length of 3-cm. This 3-cm length is considered to represent a 3-month retrospective measure of hair Cortisol, assuming a 1-cm/month growth rate of hair, and is a commonly used length for sampling (e.g., Russell et al., 2012; Stalder & Kirschbaum, 2012). For children, only one sample (0–3 cm from the scalp) was collected at 12 months. For mothers, a sample of a 6-cm length was collected at 12 months which was then divided into two 3-cm segments. Assuming the 1-cm/month growth of hair, the first 3-cm length of hair from the scalp for the mothers represents cortisol output from 9 to 12 months postpartum, while the length of hair 4–6 cm from the

scalp for the mothers represents a cortisol output from 6 to 9 months postpartum. Samples were stored in plastic vials labeled only by ID in a locked room, and at room temperature according to storage standards (Meyer & Novak, 2012) for laboratory assay.

3.5 | Hair processing and cortisol assay

The samples were sent for assay to the Laboratório Especializado em Análises Científicas (LEAC). Starting with ~50 mg of hair, two washes with 40 ml of water followed by two washes with 40 ml of isopropanol on a plate rotating at 130 rpm for 3 min per wash were performed. After each set of washes, hair samples were cut into small pieces using small surgical scissors. Samples were put into disposable glass scintillation vials and HPLC grade methanol was added at a concentration of 100 µl/mg of hair. Next, samples were sonicated for 30 min followed by a 24-hr incubation period at 50°C. After incubation, samples were centrifuged for 30 min at 3,000 rpm, aliquot the supernatant into separate glass tubes and evaporated the methanol under a gentle stream of nitrogen. For samples where less than 30 mg of hair was available, smaller volumes of the extract were aliquoted, corresponding to 5, 10, or 15 mg of hair. Once the methanol was removed, the sample was resuspended in 150–250 µl of phosphate buffered saline (PBS) at pH 7.0. Samples were vortexed for 1 min followed by another 30 s until they were well mixed. For cortisol measurement in the extracts, we used a commercially available salivary cortisol enzyme-linked immunosorbent assay (ELISA) (Cat. # KAPDB290 (CTS)—Lot 150810—DiaSource) according to the manufacturer's instructions. The intra- and inter-assay coefficient of variance was below 10.3%.

3.6 | Statistical analysis

Given that non-normally distributed hair cortisol values were obtained, hair cortisol values were log-transformed at each time point, as is typical with hair cortisol data (Pereg et al., 2010; Russell, Koren, Rieder, & Van Uum, 2012; Stalder, Steudte, Alexander, et al., 2012). For categorical variables such as maternal age group or race, mean level of maternal and child cortisol were computed. ANOVA models were used to test for subgroup differences. All statistical analysis was conducted using the Stata 14 Statistical software package.

4 | RESULTS

4.1 | Descriptives

Table 1 displays participant demographics, including race/age and socioeconomic status, pregnancy behaviors, and characteristics regarding the birth.

We also compared the means of maternal and child cortisol by maternal, birth, and infant characteristics and maternal pregnancy behaviors. There were no statistically significant differences in the means of cortisol values based on the characteristics measured for either mothers or children (appendix Table A3). A moderate trend was observed showing higher maternal cortisol levels among mothers with at least a secondary schooling relative to those with less schooling ($F = 2.35, p = .08$). These differences were statistically significant in a two-group test comparing mothers with secondary or higher education to mothers with less education ($F = 8.64, p < 0.01$).

Table 2 presents mean level cortisol values in mothers and children and correlations within mother's samples and between mothers and infants. Figures 1 and 2 displays scatterplots of key correlations. Maternal samples from the scalp, taken to reflect 6–9 months and 9–12 months of retrospective chronic stress) showed to be highly correlated ($r = .78, p < .001$). Mother's hair cortisol values and infant's values reflecting cortisol from 9 to 12 months were highly correlated ($r = .62, p < .001$). Maternal hair cortisol values from 6 to 9 months was also correlated with infant hair cortisol values from 9 to 12 months ($r = .80, p < .001$). Given extreme outliers that drove these correlations, we trimmed variables at the 95th percentile, which resulted in observations within two standard deviations of the median. In doing so, these correlations were still significant, with maternal hair cortisol across time highly correlated ($r = .79, p < .001$), maternal and infant hair cortisol correlated at 9–12 months ($r = .61, p < .001$) and maternal hair cortisol from 6 to 9 months correlated with infant hair cortisol at 9–12 months ($r = .51, p < .001$).

5 | DISCUSSION

The primary purpose of this study was to examine associations between maternal and infant hair cortisol in a “high-risk” sample and to determine stability in maternal cortisol over time. Notably, maternal hair cortisol was highly correlated with infant hair cortisol sampled at 12 months ($r = .61, p < .001$). The association between maternal and infant hair cortisol within this high-risk sample at 12 months was higher relative to previous studies even after the removal of outliers. For instance, the one other study examining maternal and infant hair cortisol at 9 and 12 months, which comprised of a largely White and highly educated sample from Boston was not found to be significant (Liu et al., 2016) nor was there a correlation in hair cortisol among a Colorado sample of newborns and their mothers (Hoffman et al., 2017). In a Boston sample that was also mostly White and highly educated, with maternal and infant hair cortisol showed a lower correlation at 12 months ($r = .45, p < .001$) (Flom et al., 2016).

In considering psychosocial mechanisms, one possibility is that synchrony is most strong under a high-risk context where families are faced with challenging circumstances. Within a high-risk context, mothers and children are exposed to similar stressors and, therefore, may have higher levels of cortisol (Stenius et al., 2008). A possible regulatory mechanism suggests that the stress response reflected in high hair cortisol levels within a high-risk environment may be due to early developmental attempts by the infant to cope with a high-risk environment (Debiec & Sullivan, 2014; Laurent, Ablow, & Measelle, 2011). This can occur during the prenatal period as stress signals to the developing fetus might arise from maternal exposures to hostile environments during pregnancy, thereby programming the development of the fetal HPA-axis (Kapoor, Dunn, Kostaki, Andrews, & Matthews, 2006). This is a possibility given observations of greater associations of maternal and infant salivary cortisol in households with intimate partner violence and where mothers are depressed (Hibel, Granger, Blair, Cox, & Family Life Project Key Investigators, 2009; Laurent et al., 2011). Such cortisol secretion reflecting the demands from continued stress exposure is particularly relevant to our sample of mothers and children from São Paulo given the adversities they face on a daily basis.

The high correlation between maternal and infant hair cortisol values obtained in this study, relative to the other studies on mothers and infants, point to the possibility of context as a moderator of maternal and infant hair cortisol synchrony. While we did not have any specific information on the circumstances within the timeframe reflected in the sampling—these exposures, whether they are extreme or whether they have a chronic effect on physiological synchrony (DiCorcia & Tronick, 2011) likely matter. An additional consideration is the role of maternal sensitivity on synchrony (Moore et al., 2009). A few studies have showed slightly higher synchrony among mothers with lower sensitivity (Atkinson et al., 2013; Laurent, Ablow, & Measelle, 2012). One study showed higher synchrony between maternal and 7-year-old daughters hair cortisol, under poor parenting conditions (Ouellette et al., 2015). This study did not have any specific data on maternal or dyadic experiences such as maternal sensitivity or relationship quality although this is something to be measured in conjunction with maternal–child hair cortisol in the future. Altogether, much more work examining parents and infants from high-risk contexts, their specific exposures and parenting styles, is needed to better understand the associations of maternal and infant hair cortisol.

Our study also allowed us to examine intra-individual stability in hair cortisol among mothers in our high-risk sample, with our finding reinforcing the potential of hair cortisol as a marker for chronic stress during the postpartum period. While intra-individual stability has been established before in a low-risk sample of Boston mothers across 9 and 12 months ($r = .41, p < .05$) (Liu et al., 2016) and in another sample of Boston mothers across 6 and 12 months ($r = .28, p < .05$) (Flom et al., 2016), the stability in our sample was much higher ($r = .82, p < .001$). In another study, correlations between .68 and .79 were found across 2- and 12-month periods among adults who had completed a study on endurance sports (Stalder, Steudte, Miller, et al., 2012). The differences in stability of values could be due to the time between samplings, and the variability of either physical or psychosocial exposures that could contribute to increased cortisol secretion over a period of time. The high correlations from our study may have been due to our use of two consecutive 3-cm samples from the same strands of hair, which could have reduced the variability in hair cortisol concentrations compared to these other studies that obtain samples from different strands. While the occurrence of specific exposures was not measured in our sample over the period of time, we speculate that stress may be more chronic in our sample, where stressful exposures (neighborhood violence, poverty) are likely to be high but invariable over time.

6 | LIMITATIONS AND FUTURE DIRECTIONS

Our study contains limitations that ought to be considered in the interpretation. Some features of our study limit its generalizability. No associations were observed between maternal, infant, and birth characteristics in maternal and infant cortisol values as our sample size may have been too small to detect possible correlates of hair cortisol in this population. Our data are specific to a population from one impoverished community in São Paulo, however, there is likely to be variability in the experiences of individuals within each of these communities, with respect to both risks and supports. Our study may be biased toward mothers and children who had enough hair or who were willing to have their hair sampled. While we presume that each centimeter of hair sampled reflects a 1-month time period given

the prior literature, we did not have specific growth rates on each of our participants, as is generally the case with other studies that utilize hair cortisol as a measure. As the purpose of our study was to examine hair cortisol correlates across time and individuals, causality cannot be inferred. We did not assess potential moderation from either environmental or genetic factors, nor did we have access to individual and dyadic level variables such as maternal sensitivity (Flom et al., 2016; Ouellette et al., 2015), social supports, and child temperament (Groeneveld et al., 2013), all of which might play a role in hair cortisol level.

7 | SUMMARY

Our study raises the possibility that residing within the Brazilian slums and exposures to urban poverty and adversity are associated with increased maternal and infant synchrony in hair cortisol. We also observed high levels of intra-individual stability over time in mothers within our sample, suggesting that such stability also occurs in high-risk contexts. While specific stress exposures, individual differences in stress response, and parenting styles have yet to be identified as possible moderators to this synchrony, these findings suggest the utility of hair cortisol as a biomarker for mothers and infants in a high-risk environment. Altogether, there is potential for hair cortisol to shed light on the role of chronic stress exposure on health from early development, across development and among families, and over a variety of contexts.

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APPENDIX

TABLE A1

Rates and Reasons for Unavailable Data

	Cases	Percent
Child hair samples		
Hair sample collected	52	40
Hair was too short	51	40
Sick or unavailable	5	4
Refused	21	16
Total	129	100
Maternal hair samples		
Hair sample collected	67	52
Hair too short	0	0

	Cases	Percent
Sick or unavailable	5	4
Refused	57	44
Total	129	100
Sample sizes of available variables used for analyses		
Any hair cortisol measure	69	100
Any hair cortisol measure and SES	56	81
Maternal hair cortisol	67	97
Maternal hair cortisol & SES	54	78
Child hair cortisol only	52	75
Child hair cortisol & SES	41	59
All hair cortisol measures	50	100
All hair cortisol measures & SES	39	78

TABLE A2

Demographic Characteristic Comparisons Between Analytical Sample and Broader Cohort From Which the Analytic Sample Was Drawn

	Main analytical sample, <i>N</i> = 56		Cohort sample, <i>N</i> = 3,811		<i>p</i> -Value
	%	Cases	%	Cases	
Smoked in pregnancy	8.9	5	13.9	529	0.167
Drank in pregnancy	10.7	6	13.0	497	0.523
Mother completed primary education	30.4	17	26.6	1,015	0.532
Mother completed high school or college	57.1	32	57.3	2,185	0.959
Mother is married	21.4	12	20.5	783	0.861
Mother is living with partner	46.4	26	32.6	1,242	0.035
Mother is single	30.4	17	24.9	949	0.363
HH income low (2 minimum wages)	30.4	17	48.6	1,852	0.003
HH income average (2–4 minimum wages)	48.2	27	37.4	1,426	0.099
HH income high (>4 minimum wages)	21.4	12	14.0	533	0.188
Household owns car	35.7	20	37.1	1,412	0.807

Table compares maternal characteristics to larger sample of mothers interviewed as part of the Western Region Cohort Study (postpartum exit interview).

p-values based on two-sample equal means hypothesis.

TABLE A3

Mean Differences of Maternal and Infant Hair Cortisol Values (Assessed at 12 Months) by Maternal, Birth, and Infant Characteristics, and Maternal Pregnancy Behaviors

	Maternal cortisol level (pg/mg) (9–12 months)	Child cortisol level (pg/mg) (9–12 months)
Maternal age at birth		
Under 20	24.07	33.65

	Maternal cortisol level (pg/mg) (9–12 months)	Child cortisol level (pg/mg) (9–12 months)
20–24	39.45	51.03
25–29	50.98	60.59
30–34	55.66	76.71
35 and older	29.06	21.59
Maternal race		
White	44.36	55.76
Mixed	39.04	52.33
Black	22.59	17.95
Maternal marital status		
Single	48.26	66.04
Married	51.05	62.87
Not married, but living with partner	43.67	47.54
Widowed	15.81	21.60
Mother education		
Incomplete primary schooling	26.92	45.40
Complete primary schooling	27.17	46.33
Secondary schooling	60.25	58.90
Tertiary schooling	68.45	107.40
Family monthly income		
R\$0 to R\$ 622.00 (low)	6.28	19.15
R\$623.00 to R\$ 1,244.00 (low)	41.23	57.12
R\$ 1,245.00 to R\$ 2,488.00 (average)	46.82	44.82
R\$ 2,489.00 to R\$ 6,220.00 (average)	56.16	92.04
R\$ 6,221.00 to R\$ 12,440.00 (high)	39.38	12.13
Delivery modality		
Regular (vaginal)	49.26	59.99
Caesarean	32.00	44.74
Forceps	47.32	57.59
Apgar scores at 0 min after birth		
<8	49.68	32.84
8 or 9	40.59	56.74
Regular (vaginal) 49.26 59.99		
Regular (vaginal) 49.26 59.99		
Forceps 47.32 57.59		
Forceps 47.32 57.59		
10	42.50	50.77
Maturity		
Preterm	52.69	45.52
Full term	41.54	53.01
Birth weight category		
Small for gestational age	57.34	69.74

	Maternal cortisol level (pg/mg) (9–12 months)	Child cortisol level (pg/mg) (9–12 months)
Appropriate for gestational age	40.81	49.93
Large for gestational age	31.39	73.11
Single or multiple birth		
Singleton	42.38	52.72
Twin	8.61	52.94
Child gender		
Male	40.91	46.18
Female	42.70	58.79
Child race		
White	50.26	61.86
Mixed	35.89	45.01
Black	27.84	26.47
Smoking in pregnancy		
Mother did not smoke	47.20	57.98
Mother smoked at least occasionally	33.87	42.92
Drinking in pregnancy		
Mother did not drink	46.91	58.10
Mother drank occasionally	38.43	41.84

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FIGURE 1.

Scatterplots representing the natural log of maternal hair cortisol obtained from 6 to 9 months and 9 to 12 months. Excluding observations more than two standard deviations above the median

FIGURE 2.

Scatterplots representing the natural log of maternal hair cortisol obtained from 9 to 12 months and child hair cortisol from 9 to 12 months. Excluding observations more than two standard deviations above the median

TABLE 1

Descriptives of maternal, birth, and infant characteristics, and maternal pregnancy behaviors

	Cases	Percent
Maternal age at birth (years) (<i>N</i> = 69)		
Under 20	9	13.0
20–24	23	33.3
25–29	16	23.2
30–34	13	18.8
35 and older	8	11.6
Maternal race (<i>N</i> = 69)		
White	49	71.0
Mixed	16	23.2
Black	4	5.8
Maternal marital status (<i>N</i> = 56)		
Single	17	30.4
Married	12	21.4
Not married, but living with partner	26	46.4
Widowed	1	1.8
Maternal education (<i>N</i> = 56)		
Incomplete primary schooling	7	12.5
Complete primary schooling	17	30.4
Secondary schooling	29	51.8
Tertiary schooling	3	5.4
Family monthly income (<i>N</i> = 56)		
R\$0 to R\$ 622.00 (low)	1	1.8
R\$623.00 to R\$ 1,244.00 (low)	16	28.6
R\$ 1,245.00 to R\$ 2,488.00 (average)	27	48.2
R\$ 2,489.00 to R\$ 6220.00 (average)	10	17.9
R\$ 6,221.00 to R\$ 12,440.00 (high)	2	3.6
Delivery modality (<i>N</i> = 69)		
Vaginal	35	50.7
Caesarean	28	40.6
Forceps	6	8.7
Apgar scores at 0 min after birth (<i>N</i> = 69)		
<8	4	5.8
8 or 9	38	55.1
10	27	39.1
Maturity (<i>N</i> = 69)		
Preterm	2	2.9
Full term	67	97.1
Birth weight category (<i>N</i> = 69)		
Small for gestational age	6	8.7

	Cases	Percent
Appropriate for gestational age	60	87.0
Large for gestational age	3	4.4
Single or multiple birth (<i>N</i> = 69)		
Singleton	67	97.1
Twin	2	2.9
Child gender (<i>N</i> = 69)		
Male	32	46.4
Female	37	53.6
Child race (<i>N</i> = 69)		
White	30	43.5
Mixed	37	53.6
Black	2	2.9
Smoking in pregnancy (<i>N</i> = 56)		
Mother did not smoke	51	91.1
Mother smoked at least occasionally	5	8.9
Drinking in pregnancy (<i>N</i> = 56)		
Mother did not drink	50	89.3
Mother drank occasionally	6	10.7

TABLE 2

Correlations between maternal and infant hair cortisol, and display of mean level cortisol values excluding outliers

	1	2	3
1. Maternal cortisol 6–9 months	–	.79***	.51***
2. Maternal cortisol 9–12 months		–	.61***
3. Infant cortisol 9–12 months			–
Means (pg/mg)	37.6	34.3	38.5
Standard deviation (pg/mg)	34.4	27.0	26.8

Based on cortisol measures below 130 pg/mg (excluding observations more than two standard deviations above the median). $N = 63$ for within-mother comparison. $N = 45$ for mother-child correlation at 9–12 months. $N = 44$ for mother at 6–9 and child at 9–12 month comparison.

 $p < .001$.