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Changes in Maternal Depression and Children's Behavior Problems: Investigating the Role of COVID-19-Related Stressors, Hair Cortisol, and Dehydroepiandrosterone

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Abstract

Few studies have used longitudinal approaches to consider the cumulative impact of COVID-19-related stressors (CRSs) on the psychological adjustment of mothers and children. In the current study, we tracked changes in maternal depressive symptoms and children's behavioral problems from approximately 2 years before the pandemic (T1) to May through August 2020 (T2). Second, we explored maternal hair cortisol and dehydroepiandrosterone as predictors of change in maternal depressive symptoms. Mothers ($N = 120$) reported on maternal and child psychological adjustment at both time points. Hair hormone data were collected in the lab at T1. Results suggest increases in children's internalizing symptoms from T1 to T2 and that higher levels of CRSs were associated with increased maternal depressive symptoms. Maternal and child adjustment were correlated. Maternal hair cortisol, but not dehydroepiandrosterone, was associated with significant increases in depressive symptoms. Findings underscore the importance of considering the family system and cumulative risk exposure on maternal and child mental health.

Keywords

COVID-19, mental health, depression, internalizing, cortisol, dehydroepiandrosterone, DHEA

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The COVID-19 pandemic is a health crisis that has led to significant concerns about mental health. After the initial outbreak in the United States, adults were more than 3 times more likely to screen positive for depression and anxiety disorders in mid-2020 than before the pandemic in 2019 (Twenge & Joiner, 2020). More recent data suggest significant variability in outcomes; some individuals exhibit no changes, and others even show improved mental health (Cost et al., 2021; Luthar et al., 2021; Shanahan et al., 2020). These data suggest that the effects of the pandemic on mental health are not universal but likely vary as a function of individual characteristics. For example, sociodemographic characteristics such as being female, Black, Latinx/Hispanic, or from a lower socioeconomic status are known risk factors (Czeisler et al., 2020; Daly et al., 2020; McGinty et al., 2020; Shanahan et al., 2020) for poor mental health. Moreover, the effects of the pandemic likely depend on the number of COVID-19-related stressors (CRSs), such as getting sick or losing one's job (Brown et al., 2020; Rudenstine et al., 2021).

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One aim of the current study is to examine the role of CRSs in affecting maternal and child mental health.

Evidence suggests that females experienced higher rates of mental-health problems during the pandemic (González-Sanguino et al., 2020; S. Liu et al., 2020). Because of the closure of schools and the loss of child care, individuals or families with young children may have been particularly affected by the pandemic. In the early stage of the pandemic, González-Sanguino and colleagues (2020) examined a large sample of the Spanish population and found significantly more symptoms of depression, anxiety, and posttraumatic stress disorder in women than men. Relatedly, previous research from the SARS outbreak (2003) in China found significantly more posttraumatic stress symptoms in female compared with male health professionals (Chong et al., 2004). Among women, mothers of young children may be particularly vulnerable. Recent findings indicate that mothers have taken on more child-care and homeschooling responsibilities, often at a cost to their work (Krukowski et al., 2021; Manzo & Minello, 2020). Several survey studies, including those in Canada (Cameron et al., 2020; Davenport et al., 2020) and the United Kingdom (Fallon et al., 2021), have examined the prevalence of depression and anxiety symptoms in mothers during the pandemic and found that rates of these symptoms were elevated compared with prepandemic population norms. Moreover, a longitudinal study in Canada found that the proportion of mothers displaying clinically significant symptoms of anxiety and depression was higher during the current pandemic than at any previous time point (3, 5, and 8 years prior; Racine et al., 2021). Mothers who reported experiencing difficulties balancing work and homeschooling, lack of child care, and income disruptions exhibited greater increases in anxiety and depression symptoms, which provides further evidence for the need to consider the number of stress exposures when ascertaining the mental-health consequences of the pandemic.

Another substantial concern is children's psychological well-being during the pandemic. There are multiple pandemic-related risks to children's psychological health, including being deprived of social interaction with peers, physical activity, and extracurricular activities. A qualitative study based in Ireland suggested that children exhibited symptoms of anxiety and depression, feelings of social isolation, and increased behavioral problems during the first lockdown (O'Sullivan et al., 2021). Likewise, a study of preschool-age children found that the sample showed higher levels of depressive symptoms and externalizing behavioral problems compared with prepandemic norms but also that a predictable home environment served as a protective factor (Glynn et al., 2021). Quarantined children in China (Chen et al., 2020) and India (Saurabh & Ranjan, 2020) also exhibited higher rates of psychological distress, depression, and anxiety.

The well-being of mothers and children, however, cannot be understood in isolation. Transactional models of development suggest bidirectional relations between parents and children and reciprocal influences between the child and his or her environment (Sameroff & Fiese, 2000). Although a host of data indicates that maternal mental health is associated with children's outcomes (Goodman et al., 2011; Kingston & Tough, 2014), consistent with Belsky's (1984) process model of determinants of parenting, there is also evidence of mutual influence such that child-driven characteristics can affect maternal well-being (Elgar et al., 2004; Gross et al., 2009). A recent study that examined these bidirectional relations during the pandemic using a cross-lagged model, however, found that parent internalizing symptoms at Time 1 were associated with increases in adolescent internalizing symptoms at Time 2, but adolescent symptoms were not associated with increases in parent symptoms (Lorenzo et al., 2021). Furthermore, some families are at greater risk for adverse outcomes because of variation in exposure to CRSs.

Cumulative risk models suggest that children's outcomes are better predicted by considering the accumulation of risk factors compared with any one risk factor alone (Evans et al., 2013). For example, Atzaba-Poria and colleagues (2004) found that children's level of cumulative risk was positively related to their externalizing problems. Note that cumulative risk exposure can indirectly influence children's outcomes by negatively affecting parental sensitivity (Browne et al., 2016; Doan et al., 2012). Likewise, Prime and colleagues (2020) suggested that social disruptions caused by the pandemic (e.g., isolation and financial insecurity) can negatively affect the well-being of caregivers and their parenting sensitivity, which, in turn, can compromise child adjustment. Recent evidence suggests that CRSs are indeed associated with parenting quality. Exposure to higher levels of CRSs was associated with increased neglect and harsh discipline among parents (Connell & Strambler, 2021). Harsh parenting behaviors also increased with parents' greater perceived impact of the COVID-19 pandemic (Chung et al., 2020).

Relatedly, stress-proliferation models suggest that the parental experience of stress can increase the likelihood for harsher and less sensitive parenting behaviors, which consequently influence children's outcomes (Barfoot et al., 2017; Beckerman et al., 2017; C. H. Liu & Doan, 2020; Mortensen & Barnett, 2015). A cross-sectional study in Bangladesh examined children's mental health during the lockdown period and found that 57% of children were exhibiting subthreshold, moderate, or severe psychological issues and that these mental-health issues were linked to their parents' stress and negative treatment of their children (Yeasmin et al., 2020). At the same time, children with higher levels of behavioral problems may make it more challenging for mothers to cope, especially in the context of home-schooling, social distancing, and quarantines, when seeking social support and obtaining child care help is much more difficult. To date, however, few studies have assessed longitudinal change in maternal depressive symptoms and children's behavioral problems from before the pandemic to the pandemic period while simultaneously considering the impact of CRSs. Thus, in the present study, we aim to use a family-systems approach to examine the relations between changes in maternal depression and children's behavioral problems.

Hair Cortisol and Dehydroepiandrosterone

A second goal of the current study is to examine prospective relations between prepandemic maternal hair cortisol and hair dehydroepiandrosterone and change in maternal depressive symptoms during the COVID-19 pandemic, and we have a particular interest in investigating cortisol as a biological vulnerability factor. Cortisol is the end product of the hypothalamic-pituitary-adrenal axis and a marker of stress regulation and reactivity (McEwen, 1998). Dysregulated cortisol is associated with several detrimental physical-health outcomes and with psychological problems such as depression and internalizing and externalizing disorders (Adam et al., 2017). Although cortisol has been extensively studied, there are fewer psychosocial studies examining prospective relations between hair cortisol as a vulnerability factor in predicting later psychological dysregulation in response to a chronic stressor. Moreover, few studies have simultaneously considered cortisol and dehydroepiandrosterone, which is released alongside cortisol during the stress response. Although the function of dehydroepiandrosterone is not completely clear, it appears to be a buffer against the harmful effects of cortisol dysregulation (Buoso et al., 2011). Dehydroepiandrosterone has anti-inflammatory and antiglucocorticoid effects (Maninger et al., 2009) and is associated with several neurobiological benefits, including neurogenesis, neuroprotection, and neuronal survival. In humans, higher levels of dehydroepiandrosterone is associated with improved cognitive outcomes, such as better executive function, concentration, and working memory in healthy adult women and less confusion, anxiety, and negative mood in older men (Davis et al., 2008; van Niekerk et al., 2001). Concerning stress exposure, however, the data involving dehydroepiandrosterone have been inconclusive. One study found that mothers who experienced childhood maltreatment had higher levels of dehydroepiandrosterone, but not cortisol, in their hair (Schury et al., 2017). A similar study that examined childhood maltreatment found that higher salivary dehydroepiandrosterone levels buffered the effects of childhood trauma on cortisol peak levels during a laboratory stressor. On the other hand, higher dehydroepiandrosterone/cortisol ratios potentiated the impact of childhood trauma on peak levels of cortisol (Taylor-Cavelier et al., 2021).

Researchers typically collect dehydroepiandrosterone and cortisol from saliva during a lab-based stressor (Nicolson, 2008), indexing acute stress reactivity. More recently, researchers have focused on cortisol concentrations from hair samples, which capture an individual's retrospective and cumulative hormone exposure (C. H. Liu & Doan, 2019; Raul et al., 2004; Wosu et al., 2013). These cumulative measures may be a better predictor of outcomes than acute stress. However, to date, few studies have examined the extent to which cumulative hair cortisol concentrations or hair dehydroepiandrosterone concentrations predict changes in depression as a result of adverse or stressful events.

The current literature on hair cortisol and depression is inconclusive. A meta-analysis of the association between hair cortisol and major depressive disorder showed inconsistent results (Psarraki et al., 2021). In addition, few studies have examined cortisol or dehydroepiandrosterone as a premorbid vulnerability factor despite researchers' having argued for the importance of examining biological risk factors involving the stress response (Zoladz & Diamond, 2013). Nonetheless, one study found that higher hair cortisol predicted increases in subsequent depressive symptoms after a motor-vehicle crash (Petrowski et al., 2020). Hair cortisol also predicted the development of posttraumatic stress symptoms at traumatization (Pacella et al., 2017), which suggests that hair cortisol concentrations can be predictive of affect-related responses to trauma.

The Present Study

In the current study, we investigated the relations between CRSs and changes in mothers' and children's psychological adjustment during the pandemic. We also sought to contribute to the limited literature on hair cortisol and hair dehydroepiandrosterone as potential biological antecedents of psychological regulation, especially in the context of a chronic stressor such as the COVID-19 pandemic. We hypothesized that there would be increases in maternal depressive symptoms and children's behavioral problems from Time 1 (T1; before the pandemic) to Time 2 (T2; the initial months of the pandemic in the United States, from May to August 2020). We also hypothesized that CRSs would be associated with maternal depression and child outcomes. Third, we hypothesized that changes in maternal depression would be associated with changes in children's behavioral problems during the COVID-19 pandemic. Finally, we predicted that hair cortisol would be positively associated with maternal depressive symptoms over time. Given the lack of studies on hair dehydroepiandrosterone, we investigated the main and interactive effects of hair dehydroepiandrosterone, cortisol, and CRSs in an exploratory manner.

Method

Participants

Study participants were recruited from a sample of mothers ($N = 120$; age: $M = 36.3$ years, $SD = 5.1$; range = 24–50) and their children (51.7% female; age: $M = 41.81$ months, $SD = 4.65$; range = 35–56 months) who were part of a longitudinal study on emotions, parenting, and biological indicators of stress (T1) from 2017 to 2018. Mother–child dyads were originally recruited in southern California. Dyads qualified to participate in the study if the child was between the ages of 36 and 60 months, could speak and understand English, and was typically developing with no reported diagnoses of developmental disorders. The racial makeup of the participant pool of mothers was 39.2% White/European American, 11.7% Asian American, 1.7% Black American, and 14.2% Latina; the rest identified as more than one race. On average, mothers had an education level between community college and a bachelor's degree. The sample showed a diverse socioeconomic spread (28.3% of mothers had an income at or below $40,000, and 31.3% reported $101,000 or above; the remainder reported income between $41,000 and $100,000). At T2, between May and August 2020, 99 (82.5%) of these dyads agreed to participate in the study. There were no significant differences between participants who remained in the study and those who did not, except that participants who returned reported higher levels of depressive symptoms at T1, $t(106) = -1.71$, $p = .05$. Pomona College's institutional review board (IRB) provided approval for research with human participants. Consent from mothers was obtained before their participation in each study phase.

Procedure

At T1, mothers and their children came into the lab to complete a series of tasks and questionnaires under the guidance of two research assistants. Demographic information was collected via surveys. During the lab visit, trained research assistants collected the hair samples used to measure cortisol and dehydroepiandrosterone concentrations. Hair samples were unavailable from one participant because of insufficient hair length. T2 assessments were conducted during the pandemic (May–August 2020) through an online survey. At T2, the majority of participants (58%) completed the surveys in May, 20% completed them in June, and 11% completed them in July or August. The average number of days between when the United States declared a national emergency (March 13, 2020) to when the survey was completed was 88.57 ($SD = 28.35$; range = 61–153).

During May 2020 (Shalby & Parvini, 2020), California, where the majority of the participants were located, was under a "stay at home" order issued in March (Navarro, 2020). Residents were allowed to leave only for essential services, and nearly all businesses were closed. In June 2020, schools were still in distance-learning mode, but restaurants were allowed to operate at 60% capacity (City News Service, 2020). In July 2020, California reimposed restrictions and halted all indoor activities at restaurants, entertainment venues, and zoos and museums (County of Los Angeles Public Health, 2020). By the end of August 2020, Los Angeles County was still in the "purple" tier of the state's color-coded reopening tiers. Purple is the most restrictive: Schools, theme parks, and bars are still closed; retail operates at 25% capacity; and restaurants, gyms, and family entertainment centers are allowed to operate outdoors only (California Department of Public Health, n.d.).

Measures

Demographics. Mothers reported on their age, ethnicity, education level, and income via self-report in a questionnaire. Maternal education was coded as 0 = high school or less, 1 = some college, 2 = 4-year degree, and 3 = graduate-level degree. In addition, mothers self-reported on variables that could influence their hair hormones, including medications, hair washings, and hair treatment. None of these variables was associated with hormone levels. Nevertheless, we reran our analyses controlling for cortisone medications that are known to influence cortisol levels. Results remained the same.

CRSs. At T2, mothers completed a 30-item COVID-19-Related Stressors questionnaire on which they indicated whether they had experienced a range of different stressors since the onset of the pandemic. This questionnaire was based on prior measures designed to assess exposure to stressful life events (Brugha et al., 1985; Hankin &

Abramson, 2002) and social readjustment (Holmes & Rahe, 1967). We also modified and added items specific to the pandemic (e.g., became sick from COVID-19, had difficulty with remote work). Sample items included "You tested positive for coronavirus/COVID-19" and "You lost your job due to the pandemic." Frequency of events was tallied and used for analyses. Cronbach's α for the scale was acceptable at .70.

Maternal depression. At T1 and T2, the Beck Depression Inventory (BDI-II; Beck et al., 1996), a 21-item self-report questionnaire, was used to assess depressive symptoms. For this study, the suicide item was removed per the recommendation of our IRB, given the potential issues concerning risk management during the pandemic. Participants rated their depressive symptoms (e.g., feelings of sadness, guilt, and disappointment) on a 0 to 3 scale. Cronbach's α was .93 at baseline and .92 during the pandemic. Sum scores were used for analyses.

Children's behavioral problems. We used the Child Behavior Checklist (Achenbach & Rescorla, 2001) to measure maternal reports of their children's behavioral problems within the previous 2 months. Broadband scales measuring internalizing problems and externalizing problems were used. Participants responded on a scale from 0 (*not true*) to 2 (*very true or often true*) to items such as "my child is too fearful or anxious" and "my child destroys things belonging to his/her family or other children." Cronbach's α was .92 for externalizing at both time points, .85 for internalizing at T1, and .89 for internalizing at T2.

Hair hormones. We collected mothers' hair samples to measure maternal cortisol and dehydroepiandrosterone using standardized procedures. Hair samples were collected at T1 by a trained research assistant. Hair samples were cut from the back of the head at roughly the height of the ear. Two individual bundles of hair were taken, as close to the scalp as possible, unless the hair was less than an inch in length, in which case no hair sample was taken. The proximal 3-cm hair segment used for analysis represented hormone concentrations for the past 3 months. Samples were sent to the endocrinological laboratory at TU Dresden (Clemens Kirschbaum), where hair analyses were performed using published protocols (Gao et al., 2016). In short, hair samples were washed twice with 2.5 ml of isopropanol. The extraction process was conducted with 1.5 ml of methanol. Liquid chromatography/tandem mass spectrometry was used to quantify the hair hormone concentration using the current "gold standard" approach for hair steroid analyses (Gao et al., 2016). This approach achieves good sensitivity, specificity, and reliability for hair steroids (intra- and interassay coefficients of variability (CVs) between 3.7% and 8.8% and a limit of detection of ≤ 1 pg/mg for cortisol and intra- and interassay CVs between 4.5% and 9.1% and a limit of detection of ≤ 0.9 pg/mg for dehydroepiandrosterone; Gao et al., 2013). The weight of hair used for analysis was 7.5 mg.

Statistical analysis

Descriptive statistics (i.e., means, standard deviations, correlations) were first computed for the study variables. We also examined the distributions of all variables. The hair cortisol data revealed significant positive skew; two individuals had values that were outliers (3 *SD* above the mean). These two scores were winsorized, and the natural log transformation of hair cortisol concentrations was used to normalize the distribution before analysis. Table 1 reports the descriptive statistics for key variables of interest. For ease of interpretation, nontransformed cortisol levels are reported in Table 1 .

Hypothesis testing was conducted through a series of analyses. Mean-level changes in maternal depression and children's behavioral problems from T1 to T2 were explored using dependent *t* tests. Path modeling was employed to simultaneously examine (a) whether CRSs were associated with changes in maternal depression and children's problem behaviors, (b) whether changes in maternal depression were associated with changes in behavioral problems in children during the COVID-19 pandemic, and (c) whether maternal hair cortisol was positively associated with increases in maternal depressive symptoms over time. We also explored whether maternal hair cortisol interacted with maternal hair dehydroepiandrosterone and CRSs in predicting maternal depression. Two models were specified for internalizing and externalizing problems (see Figs. 1 and 2). As depicted in Figure 1, the direct effects of CRSs on maternal depression and children's problem behaviors at T2 were specified for examining relations between CRSs and maternal and child outcomes.

In addition, the covariance between maternal depression and child behavioral problems at T2 was used to examine the correlated change in these constructs over time. Finally, the direct associations of maternal hair cortisol and maternal hair dehydroepiandrosterone on change in maternal depression and children's problem behaviors from T1 to T2 were specified. The interactions among maternal hair cortisol, maternal hair dehydroepiandrosterone, and CRSs in predicting change in maternal depression were also examined by including interaction terms in the path models. In both models, children's age, maternal race, and household income were included as covariates. Little's (1988) missing completely at random (MCAR) test was not significant, $\chi^2 = 135.00$, $df = 139$, $p = .57$, which suggests that data were MCAR. We use the maximum likelihood estimator (Allison, 2017)

Table 1. Descriptive Statistics for Key Variables

Variable	*N*	*M*	*SD*	Range
Maternal age	120	36.3 years	5.1	24–50 years
Income 2019[a]	99	4.33	2.90	1–10
T1 maternal depression	108	8.73	8.34	0.00–41
T2 maternal depression	99	10.38	8.53	0.00–44
T1 maternal cortisol	119	13.79 pg/mg	22.71	1.58–130.83 pg/mg
T1 maternal DHEA	111	12.92 pg/mg	10.10	1.02–59.58 pg/mg
T1 child internalizing	115	7.42	6.31	0.00–41
T1 child externalizing	115	12.43	8.45	0.00–43
T2 child internalizing	98	9.23	7.83	0.00–42
T2 child externalizing	98	12.26	8.90	0.00–36
COVID-19 related stressors	99	9.90	3.60	3.0–22

Note: T1 = Time 1; T2 = Time 2; DHEA = dehydroepiandrosterone.
[a]Income was coded as 1 = < $ 20,000; 2 = $20,000–$39,999; 3 = $40,000–$59,999; 4 = $60,000–$79,999; 5 = $80,000–$99,999; 6 = $100,000; 7 = $119,999; 8 = $120,000–$149,999; 9 = $150,000–$174,999; 10 = > $175,000.

to fit the data. This approach was adopted for the estimation of descriptive statistics, correlations, and the path model. Model fit of the path models was examined using the indices of comparative fit index (CFI) ≥ .95, root mean square error of approximation (RMSEA) ≤ .06, and standardized root mean squared residual (SRMR) ≤ .08 (Hu & Bentler, 1999). Analyses were conducted using the R software environment (Version 3.4.3;

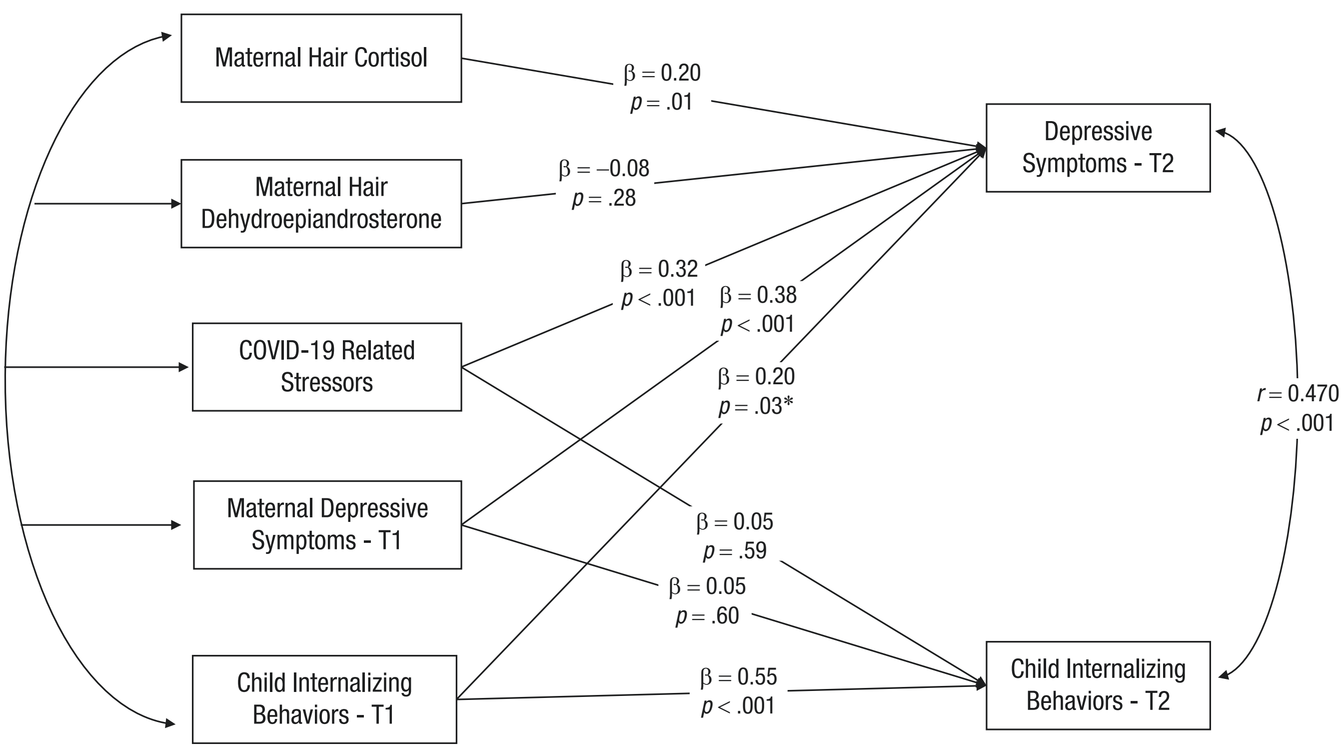

Fig. 1. Cross-lagged model for children's internalizing behaviors and maternal depressive symptoms. Single-headed arrows = standardized regression; double-headed arrows = correlation. Correlations among predictors are not shown but can be obtained in Table 2. Effects of child age, child sex, income, and maternal race were controlled for but not shown in the figure.

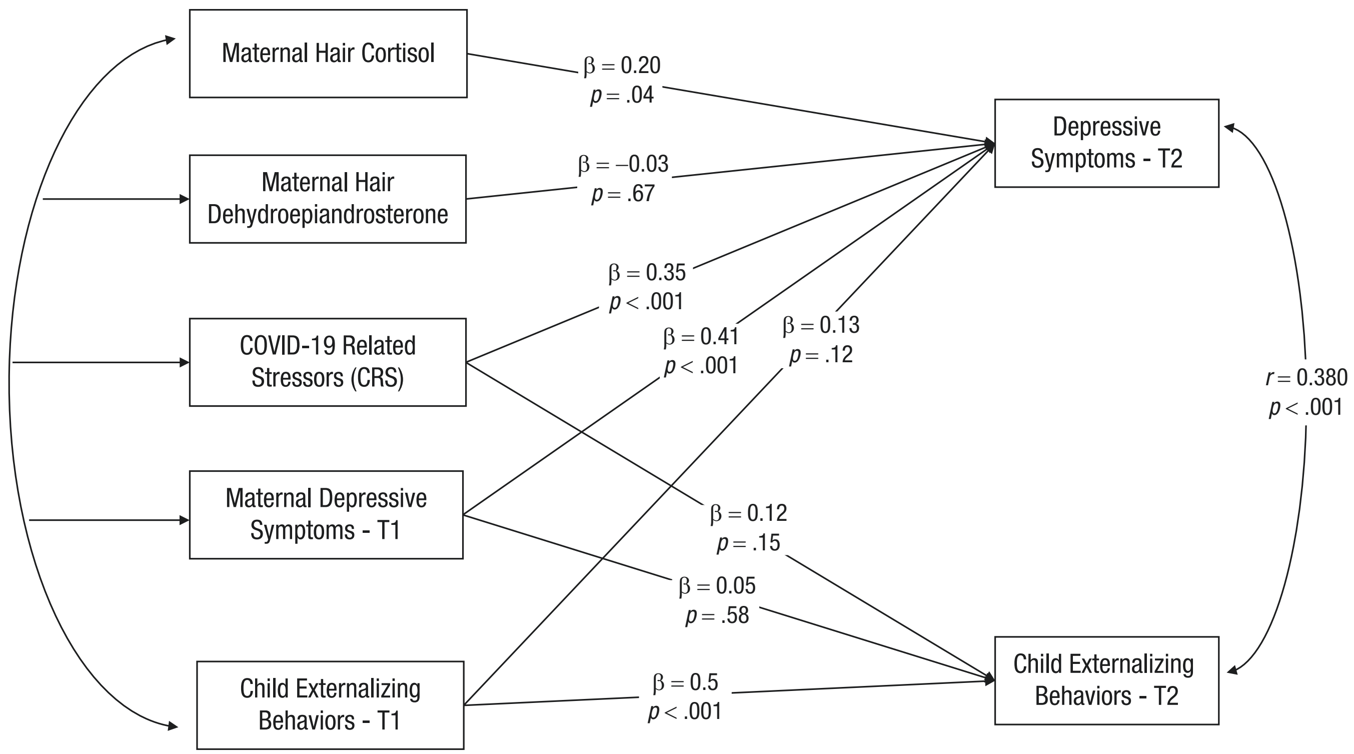

Fig. 2. Cross-lagged model for children's externalizing behaviors and maternal depressive symptoms. Single-headed arrows = standardized regression; double-headed arrows = correlation. Correlations among predictors are not shown but can be obtained in Table 2. Effects of child age, child sex, income, and maternal race were controlled for but not shown in the figure.

R Core Team, 2017) in combination with the *psych* package (Version 1.7.8; Revelle, 2017) and *lavaan* package (Version 0.6–2; Rosseel, 2012).

Results

See Table 1 for descriptive statistics and Table 2 for correlations among the variables. First, we examined relations of demographic variables, including child age, sex, family income, and medication, in relation to our variables of interest. Age was not associated with any of our variables. There were no sex differences in internalizing or externalizing problems at T1. However, during the pandemic, at T2, female children had lower levels of internalizing and externalizing problems compared with male children (rs = −.23 and −.22; ps = .02 and .03, respectively). Family income was negatively associated with maternal hair cortisol, $r = -.27$, $p = .008$, which indicates that higher income was associated with lower levels of cortisol. Income was also associated with lower levels of depressive symptoms at T1, $r = -.25$, $p = .02$. Maternal hair cortisol was not significantly correlated with depressive symptoms at either time point.

To examine differences over time in maternal depressive symptoms and children's behavioral problems, we conducted dependent samples t tests were conducted. All significance tests were two-tailed. There was a significant change in internalizing behaviors from T1 (M = 7.42, SD = 6.31) to T2 (M = 9.23, SD = 7.86), $t(95) = 3.13$, $p = .002$, but not in externalizing problems (T1: M = 12.43, SD = 8.45; T2: M = 12.26, SD = 8.90), $t(95) = -0.18$, $p = .86$. Maternal depressive symptoms increased from T1 (M = 8.73, SD = 8.34) to T2 (M = 10.38, SD = 8.53), but the difference was not significant, $t(93) = -1.42$. $p = .16$. We reran the analyses using an structural equation model framework and full information maximum likelihood for missing data; results remained the same. An additional analysis using BDI-II cutoff scores of 14 and above for depression also suggested there was an increase from T1 (18.5%) to T2 (28.3%). However, a McNemar's test showed that the change was not significant, $\chi^2(1) = 1.44$, $p = .23$.

Next, a series of cross-lagged path models was conducted to examine the role of CRSs in relation to change in maternal depressive symptoms and child behavioral problems; separate models were included for internalizing and externalizing problems. These models also investigated relations between the maternal hormone data and T2 depressive symptoms.

The model that examined children's internalizing problems had an excellent fit to the data, $\chi^2(2) = 2.496$, $p = .287$, CFI = .996, RMSEA = .045, SRMR = .015. Figure 1

Table 2. Correlations Among Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. Child age in months	—											
2. Child sex	−.01	—										
3. Income	−.03	.00	—									
4. Maternal race	−.13	.09	−.26*	—								
5. T1 maternal BDI-II	.05	.04	−.25*	.10	—							
6. T1 child internalizing	.02	−.17	.01	−.11	.30**	—						
7. T1 child externalizing	.01	−.13	.07	−.00	.17	.66**	—					
8. COVID-19 stressors	.10	−.11	.10	−.16	.18	.25*	.15	—				
9. T2 maternal BDI-II	.07	.07	−.03	.01	.49**	.38**	.23*	.46**	—			
10. T2 child internalizing	.01	−.23*	.01	.03	.23*	.61**	.43**	.21*	.50**	—		
11. T2 child externalizing	.11	−.24*	−.02	.08	.16	.40**	.54**	.23*	.44**	.70**	—	
12. Maternal hair cortisol	.01	−.05	−.27**	.05	.01	.04	−.02	.05	.16	.01	.08	—
13. Maternal hair DHEA	−.02	.20*	−.09	.03	.04	−.03	−.12	−.08	−.05	.08	−.07	.01

Note: All tests were two-tailed. Parameters were estimated with maximum likelihood. Child sex is coded as 0 = male, 1 = female. Race is coded as 0 = White, 1 = ethnic minority. BDI-II = Beck Depression Inventory II (Beck et al., 1996); DHEA = dehydroepiandrosterone.
*$p < .05$. **$p < .01$.

depicts the standardized parameters along with corresponding p values. CRSs ($\beta = 0.32$, $p < .001$) and children's internalizing behaviors at T1 ($\beta = 0.20$, $p = .03$) were significantly associated with change in maternal depression. CRSs were not associated with change in children's internalizing problems ($\beta = 0.05$, $p = .59$). Changes in maternal depression were associated with changes in children's internalizing problems during the COVID-19 pandemic ($r = .47$, $p < .001$). Finally, maternal hair cortisol was significantly associated with increases in maternal depressive symptoms over time ($\beta = 0.20$, $p = .006$). Although not depicted in Figure 1, we found that dehydroepiandrosterone did not moderate the relations between cortisol and depressive symptoms ($\beta = 0.07$, $p = .91$). In addition, CRSs did not interact with either index of maternal hair hormones in predicting maternal depression (cortisol: $\beta = 0.31$, $p = .27$; dehydroepiandrosterone: $\beta = 0.06$, $p = .81$).

The model that examined children's externalizing problems also had an excellent fit to the data, $\chi^2(2) = 0.63$, $p = .73$, CFI = 1.000, RMSEA = < .001, SRMR = .007. Figure 2 depicts the standardized parameters along with corresponding p values. CRSs were significantly associated with change in maternal depression ($\beta = 0.35$, $p < .001$) but not children's externalizing problems ($\beta = 0.12$, $p = .15$). Changes in maternal depression were associated with changes in children's externalizing problems during the COVID-19 pandemic ($r = .38$, $p < .001$). Maternal hair cortisol was significantly associated with increases in maternal depressive symptoms over time ($\beta = 0.16$, $p = .04$). Consistent with the internalizing models, we found that cortisol and dehydroepiandrosterone did not interact to predict externalizing problems, $\beta = 0.30$ $p = .68$. We also investigated the extent to which the hormones interacted with CRSs to predict maternal depression. The two hair hormones did not interact with CRSs in predicting change in maternal depression (cortisol: $\beta = 0.20$, $p = .56$; dehydroepiandrosterone: $\beta = 0.00$, $p = .99$). Full results for these models are included in the Supplemental Material available online.

Discussion

In the current study, we examined relations between mother-reported CRSs and maternal depressive symptoms and children's behavioral problems. We also investigated the relations between maternal hair cortisol and maternal dehydroepiandrosterone as biological vulnerability factors associated with mothers' psychological response to the COVID-19 pandemic.

Our results show significant increases in children's internalizing behaviors, but not in externalizing behaviors or maternal depressive symptoms, which suggests caution regarding the assumption that the negative effects of the pandemic on maternal and child mental health are widespread and universal. Exposures to higher rates of CRSs were associated with increases in maternal depressive symptoms, and change in maternal depressive symptoms was positively associated with changes in children's behavioral problems. However, there were no direct relations between CRSs and child outcomes. Note that children's internalizing behaviors at T1 were associated with increases in maternal depressive symptoms during the pandemic, consistent with a transactional model of development (Sameroff & Fiese, 2000). Finally, hair cortisol, but not dehydroepiandrosterone, was associated with changes in maternal depressive symptoms over time.

Our finding that higher levels of CRSs were associated with greater increases in maternal depressive symptoms is consistent with previous work that showed that stressors from the pandemic were associated with concurrent depressive symptoms (Brown et al., 2020). However, our findings show that CRSs account for longitudinal change in depressive symptoms. Although CRSs were concurrently associated with children's externalizing problems at T2, it was not related to changes in children's behavioral problems from before the pandemic to during the pandemic. Note that in our cross-lagged models, changes in maternal depressive symptoms were associated with changes in children's behavioral problems. These associations among CRSs, maternal depression, and children's behavioral problems suggest the importance of considering the family system in understanding the effects of COVID-19 on children's mental health. One possibility is that CRSs affect children's outcomes indirectly through maternal mental health and consequently through parenting behaviors. However, we could not test a full mediation model to determine this without data on parenting behaviors and access to three time points of data.

As a marker of biological risk, hair cortisol was also associated with increases in maternal depressive symptoms over time. Higher levels of hair cortisol at T1 were positively associated with increases in mothers' depressive symptoms from T1 to T2 amid the pandemic. These findings are consistent with past studies that have found elevated hair cortisol to be related to higher levels of depression in individuals with first-episodic depression (Wei et al., 2015) and with other data demonstrating that higher levels of hair cortisol can be a vulnerability factor when considering responses to trauma (Pacella et al., 2017; Petrowski et al., 2020). The prospective relation between hair cortisol and changes in depressive symptoms provides further validity for this relatively novel marker of cumulative stress in the context of a real-world stressor. At the same time, we found that hair dehydroepiandrosterone was not associated with depressive symptoms, and it did not moderate the relations between cortisol and depressive symptoms or interact with CRSs to predict outcomes. These results are inconsistent with past research that demonstrated that dehydroepiandrosterone could be beneficial for depression (Peixoto et al., 2018) but consistent with other previous work that showed that dehydroepiandrosterone levels did not negate increased cortisol activity (Markopoulou et al., 2009). One possibility for this discrepancy is the age of our participants. The benefits of dehydroepiandrosterone seem most prominent among older populations, in which there is a significant decline in dehydroepiandrosterone levels. Our sample of mothers is still relatively young; thus, there may not be enough variability in their dehydroepiandrosterone levels. Further work is needed to investigate the role of dehydroepiandrosterone in association with psychological outcomes, particularly in the context of a chronic stressor. Hair hormone levels also did not interact with CRSs, which suggests independent contributions to maternal depressive symptoms. The ability to detect such effects may be limited by power and variability in CRSs given the relatively small sample.

Limitations and Future Directions

Several limitations should be noted. First, mothers reported on both their depressive symptoms and their children's behavioral problems. Mothers' experience of depression could potentially affect their perceptions of children's behavioral tendencies. Given maternal reports of both variables, we are unable to determine the direction of effects. Furthermore, although we argued that the impact of CRSs on child outcomes might operate through its effects on maternal mental health, we lack three time points of data that would allow us to test for causal mediation. In the current study, we do not have data on parenting behavior; thus, it is unclear the exact ways in which maternal depressive symptoms might influence parenting behaviors during the pandemic.

In addition, note that the severity of the pandemic and measures to mitigate it vary tremendously across cities. For example, California had some of the most stringent measures during data collection, including public schools closing, mask mandates, and closures for a variety of businesses. Thus, our findings may not be generalizable across states and countries. Finally, we focused only on mothers in the current study, and thus, we are not able to document the influence of other family members, including fathers or siblings, on maternal and child mental health.

Regardless of these limitations, our study makes significant contributions to the literature. Consistent with recent research (Cost et al., 2021; Luthar et al., 2021; Shanahan et al., 2020), we found that our data suggest caution with regard to automatically assuming increases in a wide range of mental-health problems during the pandemic. The effects of the pandemic vary greatly, and whether there is change is likely to depend on whether the pandemic led to increases in life stressors. Consistent with this perspective, our data demonstrated that CRSs were associated concurrently with maternal depressive symptoms. Moreover, we showed that children's internalizing behaviors at T1 were associated with changes in maternal depressive symptoms and that changes in maternal depressive symptoms were associated with changes in children's internalizing problems. These data underscore the importance of considering a family-systems perspective when characterizing parent and child functioning. Finally, our findings regarding the role of hair cortisol in predicting changes in maternal depressive symptoms provide much-needed evidence for the role of hair cortisol as a potential biological vulnerability factor for changes in mental health under stress conditions.

Transparency

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Author Contributions

S. N. Doan and P. A. Smiley conceptualized and design the study. C. H. Liu assisted in study design for Time 2. A. B. Burniston and M. Ding assisted with data collection and drafted the manuscript. C. C. Chow analyzed the data, wrote the results, and assisted in interpretations of findings. All of the authors were involved in writing the final manuscript and approved it for submission.

Declaration of Conflicting Interests

The author(s) declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

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Supplemental Material

Additional supporting information can be found at http://journals.sagepub.com/doi/suppl/10.1177/21677026221076845

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