

Original Article

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Continuity of psychopathology *v.* resilience across the transition to adolescence: role of hair cortisol and sensitive caregiving

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Abstract

Background. The transition to adolescence implicates heightened vulnerability alongside increased opportunities for resilience. Contexts of early life stress (ELS) exacerbate risk; still, little research addressed biobehavioral mediators of risk and resilience across the adolescent transition following ELS. Utilizing a unique cohort, we tested biosocial moderators of chronicity in adolescents' internalizing disorders *v.* resilience.

Method. Families exposed to chronic war-related trauma, *v.* controls, were followed. We utilized data from three time-points framing the adolescent transition: late childhood ($N = 177$, $M_{\text{age}} = 9.3 \text{ years} \pm 1.41$), early adolescence ($N = 111$, $M_{\text{age}} = 11.066 \text{ years} \pm 1.23$), and late adolescence ($N = 138$, $M_{\text{age}} = 15.65 \text{ years} \pm 1.31$). In late childhood and late adolescence children's internalizing disorders were diagnosed. At early adolescence maternal and child's hair cortisol concentrations (HCC), maternal sensitivity, and mothers' post-traumatic symptoms evaluated.

Results. War-exposed children exhibited more internalizing disorders of chronic trajectory and mothers were less sensitive and more symptomatic. Three pathways elucidated the continuity of psychopathology: (a) maternal sensitivity moderated the risk of chronic psychopathology, (b) maternal post-traumatic symptoms mediated continuity of risk, (c) trauma exposure moderated the association between child internalizing disorders at late childhood and maternal HCC, which linked with child HCC. Child HCC linked with maternal post-traumatic symptoms, which were associated with child disorders in late adolescence.

Conclusion. Results demonstrate the complex interplay of maternal and child's biosocial factors as mediators and moderators of risk chronicity across the adolescent transition following trauma. Findings are first to utilize maternal and child's HCC as biomarkers of chronic stress *v.* resilience during adolescence, a period of neural reorganization and personal growth that shapes the individual's lifetime adaptation.

Introduction

Early life stress (ELS) carries long-term negative consequences for children's well-being, impairing social relationships, stress management, affective processing, and physical and mental health (Cicchetti, 2016; McLaughlin, 2016; O'Connor, Thayer, & Vedhara, 2021). ELS increases the risk for all common psychiatric disorders (Green et al., 2010; Kessler et al., 2010), which often exhibit a persistent pattern throughout life (McLaughlin et al., 2010). Given the heterogeneity of ELS and its deleterious effects, it is important to disentangle effects that are shared by all harsh rearing conditions from those characterizing specific adversities. Furthermore, since most ELS studies use adults' retrospective account of adverse childhood experiences, it has been recommended that studies utilize physiological measures of chronic stress and pinpoint biosocial mechanisms that may mediate the effects of ELS on development (Lopez et al., 2021). While retrospective studies can shed light on the trajectories leading from ELS to negative outcomes in later life, such accounts are less suitable for elucidating physiological mechanisms that underpin the long-term effects of ELS. For this goal, there is a need to assess links between stress exposure and physiological markers measured at the same time-point or in close temporal proximity.

Among the key pathways by which ELS exerts its long-term influences is the hypothalamic–pituitary–adrenal (HPA) axis and its main biomarker in humans, cortisol (Bunea, Szentágotai-Tátar, & Miu, 2017; van Bodegom, Homberg, & Henckens, 2017; Young et al., 2021). Hair cortisol concentrations (HCC) offers a non-invasive retrospective account of cortisol secretion over time and correlates with mean salivary cortisol levels measured over long periods (Stalder & Kirschbaum, 2012). The associations between HCC and ELS or trauma exposure during childhood, which marks a specific form of ELS, has been extensively studied

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over the past two decades; however, results have been mixed (Khoury, Enlow, Plamondon, & Lyons-Ruth, 2019; Russell, Koren, Rieder, & Van Uum, 2012; Stalder et al., 2016; Staufenbiel, Penninx, Spijker, Elzinga, & van Rossum, 2013). While most studies on the associations between HCC with trauma exposure reported increase in HCC among trauma-exposed individuals (Khoury et al., 2019; Stalder et al., 2016), other studies described HPA-axis hypo-activity in the aftermath of trauma, highlighting the need to consider potential moderators in the interpretation of the findings, such as type of stressor, timing effects, or individual and contextual determinants (Khoury et al., 2019; Steudte-Schmiedgen, Kirschbaum, Alexander, & Stalder, 2016).

Most studies on HCC in children and adolescents focused on socioeconomic adversities, maltreatment, or other forms of interpersonal violence, and only few addressed other traumas (Bates, Salsberry, & Ford, 2017; Bryson, Mensah, Goldfeld, Price, & Giallo, 2021a; Bryson, Price, Goldfeld, & Mensah, 2021b; Gray et al., 2018). Similar to adults, correlations were found between HCC and the number of traumatic events in a community-based children sample (Simmons et al., 2016). However, others reported lower HCC in maltreated children (White et al., 2017) or no associations between HCC and measures of stress (Boeckel, Viola, Daruy-Filho, Martinez, & Grassi-Oliveira, 2017; Gerber et al., 2017; McConnell, 2014; Michels, Van De Wiele, & De Henauw, 2017; Villanueva, Montoya-Castilla, & Prado-Gascó, 2017). The relationship between stress and HCC in children may be specific to some adversities but not others. For example, a recent meta-analysis of 44 studies found no association between social adversity and HCC in young children (Bryson et al., 2021a, 2021b), whereas a study on war-exposed Palestinian adolescents reported that HCC was significantly elevated among children suffering from PTSD compared to non-exposed adolescents (Shaheen et al., 2020). These findings underscore the need to disentangle different types of adversity and specify contextual determinants.

Children's stress physiology is highly sensitive to the mother's condition, including her stress response, parenting behavior, and mental state (Martins, Blumenberg, Tovo-Rodrigues, Gonzalez, & Murray, 2020), and it has been shown that maternal warmth and sensitive support can buffer the negative effects of trauma exposure on child outcome (Ulmer-Yaniv et al., 2017). Several studies assessed links between parenting style and children's HCC, as well as concordance between maternal and child HCC, but results are inconclusive. Harsh parenting was negatively associated with 6-year-old's HCC, but only among those preterm and low birth-weight children (Windhorst et al., 2017) and negative correlations were reported between HCC and positive parenting in 4-year-old children (Simmons et al., 2019). In other studies, no significant associations were found between parenting and children's HCC in refugee preschoolers (Lembcke, Buchmüller, & Leyendecker, 2020) or in a community sample of 2-year-old children (Bryson et al., 2021a). With regards to maternal and child's HCC concordance, poor parenting moderated the association between HCC in mothers and their 7-year-old daughters (Ouellette et al., 2015), whereas another study indicated that greater maternal sensitivity linked with stronger mother-child HCC concordance among 4-5-year-olds (Schloß et al., 2019). Maternal psychological symptoms have similarly been shown to correlate with children's HCC in some studies (Halevi et al., 2017) but not others, and, overall, positive, negative, and no associations were reported between maternal symptoms and children's HCC (Bryson et al., 2021a, 2021b). Since most studies targeted infants

and toddlers, testing HCC in relation to adolescents' mental health, parental psychopathology, and parenting behavior in the context of trauma exposure is required (Bryson, Goldfeld, Price, & Mensah, 2019; Flom, St. John, Meyer, & Tarullo, 2017; Galbally, van Rossum, Watson, de Kloet, & Lewis, 2019; Gray et al., 2018). Another point to consider is the minimal attention directed to the role children play in shaping their parents' physiology and behavior, despite evidence suggesting that mother and child exert bidirectional influences on each other's condition, particularly in the context of trauma (Yirmiya, Motsan, Kanat-Maymon, & Feldman, 2021). While it has shown that maternal HCC can explain variance in children's psychopathology above and beyond children's HCC (Lembcke et al., 2020), the opposite direction, from child psychiatric condition to maternal HCC, has so far not been reported.

Although chronic stress and trauma have been linked with alterations in HPA-axis functioning across the lifespan, some developmental stages are more susceptible to the effects of trauma exposure due to the rapid maturation of stress-management support systems (Danese & McEwen, 2012). During the transition to adolescence, there is a marked increase in rates of psychopathology (Kessler et al., 2005; Merikangas et al., 2010), and the transition is especially risky for children who are growing up in stressful environments (LeMoult et al., 2020; Rudolph & Flynn, 2007), partially due to the heightened stress reactivity that characterizes the onset of puberty (Busso, McLaughlin, & Sheridan, 2017; Dahl & Gunnar, 2009; Doom & Gunnar, 2013). Yet, the transition to adolescence is also a period of increased opportunities for positive growth (Crone & Dahl, 2012), and the biobehavioral reorganization that takes place during that time may enable some youth to emerge from the transition with greater resilience. Despite the importance of the adolescent transition to well-being and adaptations throughout life (Johnson, Dupuis, Piche, Clayborne, & Colman, 2018; Patton et al., 2014), little longitudinal research described factors that may mediate the continuity of risk *v.* the emergence of resilience across the transition to adolescence or tested specific biological and relational factors that may augment or buffer the effects of stressful early environment on children's mental health.

In the current study, we utilized a cohort of children exposed to chronic war-related trauma since birth who were followed in our lab from early childhood to late adolescence. Prior reports from this cohort have shown that across the three assessment points in the first decade of life, war-exposed children presented more psychiatric disorders compared to non-exposed controls. Furthermore, it was found that maternal and child factors measured in early and late childhood, such as maternal post-traumatic stress symptoms (PTSS), sensitive caregiving, and child cortisol, shaped the trajectories of risk and resilience across the 10-year span (Halevi et al., 2017; Halevi, Djalovski, Vengrober, & Feldman, 2016).

Consistent with our conceptual model on resilience (Feldman, 2020, 2021), which considers the coordination of biological and behavioral processes in mother and child as an important mechanism by which mother externally regulates her child's psychophysiological systems and tunes him to social life, the current study aimed to describe key factors associated with resilience, particularly physiological systems implicated in the management of stress and sensitive parenting. Here, we utilized data from our cohort of war-exposed children and their mothers collected during the three assessment points in the second decade of life; late childhood, early adolescence, and late adolescence, in order to frame the adolescent transition. We aimed to pinpoint maternal

and child biobehavioral factors that may mediate and moderate the chronicity of psychopathology *v.* resilience across the transition from late childhood, before the onset of the transition, to late adolescence, following the transition. Consistent with findings from previous assessments of this cohort during the first decade (Halevi et al., 2016), we hypothesized that trauma-exposed children will display more psychopathologies in late adolescence and that exposed mothers and children will have higher HCC levels compared to controls. Furthermore, we hypothesized that trauma exposure, sensitive caregiving and chronic stress physiology as indexed by maternal and child HCC will influence the continuity of psychopathology across the transition to adolescence. Specifically, we hypothesized three main pathways affecting the continuity of psychiatric disorders: (1) Exposed mothers will be less sensitive and this will moderate the continuity of psychiatric disorders so that children with psychiatric diagnosis in late childhood who are reared by less sensitive mothers will be at a greater risk to exhibit a psychiatric diagnosis in late adolescence. (2) Maternal PTSS will mediate the continuity of the child's psychiatric condition from late childhood to late adolescence. (3) Trauma exposure will moderate the association between children's diagnosis in late childhood and mothers' HCC, such that exposed mothers whose children are diagnosed with an internalizing disorder would show elevated HCC levels. Furthermore, maternal HCC will be positively associated with children's HCC, which would link with greater prevalence of maternal PTSS in early adolescence, and this in turn, will be associated with child psychopathology at late adolescence.

Methods

Participants

Participants were recruited during 2004–2005 and included 232 children and their mother ($M_{\text{age}} = 2.76 \text{ years} \pm 0.91$, 47.6% males and 47.1% firstborns). Of these, 148 dyads were living in the same front-line neighborhoods in Sderot, Israel, and comprised the trauma-exposed group. A comparison group of 84 dyads was recruited from comparable towns, matched for socio-demographic variables. The trauma-exposed group from Sderot comprised families who live near the Gaza strip border and have been exposed to repeated and unpredictable missile and rocket attacks, as well as several military operations over the past 20 years. During these attacks, which last from several days to several months, siren warning of incoming missiles are heard, sometimes dozens of times per day, allowing citizens 7–15 s to reach shelter before explosion. Sporadic rocket and missile attacks are also common during relatively calm periods. Overall, many citizens from this area have suffered from physical injuries, as well as significant property and infrastructure damage, leading to severe psychological distress among this population.

Results from early and middle childhood ($M_{\text{age}} = 7.68 \text{ years} \pm 0.7$) are described elsewhere (Feldman & Vengrober, 2011; Feldman, Vengrober, & Ebstein, 2014; Feldman, Vengrober, Eidelman-Rothman, & Zagoory-Sharon, 2013). Here, we use data from late childhood, early adolescence, and late adolescence. At late childhood, 177 families of the initial sample were visited at their homes ($M_{\text{age}} = 9.3 \text{ years} \pm 1.41$; 101 war-exposed, 76 controls) and underwent psychiatric evaluation and observations. At early adolescence, 111 mother–child dyads visited the laboratory ($M_{\text{age}} = 11.66 \text{ years} \pm 1.23$; 58 war-exposed, 53 controls). At late adolescence data from 138 families (64 males) were home-

visited ($M_{\text{age}} = 15.65 \text{ years} \pm 1.31$; 70 war-exposed, 68 controls). Attrition was mainly related to inability to locate families or families moving out of Sderot. No differences in child age, child sex, maternal education, maternal age, and family socioeconomic status (SES) were found between continuing or non-continuing families. The study was approved by the University's Institutional Review Board, and all parents signed informed consent.

Procedures

Late childhood

Mothers and children were visited at home and engaged in interaction paradigm in which they were asked to plan the 'best day ever' to spend together for 7 min (Halevi et al., 2017; Ulmer-Yaniv et al., 2017). Mothers and fathers completed psychological questionnaires regarding themselves and their child and mothers completed the Developmental and Well-Being Assessment (DAWBA) through interview by a trained psychologist. (Study time-line and participants are presented in Fig. 1.)

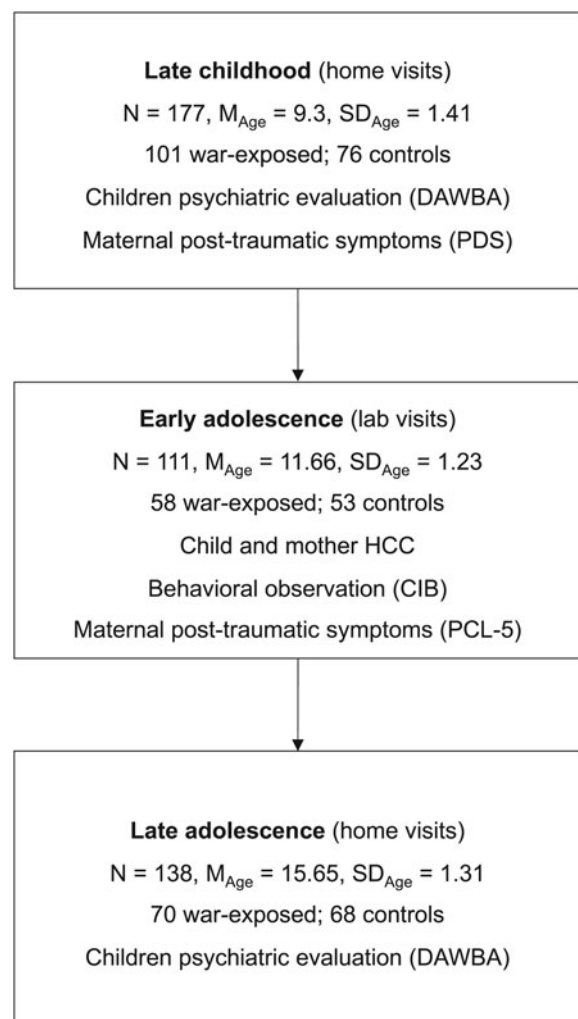


Fig. 1. Time-line and study variables from late childhood to late adolescence. *Note:* Child diagnoses at late childhood and late adolescence were evaluated using The Developmental and Well-Being Assessment (DAWBA); maternal sensitivity was evaluated using the Coding Interactive Behavior (CIB). HCC, hair cortisol concentration; PDS, Post-Traumatic Diagnostic Scale; PCL, Post-Traumatic Stress Checklist.

Early adolescence

A lab visit included interviews, hormonal assessment, and relational and individual paradigms. Dyads were asked to play 'Etch a Sketch' game for 7 min. This is a game in which mother and child each control one of two knobs that enable the drawing of either vertical or horizontal lines. Dyads need to coordinate their activity to create a drawing. Mothers and children completed psychological questionnaires.

Late adolescence

Home visits were held in which trained clinicians re-evaluated the subjects' psychiatric condition using the DAWBA.

Measures

Child psychiatric diagnosis

The DAWBA was used to diagnose children's Axis-I internalizing disorders at late childhood and late adolescence. The DAWBA is a structured interview generating ICD-10 and DSM-IV psychiatric diagnoses in 5–17-year-old children (Goodman, Ford, Richards, Gatward, & Meltzer, 2000). The DAWBA, administered to mothers, is well-validated, including a large epidemiological study in Israel (Mansbach-Kleinfeld, Apter, Farbstein, Levine, & Poznizovsky, 2010). The DAWBA was administered by clinical psychologists and supervised by the same child psychiatrist, blind to all other information, at both stages. Cases were conferred every few weeks with reliability exceeding 85%.

Hair cortisol concentrations

At early adolescence, hair strands were cut as close as possible to the scalp from a posterior vertex position, and the first 3 cm of hair cut proximal to the scalp were analyzed. Hair samples were stored in an envelope in the dark at room temperature until assayed. We extracted steroids from hair using our published protocol for hair-testing (Schonblum et al., 2018). Briefly, hair was weighed and placed in a glass vial. Methanol was added and the vials were sonicated for 30 min and then incubated overnight at 50 °C with gentle shaking. The methanol was collected and evaporated under a stream of nitrogen. Samples were reconstituted in 10% methanol and 90% assay diluent that was provided with the commercial enzyme-linked immunosorbent assays (ELISA) according to manufacturer's recommendations. HCC was quantified in hair extracts using commercial ELISA according to the manufacturer's recommendations (Salimetrics; item no. 1-3002-5; Ann Arbor, MI, USA). Serial dilutions of separate pools for mother and children showed parallelism with the provided kit standards (univariate analysis of variance in SPSS; $p = 0.02$).

Linearity was demonstrated for all the weight range examined, between 10 and 140 mg of hair extract, we therefore used 10–80 mg of hair for cortisol extraction. According to the manufacturer, antibody cross-reactivity was reported as 19.2% with dexamethasone and less than 0.568% with all other steroids. Intra-assay variability was determined using six duplicates of the pool on the same ELISA plate (CV; 5.26%). Inter-assay precision was determined by running duplicates of the pool on four different days (CV; 4.75%). Recovery was estimated by the addition of a known amount of cortisol standard to the hair extract (105.5%).

Maternal sensitivity

Early adolescence interactions were coded using the Coding Interactive Behavior Manual (CIB) (Feldman, 1998). The CIB is

a well-validated tool to evaluate social behavior across ages and has shown good psychometric properties across different ages and cultures. Interactions are coded on multiple global scales from 1 (low) to 5 (high) based on frequency, intensity, and duration of each behavior or social orientation. Maternal sensitivity included the codes of maternal acknowledgment, appropriate range of affect, containment, supportive presence, and empathy. Two trained coders, blind to other information, coded the interactions and reliability on 20% of the interactions exceeded 90% on all codes ($k > 0.82$, range 0.78–96). Variables were averaged to create the maternal sensitivity score (Cronbach's $\alpha = 0.91$).

Maternal PTSS

In late childhood, mothers completed the Post-traumatic Diagnostic Scale (PDS), a 17-item self-report questionnaire for assessing PTSS based on DSM-IV criteria (Foa, Cashman, Jaycox, & Perry, 1997). Each item is scored on a scale of 0–3 and all symptoms are summed to create a total severity score (range 0–51), with higher scores indicating greater PTSS. At early adolescence, mothers completed the fifth version of the PTSD Checklist (PCL-5) (Weathers et al., 2013), a 20-item self-report designed to assess the DSM-5 symptoms of PTSD. Respondent rated on a five-point Likert scale distress associated with each symptom to a total symptom severity score (range 0–80) obtained by summing the 20 items.

Statistical analysis

We first examined differences between exposed and non-exposed groups in demographic condition and study variables using t tests, χ^2 and McNemar's tests. Hair cortisol was positively skewed and Box–Cox transformed (Osborne, 2010). For a comprehensive model on the direct, mediated, and moderated paths from child symptomatology at late childhood to late adolescence, as mediated and moderated by war-exposure, maternal and child HCC, maternal sensitivity and PTSS, we conducted structural equation model (SEM) with Amos 21.0 (Arbuckle, 2012; Byrne, 2016). We ran two identical models; one for internalizing and one for externalizing diagnoses. All variables in the models were standardized using z -transformation. To assess model fit the following indices were used: χ^2 , comparative fit index (CFI), Bollen's incremental fit index (IFI), and the root mean square error of approximation (RMSEA). CFI and IFI ≥ 0.90 and RMSEA ≤ 0.08 values are considered to indicate a good fit (Hu & Bentler, 1999). Ideally, the χ^2 statistic is expected to be non-significant in the case of adequate fit, however this index is no longer used to evaluate fit because of its hypersensitivity to sample size (Hu & Bentler, 1999). Full information maximum-likelihood method accounted for missing data was estimated in all analyses. Children's age and gender were inserted as covariates. An additional model included maternal PTSS in late childhood as a covariate, to test the inference of the longitudinal ordering and effects, as suggested by Cole and Maxwell (2003). Significance of moderation effects, simple slopes and confidence intervals (CI) were computed with PROCESS for SPSS (v. 3.3) (Hayes, 2013). PROCESS employs bootstrapping calculations, which provides the most powerful method for defining confidence limits for conditional indirect effects at different levels of the moderators and accounts for violation of normality that can occur in more traditional approaches (Hayes, 2022). Bias-corrected standard errors and CIs were generated using 5000 bootstrapped resamples drawn to derive the 95% CI. Conditional mediation is present when the CI for the

estimation of indirect effect does not contain zero. We used PROCESS Model 1 to test each moderation effect, and compared the effect size and s.e. from the AMOS and PROCESS analyses to ascertain consistence across methods. To test the presence of mediation paths from child diagnosis in late childhood to diagnosis in late adolescence via mothers' and children's HCC and maternal PTSS we used the 'Mediation' package within the R statistical software (Tingley, Yamamoto, Hirose, Keele, & Imai, 2014). This package enables to test the indirect effects using the Monte Carlo CI for complex functions method (Tofighi & MacKinnon, 2016). Two children's hair samples were excluded as HCC data were extreme outliers (>3 standard deviations above the mean). We included in our final model behavioral/psychological assessments and hair samples from 78 mothers and 53 children.

Results

Sample characteristics and child psychopathology in war-exposed and control

Detailed sample characteristics by exposure are provided in Table 1. No differences in child age, child gender, maternal age and family SES were found between the exposed and control groups ($p > 0.05$ for all variables). Results presented in Table 1 and Fig. 2 show that at late childhood and late adolescence war-exposed children had more internalizing psychopathologies, and at early adolescence exposed mothers had more PTSS and were less sensitive than non-exposed mothers. Children's main internalizing disorders in a descending prevalence at late childhood included specific phobia, PTSD, anxiety NOS, generalized anxiety disorder, separation anxiety, and depression. At late adolescence internalizing disorders in a descending prevalence were

specific phobia, anxiety NOS, generalized anxiety disorder, PTSD, social phobia, separation anxiety, social anxiety, and depression. Group differences in main psychopathologies at each time-point are presented in Fig. 2. There was a 4.2% increase in internalizing pathologies from late childhood to late adolescence for the whole sample (from 30.6 to 34.8%). Among exposed children, prevalence of internalizing disorders increased from 42.9% at late childhood to 51.4% at late adolescence, describing an 8.5% increase, while among controls, internalizing disorders decreased from late childhood to late adolescence (from 19.1 to 17.6%). McNemar's test for paired nominal data yielded non-significant results (which may be related to missing data), nor were there differences in the type of specific psychopathologies at the two ages (see Fig. 2).

Cortisol levels

Hair cortisol levels were between 0.01 and 11.90 pg/mg for children ($M = 2.60 \pm 3.05$) and 0.01 and 24.01 pg/mg for mothers ($M = 5.88 \pm 5.16$) for the entire sample. There was a trend toward higher HCC in exposed mothers ($p = 0.07$), but not in the children (see Table 1). No correlations emerged between HCC and children's age [$r_{(51)} = 0.02$, $p = 0.88$] and no gender differences [$t_{(51)} = -0.45$, $p = 0.65$]. Mothers' and children's HCC was inter-related [$r_{(40)} = 0.52$, $p < 0.001$].

HCC, maternal sensitivity, and PTSS impact internalizing disorders in adolescence

SEM tested our model on the mediating and moderating role of war-exposure, HCC, maternal sensitivity, and PTSS in the association between internalizing disorders across the adolescent

Table 1. Group differences among study variables

	Control		N	Exposed		N	
	M/%	s.d.		M/%	s.d.		
Sociodemographic variables							
Gender (female)	57.0%		54	45.3%		39	$\chi^2_{(1)} = 2.42$, $p = 0.120$
Child age T5	15.66	1.20	68	15.30	1.44	70	$t_{(136)} = -1.20$, $p = 0.232$
Mother age T5	42.53	4.50	62	41.76	5.58	68	$t_{(128)} = 0.86$, $p = 0.393$
Family SES (1–7)	4.18	1.41	68	4.14	0.99	68	$t_{(134)} = 0.14$, $p = 0.889$
Late childhood							
Child internalizing psychopathology	19.1%		17	42.9%		36	$\chi^2_{(1)} = 11.48$, $p = 0.001$
Maternal post-traumatic symptoms (PDS)	1.23	3.41	88	5.69	9.55	82	$t_{(168)} = -4.00$, $p < 0.001$
Early adolescence							
Child HCC (pg/mg)	2.35	2.75	28	2.88	3.39	25	$t_{(51)} = -0.63$, $p = 0.533$
Mother HCC (pg/mg)	4.92	4.46	42	6.98	5.74	36	$t_{(76)} = -1.79$, $p = 0.077$
Maternal sensitivity	3.40	1.02	49	2.93	0.93	51	$t_{(98)} = 2.42$, $p = 0.017$
Maternal post-traumatic symptoms (PCL-5)	6.69	11.14	49	20.40	17.58	57	$t_{(104)} = -4.86$, $p < 0.001$
Late adolescence							
Child internalizing psychopathology	17.6%		12	51.4%		36	$\chi^2_{(1)} = 17.35$, $p < 0.001$

Internalizing psychopathology was measured using the Developmental and Well-Being Assessment DAWBA, hair cortisol concentration (HCC) was Box-Cox transformed, maternal sensitivity was measured using the Coding Interactive Behavior Manual (CIB), and maternal post-traumatic symptoms were measured at late childhood using the Post-Traumatic Diagnostic Scale (PDS) and at early adolescence using the PTSD Checklist (PCL-5).

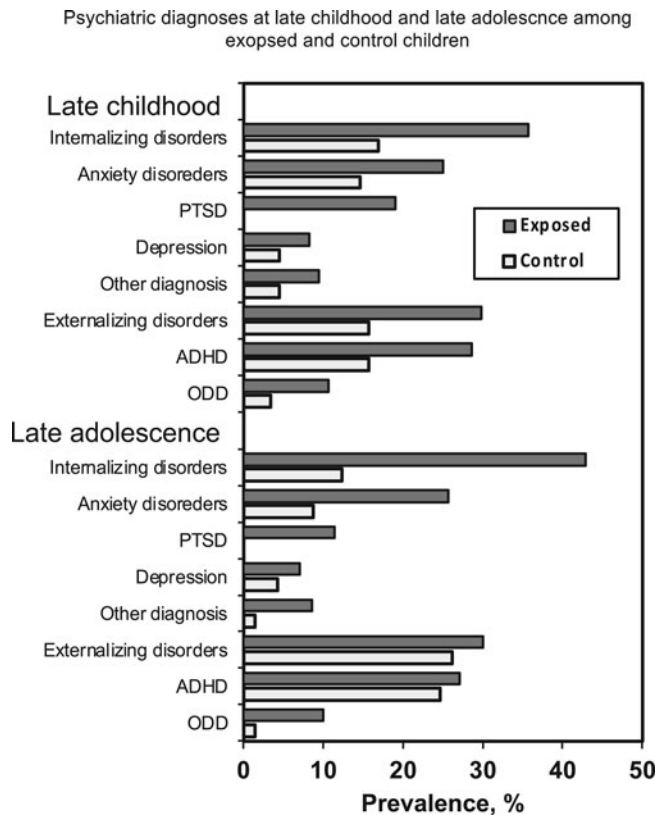


Fig. 2. Prevalence of psychiatric disorders in late childhood and late adolescence. Note: Significant difference in overall rate of internalizing diagnoses between exposed and control children at late childhood [$\chi^2_{(1)} = 7.99, p = 0.005$] and late adolescence [$\chi^2_{(1)} = 15.55, p < 0.001$]; significant between-group difference in anxiety disorders at late adolescence [$\chi^2_{(1)} = 6.26, p = 0.012$]; PTSD late childhood [$\chi^2_{(1)} = 18.68, p < 0.001$]; PTSD late adolescence [$\chi^2_{(1)} = 7.90, p = 0.005$]; ADHD late childhood [$\chi^2_{(1)} = 4.16, p = 0.041$]; ODD late adolescence [$\chi^2_{(1)} = 4.33, p = 0.037$].

transition, from late childhood to late adolescence. The overall model provided good fit to the data [$\chi^2_{(9)} = 18.12, p = 0.034, RMSEA = 0.06, CFI = 0.92, IFI = 0.91$]. The final path model is presented in Fig. 3: child psychiatric diagnosis at late childhood linked with child psychiatric diagnosis at late adolescence via three main paths:

Maternal sensitivity moderates the continuity of child diagnosis

Links between child diagnosis at late childhood and late adolescence were moderated by maternal sensitivity (coefficient = $-8.23, s.e. = 0.40, 95\% CI -1.62$ to -0.02). Child diagnosis at late childhood predicted diagnosis at late adolescence, but only for children with less sensitive mother. To further probe this indirect effect, we evaluated this path at high (1 s.d. above mean) and low (1 s.d. below mean) levels of maternal sensitivity (Hayes, 2018). A significant simple slope emerged for low maternal sensitivity ($B = -1.86, s.e. = 0.56, 95\% CI 0.75-2.96$), but when sensitivity was high, the simple slope was non-significant ($B = 0.25, s.e. = 0.41, 95\% CI -0.56-1.07$). This indicates that for children with an internalizing diagnosis in late childhood, the likelihood to be diagnosed also at late adolescence was higher for children who had less sensitive mothers.

Maternal PTSS mediates continuity of child psychopathology

The second pathway involved mediation; child diagnosis at late childhood linked with higher maternal PTSS, which in turn

predicted greater prevalence of internalizing disorders at late adolescence (estimate: 0.08, 95% CI 0.008–0.14).

Exposure, HCC, and maternal PTSS

The third pathway involved a moderation-mediation path in which war exposure moderated the link between child diagnosis and maternal HCC. This pathway began with an interaction effect (moderation), which revealed that HCC was highest among war-exposed mothers whose child showed psychiatric diagnosis at late childhood. This moderation effect was significant (coefficient = 0.28, s.e. = 0.11, 95% CI 0.05–0.51), and can be seen in Fig. 4. Evaluation of this moderation effect revealed significant positive simple slope for exposed ($B = 0.32, s.e. = 0.15, 95\% CI 0.01-0.62$), but non-significant simple slope for controls ($B = -0.23, s.e. = 0.17, 95\% CI -0.58-0.10$), indicating that only among exposed families a significant association between child's psychiatric diagnosis at late childhood and maternal HCC was found. The mediation pathway included maternal HCC, which was correlated with child HCC, later linked with maternal PTSS, which in turn predicted greater risk for psychiatric diagnosis in late adolescence. Test of mediation showed that this indirect path from child diagnosis at late childhood to late adolescence via mother and child HCC, and maternal PTSS was significant (estimate: 0.01, 95% CI 0.001–0.03). In this pathway, child diagnosis in late childhood (x) predicted child diagnosis at late adolescence (y) via exposure (moderator), maternal and child HCC (mediators), and maternal PTSS (mediator). A similar indirect pathway began with the same moderation effect, in which war exposure moderated the link between child diagnosis at late childhood and maternal HCC at early adolescence. Maternal HCC, in turn, positively predicted child's diagnosis at late adolescence (estimate: 0.06, 95% CI 0.007–0.18). Adding maternal PTSS in late childhood as a covariate did not significantly change the estimates and s.e.; however, this model provided a less adequate fit to the data (see online Supplementary Fig. S1).

Testing paths leading from HCC, maternal sensitivity, and mothers' PTSS to adolescents' externalizing disorders

To ascertain that the pathway is specific to internalizing pathology, we tried to fit externalizing disorders instead of internalizing disorders to the suggested model and found that most pathways were not significant, possibly due to the strong direct association between externalizing disorders in late childhood and externalizing disorders in late adolescence. Furthermore, the alternative externalizing model did not provide an adequate fit to the data (see online Supplementary Fig. S2), leading to the conclusion that the mediators and moderators examined here apply specifically to the continuity of internalizing disorders.

Discussion

The adolescent transition marks a period of great plasticity associated with increased risk as well as enhanced opportunities for resilience. Our study focuses on the role of maternal and child's physiological stress response, sensitive caregiving, and the mothers' post-traumatic symptomatology as moderators and mediators of the continuity of risk v. resilience across the transition to adolescence in children exposed to a specific and chronic trauma (Halevi et al., 2017; Ulmer-Yaniv et al., 2017; Yirmiya, Djalovski, Motsan, Zagoory-Sharon, & Feldman, 2018). To our

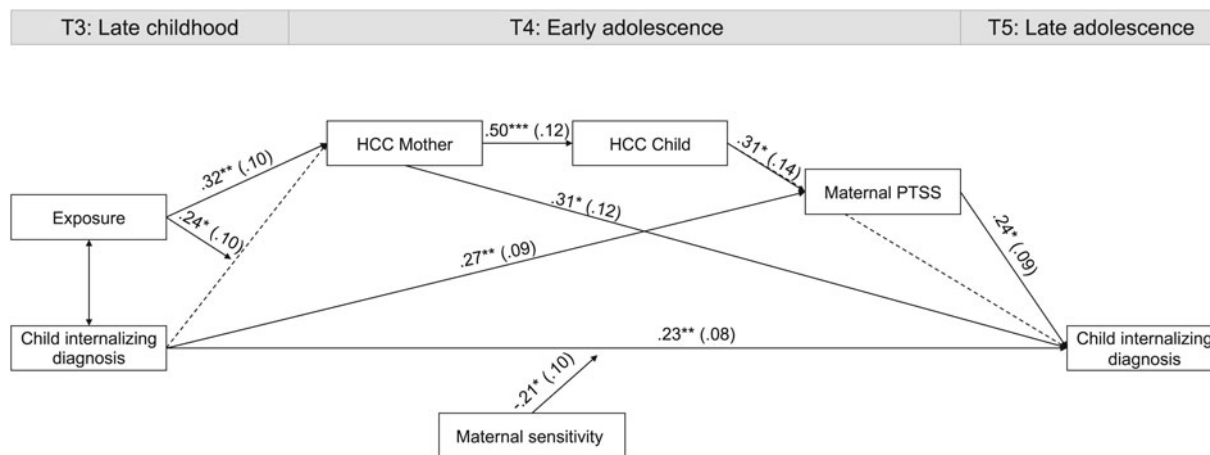


Fig. 3. Path model leading from child internalizing disorder at late childhood to child internalizing disorder at late adolescence via three mediating and moderating paths of maternal sensitivity, maternal post-traumatic stress symptoms, and child and mother HCC. Note: Coefficients represent standardized regression weights and standard errors. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. †Controlling for child age and child gender. Child diagnoses at late childhood and late adolescence were evaluated using The Developmental and Well-Being Assessment (DAWBA); maternal sensitivity was evaluated using the Coding Interactive Behavior (CIB); maternal PTSS were evaluated in early adolescence using the Post-Traumatic Stress Checklist (PCL-5). HCC, hair cortisol concentration; PTSS, post-traumatic stress symptoms.

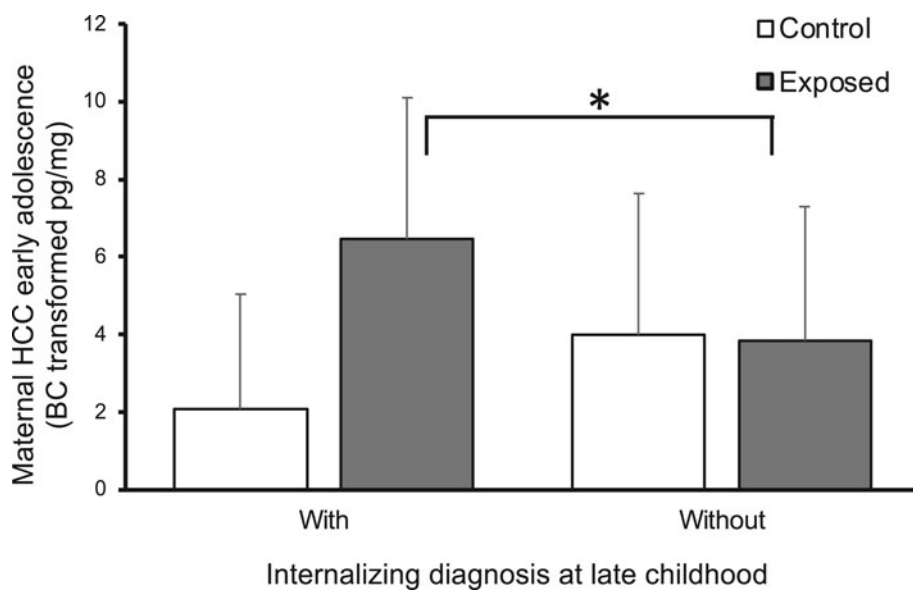


Fig. 4. The effect of internalizing diagnosis at late childhood and exposure in predicting mother's HCC levels at early adolescence: Internalizing disorder at late childhood predicted mothers' higher HCC at early adolescence for the exposed group, but not for the control group. Note: Child internalizing diagnosis was evaluated using The Developmental and Well-Being Assessment (DAWBA). HCC, hair cortisol concentration.

knowledge, this is the first study that examines the long-term effects of trauma exposure on adolescents' mental health which utilizes measures of maternal and child HCC. Overall, our sample provides a unique 'natural experiment' to study the long-term effects of trauma, as all children in the study were exposed to the exact same stressors, a rare condition in ELS and trauma-exposure research, and this opportunity may help shed further light on the direct and indirect pathways to psychopathology and resilience across a key developmental transition.

Our results indicate that more than 60% of trauma-exposed children exhibited at least one full-blown DSM internalizing disorder in late childhood and/or late adolescence, as compared to only 25% of controls, highlighting the immense burden of growing up in a harsh, unpredictable, and traumatic environment. Moreover, while only 4.2% of the control adolescents displayed unremitted psychopathology across the adolescent transition, more than half of the war-exposed children who suffered

from an internalizing diagnosis in late childhood remained symptomatic. These findings on the chronicity of war-related psychopathologies accord with research in younger children and adults (Feldman et al., 2014; Halevi et al., 2016; Hobfoll et al., 2009), but few, if any, studies tested such chronicity across the transition to adolescence. It appears that prolonged early stress leads to early-onset psychopathology that is characterized by a persistent course, with few opportunities for recovery. Still, even in such a harsh context we found that some children exhibited resilience to chronic stress exposure and the results pinpoint the interplay between maternal and child biobehavioral mediators and moderators of resilience.

Maternal sensitivity moderated the continuity of internalizing disorders from late childhood to late adolescence. Overall, exposed mothers were less sensitive compared to mothers of control children, consistent with prior research on the reduction in sensitive parenting in the context of early adversity (Crech,

Hadley, & Borsari, 2014; Kelley *et al.*, 2010; Lewig, Arney, & Salveron, 2010; Ulmer-Yaniv *et al.*, 2017; Yirmiya *et al.*, 2018). Our results suggest that only mothers who were sensitive throughout the transition showed a stress-buffering function and decreased the risk of persistent psychiatric diagnosis across the adolescent transition. Our findings also accord with studies on the concurrent and longitudinal relations between maternal insensitivity and the development of children's internalizing problems across childhood and adolescence (Feldman, 2010; Feldman & Eidelman, 2004; Kok *et al.*, 2013; Mäntymaa *et al.*, 2009; van der Voort *et al.*, 2014).

Inhibited and withdrawn parental behaviors in reaction to adolescent-related stressors were found to pose a risk for depression (Buck & Dix, 2012). Sensitive mothering may protect specifically against such age-specific stressors since research shows that behavioral inhibition in middle childhood mediated the relations between maternal sensitivity and internalizing problems in adolescence (van der Voort *et al.*, 2014). Adolescents' emotional insecurity, expressed in the parent-child relationship, may be another mediator between maternal warmth and internalizing problems in adolescence, since mental representations of the attachment relationship is important for expanding the adolescent's social world (Alegre, Benson, & Pérez-Escoda, 2014). Despite the adolescent's growing autonomy, studies have shown that adolescents still rely on closeness with their parents (Lieberman, Doyle, & Markiewicz, 1999; Yirmiya *et al.*, 2021). Consistently, maternal sensitivity has been found to predict internalizing problems in prepubertal and post-pubertal children (Haltigan, Roisman, Cauffman, & Booth-LaForce, 2017); maternal attunement moderated the effect of mother's parenting stress on adolescents' internalizing problems (Arbel *et al.*, 2020); and maternal responsiveness and autonomy support have been shown to predict adolescents' attachment style, which in turn linked with internalizing symptoms (Brenning, Soenens, Braet, & Bal, 2012).

Maternal post-traumatic symptomatology mediated the link between children's internalizing diagnosis across the transition to adolescence, and this path was significant both directly and indirectly via mother and child's HCC. The co-occurrence of mothers' and children's psychiatric symptoms following trauma has been repeatedly reported (Leen-Feldner *et al.*, 2013; Smith, Perrin, Yule, & Rabe-Hesketh, 2001; Thabet, Tawahina, El Sarraj, & Vostanis, 2008; Yirmiya *et al.*, 2021); however, most studies did not test longitudinal associations, measured bidirectional effects, or focused on adolescence. The few existing longitudinal studies showed that maternal PTSD chronicity predicted higher PTSD and anxiety among adolescents exposed to earthquake 10 years earlier (Chen *et al.*, 2020). Maternal PTSD was also found to mediate the association between hurricane-related trauma exposure and adolescents' internalizing symptoms (Spell *et al.*, 2008). These studies, combined with the current results, highlight the mother's psychopathology as a risk factor in mental health outcome of disaster-exposed even when controlling for trauma exposure.

The transmission between mothers' and children's psychiatric symptoms following trauma could be attributed to genetic factors (Sartor *et al.*, 2012). Such genetic vulnerability may increase the risk for trauma-related psychopathologies directly in both mother and child, or indirectly, via the dyadic relationship and behaviors secondary to parental psychopathology. The association between parent's and offspring's trauma-related symptoms may also stem from shared environmental factors; for instance, correlations between parent and child's depressive symptoms were found among genetically-related and unrelated dyads, which were not

explained by shared adversity factors, such as negative life events or family income (Lewis, Rice, Harold, Collishaw, & Thapar, 2011). Furthermore, in cohorts such as ours, where the whole family is exposed to the same stressor, reciprocal influences between children and parents can be expected. This phenomenon, termed the 'compound effect', describes situations in which families face trauma together and the symptoms of each family member influence and intensify those of other members (Scheeringa & Zeanah, 2001). Maternal PTSS may also relate to pathological alterations in the mother's stress response, which may link with genetic or epigenetic transmission of vulnerability to her children. Traumatic experiences and other stressors may lead to changes in stress biomarkers, such as HCC, and these may depend on the shared mother-child genotype (Koenig *et al.*, 2018).

The mother's stress-management systems in general, and HPA-axis functioning in particular, have been extensively studied as a stress-buffering mechanism for the offspring's hormonal and behavioral regulation (Hostinar, Sullivan, & Gunnar, 2014). Here, the highest levels of maternal HCC in early adolescence were among war-exposed mothers whose children suffered from internalizing disorders in late childhood, pointing to the cumulative effects of chronic stressors on maternal HPA-axis regulation. Moreover, mothers' HCC predicted both directly and indirectly, via the child's HCC and post-traumatic symptoms, the child's psychiatric diagnosis in late adolescence. Evidence from animal studies indicates that maternal HPA-axis shapes the offspring's stress response even before birth and mediates the effects of multiple contextual and psychological stressors on the maturation of stress reactivity (Barbazanges, Piazza, Le Moal, & Maccari, 1996; Dinces, Romeo, McEwen, & Tang, 2014; Seckl & Meaney, 2004). In humans, maternal HPA regulation during pregnancy shapes the infant's stress reactivity and physiological well-being (Davis, Glynn, Waffarn, & Sandman, 2011; Graham *et al.*, 2019; Khalsa *et al.*, 2018), and maternal HPA-axis regulation during gestation predicts later child internalizing problems (Graham *et al.*, 2019). Although much research has been conducted on the role of maternal-infant bonding in shaping infant stress reactivity, much less attention has been directed to adolescence in general and the adolescent transition in particular (Hostinar *et al.*, 2014). Furthermore, at both late childhood (Halevi *et al.*, 2017) and early adolescence, a strong dyadic HCC linkage was found, which reflects the coupling of maternal and child physiological responses. Since the mother signals environmental threats to her offspring, such linkage may be an important survival-related mechanism that contributes to infant adaptation and resilience.

In contrast to our hypothesis, we did not find significant differences between exposed and control participants' HCC levels. While some studies reported a decrease in HCC following trauma-exposure (Buchmüller *et al.*, 2020; Steudte *et al.*, 2013), most studies reported elevated HCC levels among trauma-exposed adults (Mewes, Reich, Skoluda, Seele, & Nater, 2017; Schumacher *et al.*, 2022; Stalder *et al.*, 2016), and in our cohort there was a trend toward higher HCC among exposed mothers. Children's HCC levels showed no differences between the exposed and control groups, which is consistent with another study on a similar cohort of war-exposed youth (Shaheen *et al.*, 2020). Such lack of difference is surprising, and suggests that the effects of trauma exposure on HCC are indirect and other factors mediate this association. One possible mediator is the type of psychiatric diagnosis; war-exposed participants varied in their psychiatric diagnoses, and previous studies demonstrated that some of these psychiatric conditions

can influence HCC in opposite directions (Koumantarou Malisiova et al., 2021; Staufenbiel et al., 2013).

In sum, the current study is first to examine maternal and adolescent's HCC, maternal PTSS, and parenting behavior as mediators and moderators of the continuity of internalizing psychopathology across the transition to adolescence. Our cohort is unique and was followed for a lengthy period. Chronic exposure to war, terror, and trauma is known to affect children's propensity to psychopathology; yet, despite much research on the effects of and the role of HPA-axis regulation, few studies focused on the adolescent transition, which shapes mental health and adaptation throughout life (Johnson et al., 2018). Our study may therefore have a unique contribution to further understanding mechanisms transmission and determinants of resilience at the transition to adolescence.

Several study limitations should be acknowledged. These include the exclusion of fathers' stress physiology and behavior and the stress-buffering effects of other close relationships, such as siblings, peers, or grandparents. Another limitation is the lack of the participants' subjective experiences of the trauma and the degree of stress it triggered, measures that could have provided a clearer picture on the associations between stress, HCC, behavior, and symptomology. Attrition and inability to collect HCC for all study participants is another limitation, which led to a relatively small sample size, especially in light of the complex statistical model carried out. In early adolescence, families were invited to our laboratory instead of the home visits we conducted at all other time-points and it was difficult for some families to participate at this measurement time-point. Our study may contribute to shed light on some of the roots of resilience, particularly to understanding the important role sensitive caregiving plays during adolescence and the involvement of chronic stress regulation in resilience (Feldman, 2020). Charting these pathways is essential for the construction of more effective interventions that take into account the important role of maternal physiology and behavior during the transition to adolescence.

Supplementary material. The supplementary material for this article can be found at <https://doi.org/10.1017/S0033291722001350>

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References

- Alegre, A., Benson, M. J., & Pérez-Escoda, N. (2014). Maternal warmth and early adolescents' internalizing symptoms and externalizing behavior: Mediation via emotional insecurity. *The Journal of Early Adolescence*, 34(6), 712–735.
- Arbel, R., Margolin, G., O'Connor, S. G., Mason, T. B., Leventhal, A. M., & Dunton, G. F. (2020). The curvilinear effect of mothers' parenting stress and attunement on children's internalizing symptoms: A six wave study of mother–youth dyads across the transition to adolescence. *Developmental Psychology*, 56(7), 1316.
- Arbuckle, J. L. (2012). *Amos*. Chicago: IBM SPSS.
- Barbazanges, A., Piazza, P. V., Le Moal, M., & Maccari, S. (1996). Maternal glucocorticoid secretion mediates long-term effects of prenatal stress. *Journal of Neuroscience*, 16(12), 3943–3949.
- Bates, R., Salsberry, P., & Ford, J. (2017). Measuring stress in young children using hair cortisol: The state of the science. *Biological Research for Nursing*, 19(5), 499–510.
- Boeckel, M. G., Viola, T. W., Daruy-Filho, L., Martinez, M., & Grassi-Oliveira, R. (2017). Intimate partner violence is associated with increased maternal hair cortisol in mother–child dyads. *Comprehensive Psychiatry*, 72, 18–24. <https://doi.org/10.1016/j.comppsy.2016.09.006>.
- Brenning, K., Soenens, B., Braet, C., & Bal, S. (2012). The role of parenting and mother–adolescent attachment in the intergenerational similarity of internalizing symptoms. *Journal of Youth and Adolescence*, 41(6), 802–816.
- Bryson, H. E., Goldfeld, S., Price, A. M. H., & Mensah, F. (2019). Hair cortisol as a measure of the stress response to social adversity in young children. *Developmental Psychobiology*, 61(4), 525–542.
- Bryson, H. E., Mensah, F., Goldfeld, S., Price, A. M. H., & Giallo, R. (2021a). Hair cortisol in mother–child dyads: Examining the roles of maternal parenting and stress in the context of early childhood adversity. *European Child and Adolescent Psychiatry*, 30(4), 563–577. <https://doi.org/10.1007/s00787-020-01537-0>.
- Bryson, H. E., Price, A. M. H., Goldfeld, S., & Mensah, F. (2021b). Associations between social adversity and young children's hair cortisol: A systematic review. *Psychoneuroendocrinology*, 127, 105176. <https://doi.org/10.1016/j.psyneuen.2021.105176>.
- Buchmüller, T., Lembcke, H., Busch, J., Kumsta, R., Wolf, O. T., & Leyendecker, B. (2020). Exploring hair steroid concentrations in asylum seekers, internally displaced refugees, and immigrants. *Stress*, 23(5), 538–545.
- Buck, K. A., & Dix, T. (2012). Can developmental changes in inhibition and peer relationships explain why depressive symptoms increase in early adolescence? *Journal of Youth and Adolescence*, 41(4), 403–413.
- Bunea, I. M., Szentágotai-Tátar, A., & Miu, A. C. (2017). Early-life adversity and cortisol response to social stress: A meta-analysis. *Translational Psychiatry*, 7(12), 1–8.
- Busso, D. S., McLaughlin, K. A., & Sheridan, M. A. (2017). Dimensions of adversity, physiological reactivity, and externalizing psychopathology in adolescence: Deprivation and threat. *Psychosomatic Medicine*, 79(2), 162–171. <https://doi.org/10.1097/PSY.0000000000000369>.
- Byrne, B. M. (2016). *Structural Equation Modeling With AMOS: Basic Concepts, Applications, and Programming* (Third Edition). Routledge. <https://doi.org/10.4324/9781315757421>.
- Chen, X.-Y., Chen, J., Shi, X., Jiang, M., Li, Y., Zhou, Y., ... Fan, F. (2020). Trajectories of maternal symptoms of posttraumatic stress disorder predict long-term mental health of children following the Wenchuan earthquake in China: A 10-year follow-up study. *Journal of Affective Disorders*, 266, 201–206.
- Cicchetti, D. (2016). Socioemotional, personality, and biological development: Illustrations from a multilevel developmental psychopathology perspective on child maltreatment. *Annual Review of Psychology*, 67, 187–211.
- Cole, D. A., & Maxwell, S. E. (2003). Testing mediational models with longitudinal data: Questions and tips in the Use of structural equation modeling. *Journal of Abnormal Psychology*, 112(4), 558–577. <https://doi.org/10.1037/0021-843X.112.4.558>.
- Creech, S. K., Hadley, W., & Borsari, B. (2014). The impact of military deployment and reintegration on children and parenting: A systematic review. *Professional Psychology: Research and Practice*, 45(6), 452.
- Crone, E. A., & Dahl, R. E. (2012). Understanding adolescence as a period of social–affective engagement and goal flexibility. *Nature Reviews Neuroscience*, 13(9), 636.
- Dahl, R. E., & Gunnar, M. R. (2009). Heightened stress responsiveness and emotional reactivity during pubertal maturation: Implications for psychopathology. *Development and Psychopathology*, 21(1), 1–6. <https://doi.org/10.1017/S0954579409000017>.
- Danese, A., & McEwen, B. S. (2012). Adverse childhood experiences, allostasis, allostatic load, and age-related disease. *Physiology and Behavior*, 106, 29–39. <https://doi.org/10.1016/j.physbeh.2011.08.019>.
- Davis, E. P., Glynn, L. M., Waffarn, F., & Sandman, C. A. (2011). Prenatal maternal stress programs infant stress regulation. *Journal of Child Psychology and Psychiatry*, 52(2), 119–129.
- Dinces, S. M., Romeo, R. D., McEwen, B. S., & Tang, A. C. (2014). Enhancing offspring hypothalamic–pituitary–adrenal (HPA) regulation via systematic

- novelty exposure: The influence of maternal HPA function. *Frontiers in Behavioral Neuroscience*, 8, 204.
- Doom, J. R., & Gunnar, M. R. (2013). Stress physiology and developmental psychopathology: Past, present, and future. *Development and Psychopathology*, 25(4 PART 2), 1359–1373. <https://doi.org/10.1017/S0954579413000667>.
- Feldman, R. (1998). *Coding interactive behavior (CIB) manual*. Unpublished manuscript. Bar-Ilan University.
- Feldman, R. (2010). The relational basis of adolescent adjustment: Trajectories of mother–child interactive behaviors from infancy to adolescence shape adolescents' adaptation. *Attachment & Human Development*, 12(1–2), 173–192. <https://doi.org/10.1080/14616730903282472>.
- Feldman, R. (2020). What is resilience: An affiliative neuroscience approach. *World Psychiatry*, 19(2), 132–150. <https://doi.org/10.1002/wps.20729>.
- Feldman, R. (2021). Social behavior as a transdiagnostic marker of resilience. *Annual Review of Clinical Psychology*, 17, 153–180. <https://doi.org/10.1146/annurev-clinpsy-081219-102046>.
- Feldman, R., & Eidelman, A. I. (2004). Parent–infant synchrony and the social-emotional development of triplets. *Developmental Psychology*, 40(6), 1133.
- Feldman, R., & Vengrober, A. (2011). Posttraumatic stress disorder in infants and young children exposed to war-related trauma. *JAAC*, 50(7), 645–658. <https://doi.org/10.1016/j.jaac.2011.03.001>.
- Feldman, R., Vengrober, A., & Ebstein, R. P. (2014). Affiliation buffers stress: Cumulative genetic risk in oxytocin-vasopressin genes combines with early caregiving to predict PTSD in war-exposed young children. *Translational Psychiatry*, 4(3), e370. <https://doi.org/10.1038/tp.2014.6>.
- Feldman, R., Vengrober, A., Eidelman-Rothman, M., & Zagoory-Sharon, O. (2013). Stress reactivity in war-exposed young children with and without post-traumatic stress disorder: Relations to maternal stress hormones, parenting, and child emotionality and regulation. *Development and Psychopathology*, 25 (4 PART 1), 943–955. <https://doi.org/10.1017/S0954579413000291>.
- Flom, M., St. John, A. M., Meyer, J. S., & Tarullo, A. R. (2017). Infant hair cortisol: Associations with salivary cortisol and environmental context. *Developmental Psychobiology*, 59(1), 26–38.
- Foa, E. B., Cashman, L., Jaycox, L., & Perry, K. (1997). The validation of a self-report measure of posttraumatic stress disorder: The posttraumatic diagnostic scale. *Psychological Assessment*, 9(4), 445.
- Galbally, M., van Rossum, E. F. C., Watson, S. J., de Kloet, E. R., & Lewis, A. J. (2019). Trans-generational stress regulation: Mother–infant cortisol and maternal mental health across the perinatal period. *Psychoneuroendocrinology*, 109, 104374.
- Gerber, M., Endes, K., Brand, S., Herrmann, C., Colledge, F., Donath, L., ... Zahner, L. (2017). In 6- to 8-year-old children, hair cortisol is associated with body mass index and somatic complaints, but not with stress, health-related quality of life, blood pressure, retinal vessel diameters, and cardiorespiratory fitness. *Psychoneuroendocrinology*, 76, 1–10. <https://doi.org/10.1016/j.psyneuen.2016.11.008>.
- Goodman, R., Ford, T., Richards, H., Gatward, R., & Meltzer, H. (2000). The development and well-being assessment: Description and initial validation of an integrated assessment of child and adolescent psychopathology. *Journal of Child Psychology and Psychiatry*, 41(5), 645–655.
- Graham, A. M., Rasmussen, J. M., Entringer, S., Ward, E. B., Rudolph, M. D., Gilmore, J. H., ... Buss, C. (2019). Maternal cortisol concentrations during pregnancy and sex-specific associations with neonatal amygdala connectivity and emerging internalizing behaviors. *Biological Psychiatry*, 85(2), 172–181.
- Gray, N. A., Dhana, A., Van Der Vyver, L., Van Wyk, J., Khumalo, N. P., & Stein, D. J. (2018). Determinants of hair cortisol concentration in children: A systematic review. *Psychoneuroendocrinology*, 87(October 2017), 204–214. <https://doi.org/10.1016/j.psyneuen.2017.10.022>.
- Green, J. G., McLaughlin, K. A., Berglund, P. A., Gruber, M. J., Sampson, N. A., Zaslavsky, A. M., & Kessler, R. C. (2010). Childhood adversities and adult psychiatric disorders in the national comorbidity survey replication I: Associations with first onset of DSM-IV disorders. *Archives of General Psychiatry*, 67(2), 113–123.
- Halevi, G., Djalovski, A., Kanat-Maymon, Y., Yirmiya, K., Zagoory-Sharon, O., Koren, L., & Feldman, R. (2017). The social transmission of risk: Maternal stress physiology, synchronous parenting, and well-being mediate the effects of war exposure on child psychopathology. *Journal of Abnormal Psychology*, 126(8), 1087–1103. <https://doi.org/10.1037/abn0000307>.
- Halevi, G., Djalovski, A., Vengrober, A., & Feldman, R. (2016). Risk and resilience trajectories in war-exposed children across the first decade of life. *Journal of Child Psychology and Psychiatry*, 57(10), 1183–1193.
- Haltigan, J. D., Roisman, G. I., Cauffman, E., & Booth-LaForce, C. (2017). Correlates of childhood vs. adolescence internalizing symptomatology from infancy to young adulthood. *Journal of Youth and Adolescence*, 46 (1), 197–212.
- Hayes, A. F. (2013). *Model templates for PROCESS for SPSS and SAS*. <https://doi.org/http://afhayes.com/public/templates.pdf>.
- Hayes, A. F. (2018). Partial, conditional, and moderated mediation: Quantification, inference, and interpretation. *Communication Monographs*, 85(1), 4–40. <https://doi.org/10.1080/03637751.2017.1352100>.
- Hayes, A. F. (2022). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach* (Third Edition). Guilford Press.
- Hobfoll, S. E., Palmieri, P. A., Johnson, R. J., Canetti-Nisim, D., Hall, B. J., & Galea, S. (2009). Trajectories of resilience, resistance, and distress during ongoing terrorism: The case of Jews and Arabs in Israel. *Journal of Consulting and Clinical Psychology*, 77(1), 138.
- Hostinar, C. E., Sullivan, R. M., & Gunnar, M. R. (2014). Psychobiological mechanisms underlying the social buffering of the hypothalamic-pituitary-adrenocortical axis: A review of animal models and human studies across development. *Psychological Bulletin*, 140(1), 256–282. <https://doi.org/10.1037/a0032671>.
- Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, 6(1), 1–55. <https://doi.org/10.1080/10705519909540118>.
- Johnson, D., Dupuis, G., Piche, J., Clayborne, Z., & Colman, I. (2018). Adult mental health outcomes of adolescent depression: A systematic review. *Depression and Anxiety*, 35(8), 700–716.
- Kelley, M. L., Self-Brown, S. R., Le, B., Bosson, J. V., Hernandez, B. C., & Gordon, A. T. (2010). Predicting posttraumatic stress symptoms in children following Hurricane Katrina: A prospective analysis of the effect of parental distress and parenting practices. *Journal of Traumatic Stress*, 23(5), 582–590. <https://doi.org/10.1002/jts.20573>.
- Kessler, R. C., Berglund, P., Demler, O., Jin, R., Merikangas, K. R., & Walters, E. E. (2005). Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Archives of General Psychiatry*, 62(6), 593–602.
- Kessler, R. C., McLaughlin, K. A., Green, J. G., Gruber, M. J., Sampson, N. A., Zaslavsky, A. M., ... Angermeyer, M. (2010). Childhood adversities and adult psychopathology in the WHO World Mental Health Surveys. *The British Journal of Psychiatry*, 197(5), 378–385.
- Khalsa, S. S., Adolphs, R., Cameron, O. G., Critchley, H. D., Davenport, P. W., Feinstein, J. S., ... Zucker, N. (2018). Interoception and mental health: A roadmap. *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging*, 3(6), 501–513. <https://doi.org/10.1016/j.bpsc.2017.12.004>.
- Khoury, J. E., Enlow, M. B., Plamondon, A., & Lyons-Ruth, K. (2019). The association between adversity and hair cortisol levels in humans: A meta-analysis. *Psychoneuroendocrinology*, 103, 104–117.
- Koenig, A. M., Ramo-Fernández, L., Boeck, C., Umlauf, M., Pauly, M., Binder, E. B., ... Kolassa, I.-T. (2018). Intergenerational gene × environment interaction of FKBP5 and childhood maltreatment on hair steroids. *Psychoneuroendocrinology*, 92, 103–112.
- Kok, R., Linting, M., Bakermans-Kranenburg, M. J., van IJzendoorn, M. H., Jaddoe, V. W. V., Hofman, A., ... Tiemeier, H. (2013). Maternal sensitivity and internalizing problems: Evidence from two longitudinal studies in early childhood. *Child Psychiatry & Human Development*, 44(6), 751–765.
- Koumantarou Malisiova, E., Mourikis, I., Darviri, C., Nicolaidis, N. C., Zervas, I. M., Papageorgiou, C., & Chrousos, G. P. (2021). Hair cortisol concentrations in mental disorders: A systematic review. *Physiology & Behavior*, 229, 113244. <https://doi.org/10.1016/j.physbeh.2020.113244>.
- Leen-Feldner, E. W., Feldner, M. T., Knapp, A., Bunaciu, L., Blumenthal, H., & Amstadter, A. B. (2013). Offspring psychological and biological correlates of parental posttraumatic stress: Review of the literature and research agenda. *Clinical Psychology Review*, 33(8), 1106–1133. <https://doi.org/10.1016/j.cpr.2013.09.001>.
- Lembcke, H., Buchmüller, T., & Leyendecker, B. (2020). Refugee mother–child dyads' hair cortisol, post-traumatic stress, and affectionate parenting.

- Psychoneuroendocrinology*, 111, 104470. <https://doi.org/10.1016/j.psyneuen.2019.104470>.
- LeMoult, J., Humphreys, K. L., Tracy, A., Hoffmeister, J. A., Ip, E., & Gotlib, I. H. (2020). Meta-analysis: Exposure to early life stress and risk for depression in childhood and adolescence. *Journal of the American Academy of Child and Adolescent Psychiatry*, 59(7), 842–855. <https://doi.org/10.1016/j.jaac.2019.10.011>.
- Lewig, K., Arney, F., & Salveron, M. (2010). Challenges to parenting in a new culture: Implications for child and family welfare. *Evaluation and Program Planning*, 33(3), 324–332.
- Lewis, G., Rice, F., Harold, G. T., Collishaw, S., & Thapar, A. (2011). Investigating environmental links between parent depression and child depressive/anxiety symptoms using an assisted conception design. *Journal of the American Academy of Child & Adolescent Psychiatry*, 50(5), 451–459.
- Lieberman, M., Doyle, A. B., & Markiewicz, D. (1999). Developmental patterns in security of attachment to mother and father in late childhood and early adolescence: Associations with peer relations. *Child Development*, 70(1), 202–213. <https://doi.org/10.1111/1467-8624.00015>.
- Lopez, M., Ruiz, M. O., Rovnaghi, C. R., Tam, G. K. Y., Hiscoc, J., Gotlib, I. H., ... Anand, K. J. S. (2021). The social ecology of childhood and early life adversity. *Pediatric Research*, 89(2), 353–367.
- Mansbach-Kleinfeld, I., Apter, A., Farbstein, I., Levine, S. Z., & Poznizovsky, A. (2010). A population-based psychometric validation study of the Strengths and Difficulties Questionnaire – Hebrew version. *Frontiers in Psychiatry*, 1, 151. <https://doi.org/10.3389/fpsy.2010.00151>.
- Mäntymaa, M., Puura, K., Luoma, I., Vihtonen, V., Salmelin, R. K., & Tamminen, T. (2009). Child's behaviour in mother–child interaction predicts later emotional and behavioural problems. *Infant and Child Development*, 18(5), 455–467.
- Martins, R. C., Blumenberg, C., Tovo-Rodrigues, L., Gonzalez, A., & Murray, J. (2020). Effects of parenting interventions on child and caregiver cortisol levels: Systematic review and meta-analysis. *BMC Psychiatry*, 20(1), 1–17.
- McConnell, R. (2014). Hair cortisol, perceived stress and dispositional optimism: A pilot study among adolescents. *Journal of Traumatic Stress Disorders & Treatment*, 3(3), 1000126. <https://doi.org/10.4172/2324-8947.1000126>.
- McLaughlin, K. A. (2016). Future directions in childhood adversity and youth psychopathology. *Journal of Clinical Child & Adolescent Psychology*, 45(3), 361–382.
- McLaughlin, K. A., Green, J. G., Gruber, M. J., Sampson, N. A., Zaslavsky, A. M., & Kessler, R. C. (2010). Childhood adversities and adult psychiatric disorders in the national comorbidity survey replication II: Associations with persistence of DSM-IV disorders. *Archives of General Psychiatry*, 67(2), 124–132.
- Merikangas, K. R., He, J., Burstein, M., Swanson, S. A., Avenevoli, S., Cui, L., ... Swendsen, J. (2010). Lifetime prevalence of mental disorders in US adolescents: Results from the National Comorbidity Survey Replication – Adolescent Supplement (NCS-A). *Journal of the American Academy of Child & Adolescent Psychiatry*, 49(10), 980–989.
- Mewes, R., Reich, H., Skoluda, N., Seele, F., & Nater, U. M. (2017). Elevated hair cortisol concentrations in recently fled asylum seekers in comparison to permanently settled immigrants and non-immigrants. *Translational Psychiatry*, 7(3), e1051. <https://doi.org/10.1038/tp.2017.14>.
- Michels, N., Van De Wiele, T., & De Henauw, S. (2017). Chronic psychosocial stress and gut health in children: Associations with calprotectin and fecal short-chain fatty acids. *Psychosomatic Medicine*, 79(8), 927–935. <https://doi.org/10.1097/PSY.0000000000000413>.
- O'Connor, D. B., Thayer, J. F., & Vedhara, K. (2021). Stress and health: A review of psychobiological processes. *Annual Review of Psychology*, 72, 663–688.
- Osborne, J. (2010). Improving your data transformations: Applying the Box-Cox transformation. *Practical Assessment, Research, and Evaluation*, 15(1), 12.
- Ouellette, S. J., Russell, E., Kryski, K. R., Sheikh, H. I., Singh, S. M., Koren, G., & Hayden, E. P. (2015). Hair cortisol concentrations in higher- and lower-stress mother–daughter dyads: A pilot study of associations and moderators. *Developmental Psychobiology*, 57(5), 519–534. <https://doi.org/10.1002/dev.21302>.
- Patton, G. C., Coffey, C., Romaniuk, H., Mackinnon, A., Carlin, J. B., Degenhardt, L., ... Moran, P. (2014). The prognosis of common mental disorders in adolescents: A 14-year prospective cohort study. *The Lancet*, 383(9926), 1404–1411.
- Rudolph, K. D., & Flynn, M. (2007). Childhood adversity and youth depression: Influence of gender and pubertal status. *Development and Psychopathology*, 19(2), 497–521. <https://doi.org/10.1017/S0954579407070241>.
- Russell, E., Koren, G., Rieder, M., & Van Uum, S. (2012). Hair cortisol as a biological marker of chronic stress: Current status, future directions and unanswered questions. *Psychoneuroendocrinology*, 37(5), 589–601. <https://doi.org/10.1016/j.psyneuen.2011.09.009>.
- Sartor, C. E., Grant, J. D., Lynskey, M. T., McCutcheon, V. V., Waldron, M., Statham, D. J., ... Martin, N. G. (2012). Common heritable contributions to low-risk trauma, high-risk trauma, posttraumatic stress disorder, and major depression. *Archives of General Psychiatry*, 69(3), 293–299.
- Scheeringa, M. S., & Zeanah, C. H. (2001). A relational perspective on PTSD in early childhood. *Journal of Traumatic Stress*, 14(4), 799–815. <https://doi.org/10.1023/A:1013002507972>.
- Schloß, S., Müller, V., Becker, K., Skoluda, N., Nater, U. M., & Pauli-Pott, U. (2019). Hair cortisol concentration in mothers and their children: Roles of maternal sensitivity and child symptoms of attention-deficit/hyperactivity disorder. *Journal of Neural Transmission*, 126(9), 1135–1144. <https://doi.org/10.1007/s00702-018-1944-7>.
- Schonblum, A., Arnon, L., Ravid, E., Salzer, L., Hadar, E., Meizner, I., ... Koren, L. (2018). Can hair steroids predict pregnancy longevity? *Reproductive Biology*, 18(4), 410–415.
- Schumacher, S., Engel, S., Klusmann, H., Niemeier, H., Küster, A., Burchert, S., ... Knaevelsrud, C. (2022). Trauma-related but not PTSD-related increases in hair cortisol concentrations in military personnel. *Journal of Psychiatric Research*, 150, 17–20. <https://doi.org/10.1016/j.jpsychires.2022.02.031>.
- Seckl, J. R., & Meaney, M. J. (2004). Glucocorticoid programming. *Annals of the New York Academy of Sciences*, 1032(44), 63–84. <https://doi.org/10.1196/annals.1314.006>.
- Shaheen, M., Schindler, L., Saar-Ashkenazy, R., Bani Odeh, K., Soreq, H., Friedman, A., & Kirschbaum, C. (2020). Victims of war – Psychoendocrine evidence for the impact of traumatic stress on psychological well-being of adolescents growing up during the Israeli–Palestinian conflict. *Psychophysiology*, 57(1), 1–11. <https://doi.org/10.1111/psyp.13271>.
- Simmons, J. G., Azpitarte, F., Roost, F. D., Dommers, E., Allen, N. B., Havighurst, S., & Haslam, N. (2019). Correlates of hair cortisol concentrations in disadvantaged young children. *Stress and Health*, 35(1), 104–111. <https://doi.org/10.1002/smi.2842>.
- Simmons, J. G., Badcock, P. B., Whittle, S. L., Byrne, M. L., Mundy, L., Patton, G. C., ... Allen, N. B. (2016). The lifetime experience of traumatic events is associated with hair cortisol concentrations in community-based children. *Psychoneuroendocrinology*, 63, 276–281. <https://doi.org/10.1016/j.psyneuen.2015.10.004>.
- Smith, P., Perrin, S., Yule, W., & Rabe-Hesketh, S. (2001). War exposure and maternal reactions in the psychological adjustment of children from Bosnia-Herzegovina. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, 42(3), 395–404. <https://doi.org/10.1111/1469-7610.00732>.
- Spell, A. W., Kelley, M. Lou, Wang, J., Self-Brown, S., Davidson, K. L., Pellegrin, A., ... Baumeister, A. (2008). The moderating effects of maternal psychopathology on children's adjustment post-Hurricane Katrina. *Journal of Clinical Child & Adolescent Psychology*, 37(3), 553–563. <https://doi.org/10.1080/15374410802148210>.
- Stalder, T., & Kirschbaum, C. (2012). Analysis of cortisol in hair -- state of the art and future directions. *Brain, Behavior, and Immunity*, 26(7), 1019–1029. <https://doi.org/10.1016/j.bbi.2012.02.002>.
- Stalder, T., Steudte-Schmiedgen, S., Alexander, N., Vater, A., Wichmann, S., Kirschbaum, C., & Miller, R. (2016). Stress-related and basic determinants of hair cortisol in humans: A meta-analysis. *Psychoneuroendocrinology*, 71, 74–75. <https://doi.org/10.1016/j.psyneuen.2016.07.193>.
- Staufenbiel, S. M., Penninx, B. W. J. H., Spijker, A. T., Elzinga, B. M., & van Rossum, E. F. C. (2013). Hair cortisol, stress exposure, and mental health in humans: A systematic review. *Psychoneuroendocrinology*, 38(8), 1220–1235. <https://doi.org/10.1016/j.psyneuen.2012.11.015>.

- Steudte, S., Kirschbaum, C., Gao, W., Alexander, N., Schönfeld, S., Hoyer, J., & Stalder, T. (2013). Hair cortisol as a biomarker of traumatization in healthy individuals and posttraumatic stress disorder patients. *Biological Psychiatry*, 74(9), 639–646. <https://doi.org/10.1016/j.biopsych.2013.03.011>.
- Steudte-Schmiedgen, S., Kirschbaum, C., Alexander, N., & Stalder, T. (2016). An integrative model linking traumatization, cortisol dysregulation and posttraumatic stress disorder: Insight from recent hair cortisol findings. *Neuroscience and Biobehavioral Reviews*, 69, 124–135. <https://doi.org/10.1016/j.neubiorev.2016.07.015>.
- Thabet, A. A., Tawahina, A. A., El Sarraj, E., & Vostanis, P. (2008). Exposure to war trauma and PTSD among parents and children in the Gaza strip. *European Child and Adolescent Psychiatry*, 17(4), 191–199. <https://doi.org/10.1007/s00787-007-0653-9>.
- Tingley, D., Yamamoto, T., Hirose, K., Keele, L., & Imai, K. (2014). Mediation: R package for causal mediation analysis. *Journal of Statistical Software*, 59(5), 1–38.
- Tofighi, D., & MacKinnon, D. P. (2016). Monte Carlo confidence intervals for complex functions of indirect effects. *Structural Equation Modeling: A Multidisciplinary Journal*, 23(2), 194–205.
- Ulmer-Yaniv, A., Djalovski, A., Priel, A., Zagoory-Sharon, O., & Feldman, R. (2018). Maternal depression alters stress and immune biomarkers in mother and child. *Depression and Anxiety*, 35(12), 1145–1157.
- Ulmer-Yaniv, A., Djalovski, A., Yirmiya, K., Halevi, G., Zagoory-Sharon, O., & Feldman, R. (2017). Maternal immune and affiliative biomarkers and sensitive parenting mediate the effects of chronic early trauma on child anxiety. *Psychological Medicine*, 48(6), 1020–1033. <https://doi.org/10.1017/S0033291717002550>.
- van Bodegom, M., Homberg, J. R., & Henckens, M. J. A. G. (2017). Modulation of the hypothalamic-pituitary-adrenal axis by early life stress exposure. *Frontiers in Cellular Neuroscience*, 11, 87.
- van der Voort, A., Linting, M., Juffer, F., Bakermans-Kranenburg, M. J., Schoenmaker, C., & van IJzendoorn, M. H. (2014). The development of adolescents' internalizing behavior: Longitudinal effects of maternal sensitivity and child inhibition. *Journal of Youth and Adolescence*, 43(4), 528–540.
- Villanueva, L., Montoya-Castilla, I., & Prado-Gascó, V. (2017). The importance of trait emotional intelligence and feelings in the prediction of perceived and biological stress in adolescents: Hierarchical regressions and fsQCA models. *Stress*, 20(4), 355–362. <https://doi.org/10.1080/10253890.2017.1340451>.
- Weathers, F. W., Litz, B. T., Keane, T. M., Palmieri, P. A., Marx, B. P., & Schnurr, P. P. (2013). *The PTSD checklist for DSM-5 (PCL-5)*. National Center for PTSD. <https://www.ptsd.va.gov>.
- White, L. O., Ising, M., von Klitzing, K., Sierau, S., Michel, A., Klein, A. M., ... Stalder, T. (2017). Reduced hair cortisol after maltreatment mediates externalizing symptoms in middle childhood and adolescence. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 58(9), 998–1007. <https://doi.org/10.1111/jcpp.12700>.
- Windhorst, D. A., Rippe, R. C. A., Mileva-Seitz, V. R., Verhulst, F. C., Jaddoe, V. W. V., Noppe, G., ... Bakermans-Kranenburg, M. J. (2017). Mild perinatal adversities moderate the association between maternal harsh parenting and hair cortisol: Evidence for differential susceptibility. *Developmental Psychobiology*, 59(3), 324–337. <https://doi.org/10.1002/dev.21497>.
- Yirmiya, K., Djalovski, A., Motsan, S., Zagoory-Sharon, O., & Feldman, R. (2018). Stress and immune biomarkers interact with parenting behavior to shape anxiety symptoms in trauma-exposed youth. *Psychoneuroendocrinology*, 98, 153–160.
- Yirmiya, K., Motsan, S., Kanat-Maymon, Y., & Feldman, R. (2021). From mothers to children and back: Bidirectional processes in the cross-generational transmission of anxiety from early childhood to early adolescence. *Depression and Anxiety*, 38(12), 1298–1312.
- Young, E. S., Doom, J. R., Farrell, A. K., Carlson, E. A., Englund, M. M., Miller, G. E., ... Simpson, J. A. (2021). Life stress and cortisol reactivity: An exploratory analysis of the effects of stress exposure across life on HPA-axis functioning. *Development and Psychopathology*, 33(1), 301–312.