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## Maternal attachment avoidance is linked to youth diurnal cortisol slopes in children with asthma

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### ABSTRACT





Prior evidence suggests that an individual's attachment orientation is linked to the health and health-related biology of his/her romantic relationship partners. The current study examined whether this effect extends to parent–child relationships. Specifically, we investigated the association between maternal attachment anxiety and avoidance and diurnal cortisol of offspring. In a sample of 138 youth with asthma and their primary caregivers, caregivers reported their attachment orientations, and their children (aged 10–17) supplied four saliva samples per day over four days to assess diurnal cortisol patterns. Growth curve analyses revealed no links to caregiver attachment anxiety, but caregiver attachment avoidance was significantly associated with children's diurnal cortisol slopes, such that greater attachment avoidance predicted flatter diurnal cortisol slopes. Maternal warmth did not mediate this link. These results support the possibility that an individual's adult attachment orientation may “get under the skin” of family members to influence their health-related biology. Future research should seek to determine the causal direction of this association and mechanisms of this effect.

### KEYWORDS

Adult attachment avoidance;  
adult attachment anxiety;  
cortisol; maternal warmth;  
asthma severity

Individuals' attachment orientations have implications for health. However, most research has focused on how one's attachment orientation affects his/her own personal health (for a review, see Pietromonaco, Uchino, & Dunkel-Schetter, 2013). Less research has focused on the links between one's attachment orientation and the health outcomes of close others, such as relationship partners and offspring. The current study investigates maternal attachment processes in a sample of youth with asthma, testing whether mothers' attachment avoidance and anxiety are related to their children's diurnal cortisol profiles.

Bowlby (1969/1982, 1973, 1980) initially conceptualized the attachment system as a set of instinctive affective, behavioral, cognitive, and motivational mechanisms designed to encourage infants to seek proximity to protective caregivers during times of stress. By viewing caregivers as attachment figures to turn to in times of emotional stress or

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uncertainty, infants can feel comfortable exploring the world around them, knowing that their caregivers are available if needed (Bowlby, 1969/1982). Disruptions to this attachment system with primary caregivers can result in alternative working models of relationships that affect subsequent relationship functioning characterized by two key dimensions: attachment avoidance and anxiety (Hazan & Shaver, 1987; Simpson, Collins, Farrell, & Raby, 2015). The avoidance dimension is characterized by discomfort with intimacy and a tendency to distance oneself from others in times of stress. Anxious attachment orientations are characterized by intense worrying about relationships, excessive need for validation by relationship partners, and extreme yearning to be closer to relationship partners. Rather than being two categorical labels, attachment anxiety and attachment avoidance are two theoretically distinct dimensions of attachment orientations (Fraley, Waller, & Brennan, 2000).

Individuals' adult attachment orientations affect their own health and health-related biological outcomes (Pietromonaco et al., 2013). For instance, highly anxious individuals have higher cortisol output and more dysregulated cellular immune responses than individuals lower in attachment anxiety (Jaremka et al., 2013). The effects of attachment on health-relevant biomarkers are even more pronounced in stressful situations: Insecurely attached individuals (i.e. high in anxiety and/or avoidance) have greater cortisol reactivity to conflict (Laurent & Powers, 2007; Powers, Pietromonaco, Gunlicks, & Sayer, 2006) and other social stressors (e.g. Ditzen et al., 2008; Kidd, Hamer, & Steptoe, 2011; Quirin, Pruessner, & Kuhl, 2008), and avoidant individuals have an increased inflammatory response following conflict discussions (Gouin et al., 2009).

Through what mechanisms might attachment impact one's own health outcomes? Evidence suggests that relationship functioning serves as a key mediator of this link. Collins and Feeney (2000) found that avoidantly attached individuals have difficulty increasing support-seeking in response to increased stressors and use indirect, ineffective ways of seeking support because they feel uncomfortable with intimacy. Moreover, anxiously attached individuals have difficulty giving effective care to their partners because they are preoccupied with their own relationship worries. Low-quality caregiving toward intimate partners and low levels of seeking support from intimate partners lead to low relationship satisfaction and increased relationship stress for both the individual and his/her partner (Collins & Feeney, 2000). Moreover, other research has implicated intrapersonal psychological mechanisms that explain intrapersonal attachment-health links. For instance, negative affect (Consedine, Fiori, Tuck, & Merz, 2013), emotion regulation (Arsiwalla, 2017), and self-compassion (Raque-Bogdan, Ericson, Jackson, Martin, & Bryan, 2011) have all been demonstrated to mediate the link between one's attachment orientation and one's health outcomes.

These studies have focused on the link between an individual's attachment orientation and that individual's own health, but the mediating role of relationship quality suggests that an individual's attachment orientation may also affect the health and health-related biological outcomes of an individual's close relationship partners. Studies examining this phenomenon have found consistent evidence that one's attachment orientation is associated with the health-related biology of a romantic partner. For example, individuals show higher cortisol levels in conflict interactions if their romantic partner is either avoidantly or anxiously attached (Beck, Pietromonaco, DeBuse, Powers,

& Sayer, 2013; Laurent & Powers, 2007; Powers et al., 2006). The authors reasoned that this effect occurs partly because individuals are not confident in their ability to resolve their conflicts with an insecure partner effectively.

These attachment-health processes should theoretically extend to mother-child relationships. Both romantic relationships and mother-child relationships involve similar dyadic attachment-caregiver processes and both types of relationships need sufficient social support to thrive (Bowlby, 1969/1982). Other parent characteristics have been shown to affect children's health-related outcomes: Children and adolescents are lower in inflammation when their parents are more empathetic (Manczak, DeLongis, & Chen, 2016), or lower in stress or depression (Wolf, Miller, & Chen, 2008). The existence of these types of crossover effects, wherein parents' characteristics are related to children's outcomes, suggests that maternal attachment may carry over to affect child health outcomes as well. Only one study to our knowledge has examined the relationship between maternal attachment orientations and child health markers: In a sample of youth with asthma (which is the same sample as the sample used in the current study), Stanton et al. (2017) found that maternal attachment avoidance predicted their children's reduced expression of the glucocorticoid receptor gene *NR3C1*, which carries out cortisol's signal for functions like reducing inflammation. This effect was found to be mediated through the children's reports of maternal warmth, such that mothers higher in attachment avoidance were less warm compared to less avoidant mothers.

Researchers are beginning to identify plausible biological mediators of the attachment-health link and diurnal cortisol looks promising in this regard (Diamond & Fagundes, 2010). Cortisol is a primary hormone of one of the human body's major stress response systems, the hypothalamic-pituitary-adrenal (HPA) axis. The HPA axis is a crucial biological system: It is heavily intertwined with other major biological systems (Miller, Chen, & Zhou, 2007), glucocorticoid receptors are found in almost all human cell types, and cortisol's extensive chemical messaging duties make it responsible for a variety of psychological and bodily functions, including learning, memory, immune regulation, blood pressure regulation, and blood vessel tone regulation (Spencer & Deak, 2017).

Cortisol production has a diurnal rhythm. After an initial increase shortly after waking, cortisol levels decline throughout the day and reach their nadir shortly before bedtime. Flatter cortisol slopes have been linked to poor health outcomes such as depression (Doane et al., 2013) and cardiovascular disease (Matthews, Schwartz, Cohen, & Seeman, 2006). A recent meta-analysis reported a robust association between flatter diurnal cortisol slopes and worse long-term health outcomes, including cancer (cancer effect size,  $r = .23$ ; average effect size across all health outcomes,  $r = .15$ ; Adam et al., 2017). Furthermore, cortisol levels and functioning, specifically diurnal cortisol decline, have been shown to be responsive to both acute and chronic stressors, particularly social stressors (Adam et al., 2017; Janson & Rohleder, 2017; Miller et al., 2007). Children's attachment to their parents has been shown to be linked with their diurnal cortisol profiles, such that children with disorganized attachment tend to have flatter cortisol slopes than those with non-disorganized attachment (Luijk et al., 2010), and anxiously attached children/adolescents tend to have a reduced cortisol awakening response (Oskis, Loveday, Hucklebridge, Thorn, & Clow, 2011). Diurnal cortisol's susceptibility to

social influences and potential implications for physical health make it an excellent biomarker to test for partner effects of attachment.

Although there is strong theoretical evidence that an individual's attachment orientation can affect their partner's health, very few studies have tested for partner effects of attachment on health. In this study, we aim to address this gap by testing whether mothers' attachment orientations were associated with their children's diurnal cortisol profiles. The current study assesses this link in a sample of youth with asthma. Although one study failed to find an association between diurnal cortisol profiles and concurrent asthma symptom severity (Wolf, Nicholls, & Chen, 2008), diurnal cortisol slope is a robust predictor of inflammatory markers (Adam et al., 2017) which cause asthma attacks (Chen & Miller, 2007), suggesting that diurnal cortisol may be linked to asthma severity.

## The present study

In this study, we aimed to build on past research regarding partner effects of attachment insecurity to test whether mother's attachment orientations were associated with their children's diurnal cortisol slopes in a sample of youth (ages 10–17) with asthma. We hypothesized that 1) higher maternal attachment avoidance would be associated with flatter diurnal cortisol profiles among youth and 2) that higher maternal attachment anxiety would also be associated with flatter diurnal cortisol profiles among youth.

In addition, we ran two exploratory analyses to investigate mechanisms linking attachment orientations, diurnal cortisol, and health outcomes. First, we tested a plausible mediator of the attachment-diurnal cortisol link, maternal warmth. Insecurely attached parents are less warm towards their children (Cowan, Cohn, Cowan, & Pearson, 1996; Adam, Gunnar, & Tanaka, 2004), and youth who experience harsher family climates characterized by less maternal warmth have poorer physical health outcomes later in life (Miller, Chen, & Parker, 2011). As noted above, maternal warmth has been found to mediate the relation between maternal attachment avoidance and expression of the glucocorticoid receptor gene in their children (Stanton et al., 2017).

Furthermore, we examined how maternal attachment and diurnal cortisol profiles predicted clinical health endpoints. The participants in this study were youth with asthma, and asthma symptoms and attacks result from increased inflammation in the airways. Because diurnal cortisol is associated with increased inflammation (Adam et al., 2017), we hypothesized that maternal attachment would predict asthma symptoms via flatter diurnal cortisol slopes.

## Method

### Participants

Participants were individuals who participated in the first wave of an ongoing longitudinal study, Asthma in the Lives of Families Today (ALOFT; recruited from November 2010 to June 2014). The ALOFT study explores family dynamics among youth and their caregivers and explores health-related biological changes and asthma morbidity among youth. Participants were recruited from hospitals and schools in the Detroit metropolitan area. Inclusion criteria required youth to be between 10 and 17 years of age and

diagnosed with asthma. This particular age range was chosen because it represents a period with distinct transitions in family relations (e.g. decreases in parental supervision, increases in behavioral autonomy). Participants with other medical conditions or who were taking oral medications known to affect asthma morbidity and asthma-related biological markers were excluded. Exclusionary medications included blood thinning medications such as Coumadin, dicumarol, and miradon; oral antibiotics; oral antifungal or antiviral medications; oral medications containing cortisone, prednisone, or hydrocortisone; hormone medications such as thyroid or growth hormone; and nicotine replacement medication. Furthermore, parent participants were excluded if they had a history of substance abuse or had used illicit drugs (e.g. cocaine, crack, heroin, methamphetamine) or if they had ever received chemotherapy or radiotherapy. Although the ALOFT study included 194 youth and their primary caregivers, only youth who supplied at least 10 out of 16 saliva samples requested over four days were included in these analyses.

Thus, the sample comprised 138 youth (80 boys and 58 girls), whose mean age was 12.9 years old ( $SD = 1.8$  years). For each of the variables in the study, we conducted a  $t$  test to compare the overall sample means to our sub-sample means (i.e. the sample including all participants to the more restrictive sample used in the current study). We found no significant differences between the groups on any included variable (all  $ps > .60$ ). Each youth had at least one caregiver available to participate in the study. The youth were 76.8% African-American/Black, 21% Caucasian/White, 1.1% Latino, and 1.1% multiracial. In regards to yearly parental income, 66.3% of the primary caregivers reported their personal income to be below \$31,850, while 10.2% of caregivers earned over \$64,251 per year. For education, 90.6% of caregivers had at least a high school diploma or equivalent, while 23% had at least a bachelor's degree. For relationship status, 40.1% of caregivers were married or living in a long-term relationship.

## Measures

### *Maternal attachment avoidance and attachment anxiety*

Maternal attachment avoidance and attachment anxiety were assessed with the Experiences in Close Relationships-Revised (ECR-R) scale (Fraley, Heffernan, Vicary, & Brumbaugh, 2011). The ECR-R scale assesses how individuals generally feel in close relationships. Participants rated 36 items on a Likert-type scale from 1 (*Strongly Disagree*) to 7 (*Strongly Agree*). Example items assessing attachment avoidance included "I find it difficult to allow myself to depend on romantic partners" and "I don't feel comfortable opening up to romantic partners" ( $\alpha = .91$ ). Example items assessing attachment anxiety included "I worry a lot about my relationship" and "I often wish that my partner's feelings for me were as strong as my feelings for him or her" ( $\alpha = .93$ ). After reverse-coding relevant items, avoidance and anxious items were averaged separately to produce an attachment anxiety score and an attachment avoidance score for each participant.

### *Salivary cortisol*

Salivary cortisol was collected using passive drool methods. Participants were instructed to give four saliva samples per day for four days at specific time points: immediately

upon awakening, 30 min after waking (to assess the cortisol awakening response), before lunch, and immediately before bed. Sample time was recorded by participant report, time stamps, and MEMS 6 TrackCap monitors (Aardex Ltd., Switzerland). Compliance was good: For 86.9% of samples, the time difference between MEMS and self-reported time was less than 10 min, and 69.4% of CAR samples were collected between 20–40 min from awakening. Samples were initially stored in participants' refrigerators, but upon return to the lab, saliva samples were stored in the laboratory refrigerator at  $-20^{\circ}\text{C}$  until assayed, which was performed using commercially available enzyme-linked immunoassay kits (DRG International, Springfield, NJ), with average intra- and inter- assay CVs of 9.88% and 12.54%, respectively. To reduce positive skewness, we natural log transformed the cortisol values (raw cortisol + 1).

### *Youth-reported maternal warmth*

The Parental Behavior Inventory (PBI; Schaefer, 1965) was used to assess youths' perceptions of the closeness and warmth in their relationships with their mothers. For the current study, 23 items tapping specific expressions of maternal warmth were used. Example items include "My mother (or female guardian) seems proud of the things I do" and "My mother (or female guardian) shows love for me" ( $\alpha = .96$ ). Youth were instructed to rate their agreement with each item on a scale of 1 (*agree*) to 3 (*disagree*); overall maternal warmth scores were computed by reverse coding scores and then averaging across the 23 items such that higher scores indicated greater maternal warmth.

### *Asthma symptoms*

Youth asthma symptoms were assessed with a composite variable consisting of daily diary items completed before bedtime each night for the four days when saliva was collected for cortisol. Youth were instructed to relate, on a 0 (*none*) to 4 (*severe*) Likert-type scale, how severe each of the following asthma symptoms were that day: wheezing, chest pain, chest tightness, and shortness of breath ( $\alpha = .79$ ). The four scores for each of the four days (16 scores total) were averaged to produce an overall asthma symptoms severity score.

### *Potential covariates*

Based on prior diurnal cortisol research (Adam & Kumari, 2009), we included several demographic covariates. Age, gender (*male* = 0, *female* = 1), race (0 = *White*, 1 = *Non-White*), child medication usage (0 = *no medication use*, 1 = *medication use*), parent socioeconomic status, and average wake time were all included as covariates.

Youth were determined to be using medication if they reported regularly using at least one of the following commonly-prescribed asthma medications: inhaled beta-agonist, inhaled corticosteroid, inhaled combination corticosteroid and beta-agonist, or leukotriene modifying agent. Parent socioeconomic status was calculated by averaging the z-scores of parental income and parental education (Evans, Li, & Whipple, 2013).

### Missing data procedures and data analysis

To appropriately address missing data, we used expectation maximization to replace missing values on continuous demographic and psychological variables (child age, child gender, child race, and parent socioeconomic status). Expectation maximization has been shown to increase statistical power and provide unbiased parameter estimates (Enders, 2001; Scheffer, 2002). However, because expectation maximization does not allow for the estimation of dichotomous variables, we used mode replacement to replace the missing values for the dichotomous variable of interest (medication use).

Hierarchical linear modeling (HLM) was used for the main data analyses. HLM is ideal for analyzing the diurnal rhythm of cortisol and allows multiple cortisol parameters (e.g. cortisol at wakeup, cortisol awakening response [CAR], cortisol slope) to be estimated simultaneously. Moreover, it allows for accurate predictions of individual differences in diurnal cortisol profiles. We used the HLM program (version 7) for Windows to run these analyses (Raudenbush, Bryk, & Congdon, 2013).

Models 1 and 2 included maternal attachment avoidance, whereas Models 3 and 4 included maternal attachment anxiety. For each set of analyses, we first ran the model without covariates (Models 1 and 3) and then conducted follow-up models with demographic and biomedical covariates (Models 2 and 4).

Time Since Awakening (TSA) represents the slope of diurnal cortisol, or how much cortisol decreases over the course of the day (i.e. steeper declining slopes have larger negative values). Based on prior research (Adam & Kumari, 2009), we included cortisol awakening response (CAR), time since waking, and Time Since Awakening Squared ( $TSA^2$ ) as variables at Level 1 to get an accurate estimate of participants' diurnal cortisol rhythms. The CAR term was dummy coded such that the second sample of a day was coded as "1" and the other three samples (i.e. the first, third, and fourth samples of a day) were coded as "0." At Level 2, we included the aforementioned covariates as variables. We allowed cortisol at awakening (intercept), the cortisol awakening response, and TSA to randomly vary at Level 2, while keeping  $TSA^2$  as a fixed effect. All variables at both levels were grand mean centered. All significance tests were two-tailed and used robust standard errors.

The following HLM equations were used for Model 2 (Table 2):

Level 1 Model:

$$\text{Log(Cortisol)} = \pi_{0j} + \pi_{1j}(\text{CAR}_{ij}) + \pi_{2j}(\text{TSA}) + \pi_{3j}(\text{TSA}^2) + e$$

Level 2 Model:

$$\begin{aligned} \pi_{0j} = & \beta_{00} + \beta_{01}(\text{WakeTime}) + \beta_{02}(\text{Maternal Attachment Avoidance}) \\ & + \beta_{03}(\text{Child Age}) + \beta_{04}(\text{Child Sex}) + \beta_{05}(\text{Child Race}) + \beta_{06}(\text{Child Medication Use}) \\ & + \beta_{07}(\text{Parent SES}) + r_0 \end{aligned}$$

$$\begin{aligned} \pi_{1j} = & \beta_{10} + \beta_{11}(\text{WakeTime}) + \beta_{12}(\text{Maternal Attachment Avoidance}) + \beta_{12}(\text{Child Age}) \\ & + \beta_{12}(\text{Child Sex}) + \beta_{12}(\text{Child Race}) + \beta_{12}(\text{Child Medication Use}) \\ & + \beta_{12}(\text{Parent SES}) + r_1 \end{aligned}$$

$$\begin{aligned} \pi_{2j} = & \beta_{20} + \beta_{21}(\text{WakeTime}) + \beta_{22}(\text{Maternal Attachment Avoidance}) + \beta_{22}(\text{Child Age}) \\ & + \beta_{22}(\text{Child Sex}) + \beta_{22}(\text{Child Race}) + \beta_{22}(\text{Child Medication Use}) \\ & + \beta_{22}(\text{Parent SES}) + r_2 \end{aligned}$$



$$\pi_{3j} = \gamma_{30}$$

Individual cortisol slopes were computed by collapsing across the four days of data collection. We extracted the cortisol slopes from the HLM program by downloading the Level 2 residual files, which contain the Bayesian estimates of the individual cortisol slope for each participant. To test whether maternal warmth mediated the effects of attachment orientations on youth diurnal cortisol, we first examined the correlation between maternal warmth and diurnal cortisol slopes. If this correlation was significant, we then planned to conduct an indirect effect analysis using a bootstrapping approach with 20,000 iterations using the PROCESS macro (Model 4; Hayes, 2013) with individual diurnal cortisol slopes as the outcome measure. Similarly, if diurnal cortisol was associated with both attachment orientations and asthma symptoms, the same type of indirect effect analysis would be run to test the path from attachment to diurnal cortisol to asthma symptoms.

## Results

Table 1 (insert Table 1 here) shows the correlations among and descriptive statistics of the study variables. Extracted diurnal cortisol slopes were associated with maternal attachment avoidance, but not maternal attachment anxiety, suggesting some support for Hypothesis 1 but not Hypothesis 2. However, these diurnal cortisol slopes were not significantly associated with maternal warmth or asthma symptoms. Without a significant association between the mediator and the outcome variable, an indirect path cannot be significant, and thus the two exploratory mediation models we had proposed were inconsistent with our data and not tested further.

Table 2 (insert Table 2 here) shows the results of hierarchical linear models of diurnal cortisol parameters with maternal attachment avoidance as a predictor to test Hypothesis 1. As shown in Model 1, maternal attachment avoidance was associated

**Table 1.** Correlations and descriptive statistics for study variables.

	1	2	3	4	5	6	7	8	9	10
1. Diurnal cortisol slopes	–									
2. Asthma Symptoms	–.07	–								
3. Maternal Attachment Avoidance	<b>.17*</b>	.07	–							
4. Maternal Attachment Anxiety	.09	.01	<b>.60**</b>	–						
5. Maternal Warmth	–.08	–.06	–.06	–.14	–					
6. Child Age	.09	.12	–.06	–.09	<b>–.16†</b>	–				
7. Child Sex (Female)	–.05	<b>.24**</b>	–.09	<b>–.20*</b>	–.06	<b>.18*</b>	–			
8. Race (White)	<b>.29**</b>	–.04	<b>.18*</b>	.10	–.09	<b>–.16†</b>	–.02	–		
9. Medication Use	–.04	–.06	–.01	.04	–.03	–.02	.02	<b>–.19*</b>	–	
10. Parent SES	<b>–.24**</b>	.08	–.08	.01	<b>.20*</b>	.04	–.10	<b>–.50**</b>	.02	–
mean (sd) or percentage	–.10 (.02)	1.3 (.34)	2.7 (1.4)	2.3 (1.2)	2.7 (.39)	12.9 (1.8)	42%	23.2%	45.7%	–0.34 (.92)

**Table 2.** Hierarchical linear models of diurnal cortisol parameters with maternal attachment avoidance [N = 138].

Fixed effect (independent variables)	Model 1 (No Covariates)	Model 2 (With Covariates)
	Estimate (Standard Error)	Estimate (Standard Error)
<b>Cortisol at awakening, <math>\pi_0</math></b>		
Intercept, $\beta_{00}$	<b>1.099 (.072)**</b>	<b>1.142 (.298)**</b>
Wake Time, $\beta_{01}$	<0.001 (<.001)	<0.001 (<.001)
Maternal Attachment Avoidance, $\beta_{02}$	0.021 (.027)	0.02 (.026)
Child Age, $\beta_{03}$	–	0.004 (.019)
Child Sex, $\beta_{04}$	–	–0.038 (.078)
Child Race, $\beta_{05}$	–	–0.023 (.087)
Child Medication Use, $\beta_{06}$	–	0.008 (.078)
Parent SES, $\beta_{07}$	–	–0.033 (.042)
<b>Cortisol awakening response, <math>\pi_1</math></b>		
Intercept, $\beta_{10}$	<b>0.193 (.087)*</b>	0.149 (.426)
Wake Time, $\beta_{11}$	<0.001 (<.001)	<b>&lt;0.001 (&lt;.001)†</b>
Maternal Attachment Avoidance, $\beta_{12}$	–0.006 (.031)	0.011 (.031)
Child Age, $\beta_{13}$	–	0.044 (.027)
Child Sex, $\beta_{14}$	–	–0.071 (.085)
Child Race, $\beta_{15}$	–	<b>–0.224 (.100)*</b>
Child Medication Use, $\beta_{16}$	–	<b>–0.143 (.083)†</b>
Parent SES, $\beta_{17}$	–	–0.015 (.051)
<b>Time since awakening, <math>\pi_2</math></b>		
Intercept, $\beta_{20}$	<b>–0.110 (.011)**</b>	<b>–0.168 (.027)**</b>
Wake Time, $\beta_{21}$	<0.001 (<.001)	<0.001 (.001)
Maternal Attachment Avoidance, $\beta_{22}$	<b>0.005 (.002)*</b>	<b>.004 (.002)*</b>
Child Age, $\beta_{23}$	–	<b>0.004 (.002)*</b>
Child Sex, $\beta_{24}$	–	–0.007 (.006)
Child Race, $\beta_{25}$	–	<b>0.015 (.007)*</b>
Child Medication Use, $\beta_{26}$	–	–0.003 (.005)
Parent SES, $\beta_{27}$	–	–0.005 (.003)
<b>Time since awakening<sup>2</sup>, <math>\pi_3</math></b>		
Average curvature, $\beta_{30}$	<b>0.003 (.001)**</b>	<b>0.003 (.001)**</b>

† $p < .10$ , \* $p < .05$ , \*\* $p < .01$ .

with flatter youth diurnal cortisol slopes as hypothesized. The effect of maternal attachment avoidance on the slope of the diurnal cortisol line is positive because the slope of the diurnal cortisol line is negative; that is, higher maternal attachment avoidance predicts a less negative (i.e. flatter) diurnal cortisol slope.

This effect held when including relevant covariates (see Model 2). Maternal attachment avoidance did not significantly predict cortisol levels at awakening or the cortisol awakening response in either model.

Table 3 (insert Table 3 here) shows the results of hierarchical linear models of diurnal cortisol parameters with maternal attachment anxiety as a predictor to test Hypothesis 2. Maternal attachment anxiety did not predict youth diurnal cortisol slopes, cortisol levels at awakening, or the cortisol awakening response. No effects emerged when controlling for covariates (see Models 3 and 4).

## Discussion

The present study tested links between mothers' attachment orientations and children's diurnal cortisol profiles. We found that mothers' greater attachment avoidance, but not attachment anxiety, was linked to flatter youth diurnal cortisol slopes. This research is

**Table 3.** Hierarchical linear models of diurnal cortisol parameters with maternal attachment anxiety [N = 138].

Fixed effect (independent variables)	Model 3 (No Covariates)	Model 4 (With Covariates)
	Estimate (Standard Error)	Estimate (Standard Error)
<b>Cortisol at awakening, <math>\pi_0</math></b>		
Intercept, $\beta_{00}$	<b>1.186 (.072)**</b>	<b>1.221 (.388)**</b>
Wake Time, $\beta_{01}$	<0.001 (<.001)	<0.001 (<.001)
Maternal Attachment Anxiety, $\beta_{02}$	-0.013 (.027)	-0.016 (.033)
Child Age, $\beta_{03}$	-	0.004 (.022)
Child Sex, $\beta_{04}$	-	-0.051 (.082)
Child Race, $\beta_{05}$	-	-0.003 (.11)
Child Medication Use, $\beta_{06}$	-	0.012 (.08)
Parent SES, $\beta_{07}$	-	-0.031 (.049)
<b>Cortisol awakening response, <math>\pi_1</math></b>		
Intercept, $\beta_{10}$	<b>0.266 (.08)*</b>	0.226 (.396)
Wake Time, $\beta_{11}$	<0.001 (<.001)	<0.001 (<.001)
Maternal Attachment Anxiety, $\beta_{12}$	-0.041 (.031)	-0.03 (.039)
Child Age, $\beta_{13}$	-	<b>0.043 (.023)†</b>
Child Sex, $\beta_{14}$	-	-0.09 (.09)
Child Race, $\beta_{15}$	-	<b>-0.196 (.116)†</b>
Child Medication Use, $\beta_{16}$	-	-0.136 (.085)
Parent SES, $\beta_{17}$	-	-0.007 (.054)
<b>Time since awakening, <math>\pi_2</math></b>		
Intercept, $\beta_{20}$	<b>-0.101 (.011)**</b>	<b>-0.163 (.03)**</b>
Wake Time, $\beta_{21}$	<0.001 (<.001)	<0.001 (<.001)
Maternal Attachment Anxiety, $\beta_{22}$	0.002 (.002)	.001 (.002)
Child Age, $\beta_{23}$	-	<b>0.004 (.002)*</b>
Child Sex, $\beta_{24}$	-	-0.007 (.006)
Child Race, $\beta_{25}$	-	<b>0.017 (.008)*</b>
Child Medication Use, $\beta_{26}$	-	-0.002 (.006)
Parent SES, $\beta_{27}$	-	-0.005 (.004)
<b>Time since awakening<sup>2</sup>, <math>\pi_3</math></b>		
Average curvature, $\beta_{30}$	<b>0.003 (.001)**</b>	<b>0.003 (.001)**</b>

† $p < .10$ , \* $p < .05$ , \*\* $p < .01$ .

the first of which we are aware to demonstrate a link between maternal attachment orientation and youth diurnal cortisol profiles.

To our knowledge, only one other study (which also used the ALOFT study sample) has found a link between mothers' insecure attachment and their children's health-related biology: Stanton et al. (2017) found that maternal attachment avoidance was linked to reduced expression of the glucocorticoid receptor gene *NR3C1* in their children via reduced maternal warmth as reported by the children (Stanton et al., 2017). The current study extends research on maternal attachment and youth health by showing that maternal attachment avoidance (but not anxiety) is linked to an additional form of irregularity in the HPA-axis.

It is not clear why maternal attachment anxiety did not predict flatter diurnal cortisol slopes in this sample because evidence suggests that anxiously-attached people tend to have worse health outcomes than individuals with secure and avoidant attachment orientations (Pietromonaco & Collins, 2017). In addition, anxious attachment has been linked to ineffective parenting behaviors such as overprotectiveness (Feeney, 2002; Jones, Cassidy, & Shaver, 2015). One possibility is that this study was not sufficiently powered to detect a small but significant association between maternal attachment anxiety and diurnal cortisol slopes. The degree of difference between the associations between avoidance and slopes versus anxiety and slopes is not substantial, and studies

with larger samples may find both to be predictive. However, it could also be due to substantial differences between avoidantly-attached parental behaviors and anxiously-attached parental behaviors. Whereas, for example, prior work has shown that avoidant attachment is associated with lower parental responsiveness, there appears to be no such association between anxious attachment and parental responsiveness (Jones et al., 2015; Edelstein et al., 2004). Overall, it is still unclear what the links between maternal attachment anxiety and youth health outcomes are, so future work should continue to examine these potential links.

An important contribution of the current study is showing the relevance of adult attachment orientations to mother-child dyads as they pertain to health-related outcomes. The measure we used to assess maternal attachment orientation was a measure that assesses attachment to romantic partners broadly (i.e. rather than a specific partner). It is notable that such a measure was able to predict youths' health-related biology. These results illustrate the potential impact of general romantic attachment orientations to affect the health of non-romantic close others.

However, it remains unclear *how* this dyadic effect occurs. As maternal attachment avoidance is known to predict maternal responsiveness to children (Jones et al., 2015; Edelstein et al., 2004) and past research from our dataset had found that maternal warmth mediated links between maternal attachment avoidance and youths' expression of the glucocorticoid receptor gene *NR3C1* (Stanton et al., 2017), we expected that it would be a plausible mediator in this study as well. However, in the subsample of youth who had cortisol data that we could include in these analyses, maternal warmth was not associated with maternal attachment avoidance nor diurnal cortisol slopes. This may be a function of the effects potentially being small and insufficient statistical power in this subsample to detect them. The current evidence suggests that maternal warmth does not impact children's diurnal cortisol outcomes, but it is possible that maternal warmth may affect youth health outcomes through other physiological pathways associated with gene expression (i.e. the effects reported in Stanton et al., 2017). Future research should continue to explore the physiological and psychological mediators of the associations between attachment orientation and various health outcomes of one's close relationship partners to better determine the likelihood of attachment orientations affecting particular health outcomes.

Similarly, we did not find any association between diurnal cortisol slope and self-reported asthma symptoms. This null finding would suggest that, although diurnal cortisol slopes are predictive of inflammatory biomarker production (Adam et al., 2017), they do not translate into greater severity of inflammatory diseases like asthma, at least when examined cross-sectionally, among youth, and through the use of self-report. However, it may also take more time for dysregulation of the HPA axis to translate into inflammatory pathology, and longitudinal analyses following individuals over several years may be more likely to find these effects. The majority of studies conducted thus far on links between diurnal cortisol and health have used adult samples (Adam et al., 2017), and these links may not emerge as strongly in children and adolescents.

We acknowledge that our findings are limited. For one, as mentioned above, our study was cross-sectional, thus causation cannot be inferred, and we were unable to identify mechanisms linking attachment to diurnal cortisol or to asthma symptoms. Longitudinal work should be better able to elucidate these mechanistic pathways. In addition, given the low number of fathers who participated in this study, we only were

able to test the associations with maternal attachment orientations. Future work should determine if paternal attachment orientations show similar associations with youth diurnal cortisol rhythms.

In addition to the potential avenues discussed above, there are a number of other promising directions for future research. First, future research should go beyond simply examining mothers' attachment orientations and explore interactions among fathers', children's, siblings', and other family members' attachment orientations and their links to health-related biology. Attachment processes inherently involve more than one individual, so it makes sense to account for the myriad of attachment orientations at play in close familial relationships. One study has found evidence that attachment orientation interaction can predict unique health outcomes (Beck et al., 2013). The authors found that when one couple member was avoidantly attached and the other member was anxiously attached, both couple members exhibited acute stress responses to a forthcoming conflict interaction. The authors reasoned that this stress responses results from avoidantly attached individuals' inability to seek help from their partners and anxiously attached individuals' inability to recognize distress in their partners. Other attachment interaction outcomes are possible. For instance, perhaps fathers' attachment orientations moderate the links between mothers' attachment orientations and their children's health outcomes. Second, while maternal warmth failed to mediate the association between maternal attachment orientations and youth diurnal cortisol slopes, a number of other plausible mediators may explain this link. For example, evidence suggests that insecurely attached parents fail to provide proper structure in their children's lives (Jones et al., 2015). Given that structure is essential to children's (especially asthmatic children's) functioning, differences in parents' success in providing structure might partially explain the association between maternal attachment avoidance and youth diurnal cortisol slopes.

In summary, the current research is the first to identify a link between mothers' attachment orientations and their youths' diurnal cortisol profiles, a key marker of stress system functioning. Mothers high in avoidant attachment, but not anxious attachment, had children with flatter diurnal cortisol slopes. This study provides further evidence for the power of one's attachment orientation to potentially affect the health-related biology of close others, including those not involved in the romantic relationship (i.e. one's children). Future research should view attachment processes through this dyadic framework by examining not just how one's attachment orientation affects one's own health, but how it affects the health of offspring and other close relationship partners as well.

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