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Socioeconomic Status, Hair Cortisol and Internalizing Symptoms in Parents and Children

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Abstract

Socioeconomic disadvantage is consistently linked with higher risk for internalizing problems, and stress is likely one important mechanism explaining this increased risk. Few studies have examined socioeconomic differences in hair cortisol, a novel biomarker of long-term adrenocortical activity and chronic stress. Moreover, no studies have examined whether differences in hair cortisol might explain socioeconomic disparities in internalizing problems. To address these gaps, we first examined relations of socioeconomic status (SES; family income and parental education) to variation in both parents' and children's hair cortisol concentrations (HCC) and then tested whether HCC and perceptions of stress mediated relations of SES to parents' and children's internalizing symptoms. Participants were a socioeconomically diverse sample of 35 parents and 26 children (ages 5 to 7). Parents completed questionnaires, and hair samples were collected from parents and children. Parents reported on children's internalizing symptoms on average 2 years after the initial visit. Results demonstrated that lower parental education was associated with higher HCC for both parents and children. Effects for child HCC held even after controlling for parent HCC. Lower family income was associated with higher parent HCC, but not child HCC. This relation was nonlinear, such that the relation between HCC and income was strongest among the most disadvantaged parents. Furthermore, associations of SES with parental anxiety were significantly mediated by parental perceptions of stress and marginally mediated by parent HCC. These findings suggest that socioeconomic disadvantage is associated with greater accumulation of cortisol in hair in parents and children, and that both perceived and biological markers of stress capture important facets of the experiences that underlie socioeconomic disparities in adult anxiety.

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Keywords

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1. Introduction

1.1 SES, Hair Cortisol and Internalizing Symptoms in Children and their Parents

There are well-established socioeconomic disparities in risk for internalizing problems, such as anxiety and depression, with a greater risk for such problems among both low SES adults (Alegria et al., 2000; Callan et al., 2015; Hudson, 2005; Lorant et al., 2003; Murali and Oyebode, 2004) and children from low SES families (Bradley and Corwyn, 2002; Evans and Cassells, 2014; McLaughlin et al., 2011; Reiss, 2013; Slopen et al., 2010; Tracy et al., 2008). Low-SES families frequently face a host of stressors, such as financial uncertainty, crowding, noise, household chaos, fewer family routines, and a generally higher level of unpredictability, all of which can contribute to an increase in stress for both parents and children (Adler and Snibbe, 2003; Combs-Orme and Cain, 2006; Evans et al., 2005). Indeed, socioeconomic disadvantage has been linked with higher levels of stress, at both the behavioral (e.g., perceptions of stress) and physiological levels (e.g., salivary cortisol) (Dowd et al., 2009). In addition, behavioral measures of stress and salivary cortisol have been linked with internalizing problems (Russell et al 2012; Staufenbiel et al 2013). Yet, few studies of SES have focused on measures of chronic physiological stress, such as hair cortisol concentration (HCC). There is also a lack of research investigating associations among SES, HCC, and risk of internalizing problems in parents and children. To address these gaps in the literature, we first examined relations of SES to HCC in parents and children. We then examined the extent to which HCC and parental perceptions of stress mediated the association between SES and internalizing symptoms in parents and children.

1.2 Associations between SES and Hair Cortisol

Several studies have demonstrated links between SES and variations in cortisol in both children and adults (Dowd et al., 2009). These earlier studies, however, used salivary, urinary, or serum measures of cortisol which are affected by acute factors and which provide estimates of HPA axis activity at a certain point in time. As such, they are limited in their ability to capture *chronic* stress (Staufenbiel et al., 2013). Recently, the measurement of cortisol in hair (HCC) has emerged as a promising technique for assessing chronic stress levels (Russell et al., 2012). Cortisol accumulates in hair as it grows and is stable for at least the first 6cm of hair, which corresponds to about 6 months of hair growth (Russell et al., 2012). As SES is a proxy for chronic stress, it may be that hair cortisol, as a biological marker of chronic stress, would be more strongly linked to SES and would better explain socioeconomic disparities in internalizing problems than would other physiological measures of stress.

Several recent studies have examined associations between SES and HCC, and findings have been mixed. In adults, one study reported that lower income was associated with higher HCC (Serwinski et al., 2016), but others have not found differences in adult HCC by income (Chen et al., 2013; Wosu et al., 2015) or education (Serwinski et al, 2016; Wosu et al.,

2015). In children, some studies have reported that lower parental education (Rippe et al., 2016; Vaghri et al., 2013; Vliegenthart et al., 2016) and lower family income (Rippe et al., 2016) are associated with higher HCC, whereas others have not found associations between child HCC and parental income (Vaghri et al., 2013) or parental education (Groeneveld et al., 2013; Karlen et al., 2013; Liu et al., 2016). At least two of these studies, however, may have been limited in their ability to detect associations of SES with HCC because they utilized small samples, which were not purposefully recruited from a broad range of socioeconomic backgrounds (Groeneveld et al., 2013; Liu et al., 2016). Differences in the measurement of SES may also have contributed to these mixed findings. Even among those measuring the same construct (i.e., income or education), some studies used continuous measures whereas others used categorical measures, which also differed across studies. Interestingly, Karlen et al. (2013) did find that children living in apartments versus in villas had higher cortisol, suggesting that socioeconomic differences may have played a role. Moreover, because there may be some genetic heritability of HCC (Karlen et al., 2013), it may be important to control for parental HCC when examining SES disparities in child HCC, in order to rule out possible genetic bias.

1.3 Associations between Hair Cortisol and Internalizing Problems

There has long been interest in understanding the role of the HPA axis in anxiety and depressive disorders. However, most prior studies examining these associations have measured salivary or serum cortisol (Staufenbiel et al., 2013). Higher HCC have been hypothesized to be associated with anxiety and depression in both children and adults, but evidence regarding these associations has been mixed (Ouellette et al., 2015). One study reported higher HCC in adults diagnosed with depression (Dettenborn et al., 2012) whereas other work has found no difference in HCC by depression diagnosis in a sample of patients with coronary artery disease (Dowlati et al., 2010) and no relation of HCC to depressive symptoms (Ouellette et al., 2015). One study of adults found that lower HCC was associated with generalized anxiety disorder (Steudte et al., 2011). In children, higher maternal depression has been associated with lower HCC at 1 year of age (Palmer et al., 2013), but another study found no association between children's HCC and their symptoms of anxiety or depression (Ouellette et al., 2015). This mixed pattern of results may be influenced by differences in the measurement of internalizing problems (i.e., diagnosis versus symptom report) or by diversity across samples in terms of demographic characteristics such as age, sex, and comorbidities.

1.4 The Current Study

In the current study, we first examined associations between SES (family income and parental education) and HCC in parents and children. Importantly, because there may be some genetic basis for HCC (Karlen et al., 2013), we controlled for parent HCC when examining socioeconomic differences in children's HCC. Family income and parental education were analyzed separately because they contribute distinctly to children's development (Duncan and Magnuson, 2012; Hanson et al., 2011; Noble et al., 2012). Second, we investigated associations between HCC and internalizing symptoms in parents and children. These analyses controlled for SES and parental perceptions of stress. Finally, given the large prior literature documenting socioeconomic disparities in risk for

internalizing problems, we examined whether relations of SES to anxiety and depression in both parents and children were mediated by parental perceptions of stress and by parents' or children's own HCC, respectively. Given that perceptions of stress and physiological measures of stress are largely dissociable (e.g., Gunnar et al., 1981), we examined the independent roles of both parental perceptions of stress and HCC as mediating mechanisms.

2. Materials and Methods

2.1 Participants

We recruited a socioeconomically diverse sample of children and their parents through local street festivals, children's events, and posting flyers in local neighborhoods in a large Northeastern U.S. city. Recruitment aimed to reach families from a range of socioeconomic backgrounds. More specifically, we aimed to enroll roughly equal numbers of mothers with high school, some college, college, and post-graduate education.

2.2 Procedure

During a lab visit, parents and their children first provided informed consent. Parents completed questionnaires, including measures of perceived stress and self-report measures of their own internalizing symptoms. Hair samples were collected from parents (n = 35) and children (n = 28) in order to assess cortisol accumulation in hair. Hair samples were not collected in instances when hair was too short or the participant did not agree to provide a sample. None of the parents were from the same household. Measures of child internalizing symptoms (n = 22 of the 28 children who provided hair samples) were collected during a follow-up phone call with parents, which on average, occurred 2 years after the initial visit. All procedures were approved by the Institutional Review Board at the New York State Psychiatric Institute.

2.3 Measures

2.3.1 Socioeconomic Status (SES)

Parental education: Parents reported the number of years of education completed by each parent in the household. Parental education level was averaged if there were two parents in the household to compute an average parental education measure.

Family income: Parents reported their annual household income and the number of people living in the household. Income-to-needs ratio (ITN) was calculated by dividing household income by the poverty threshold for the size of the family. Family income-to-needs ratio was used in all analyses and was Winsorized and log transformed to correct for a skewed distribution.

2.3.2 Hair Cortisol—A research staff member cut a small section of hair proximal to the posterior vertex of the participant's scalp. Each hair sample weighed at least 15mg and was approximately 3cm long, thereby containing cortisol deposited during roughly the past 3 months. Samples were stored at −20ºC until all data collection was complete, after which they were sent to the University of Massachusetts for analysis. Samples were processed and

analyzed using methods previously validated and described in detail (Davenport, et al., 2006; Meyer, et al., 2014). Briefly, each sample was weighed, washed twice in isopropanol to remove external contaminants, ground to a fine powder, and extracted with methanol. The methanol extract was evaporated, redissolved in assay buffer, and analyzed in duplicate along with standards and quality controls by a sensitive and specific enzyme-linked immunosorbent assay (Salimetrics, Carlsbad, CA). Assay readout was converted to pg cortisol per mg dry hair weight. Intra- and inter-assay coefficients of variation for this assay are <10%.

2.3.3 Parental Perceived Stress—Parents completed the Perceived Stress Scale (PSS) (Cohen et al., 1983), the Material Deprivation Scale, and the Life Experiences Survey (Sarason et al., 1978). The PSS is a 14-item scale that asked parents about their feelings and thoughts about their stress and ability to control their stress during the last month. For each item, they were asked to mark how often they felt or thought a certain way on a 5-point scale ranging from 0 (*never*) to 4 (*very often*). Items were reverse coded when appropriate and then summed to create a total score (α = .835).

In the Material Deprivation Scale, parents were asked a series of 14 questions based on five possible hardships in bills, utilities, food, medicine, homelessness, and housing instability. Parents were asked if they experienced hardships in these areas within the past 12 months, and provided a dichotomous answer (*yes* or *no*). All affirmative answers were recorded and summed to create a total score (α = .767).

In the Life Experiences Survey (LES; Sarason et al., 1978), parents were asked about 44 life events that may have occurred in the past year. For each event that occurred, parents rated the impact of the event on a 7-point scale ranging from -3 (*extremely negative impact*) to +3 (*extremely positive impact*). Scores from events rated as negative were summed to create a total negative life events impact score. The LES negative events scale has demonstrated good test-retest reliability (Sarason et al., 1978).

The Life Events negative impact score was positively correlated with both the material deprivation score (r = .434, p = .009) and the perceived stress scale score (r = .497, p = .002). The correlation between material deprivation and the perceived stress scale scores was also moderate and positive, although it did not reach significance (r = .261, p = .129). To reduce measurement error and increase power, we created a composite measure of parental perceptions of stress by standardizing and averaging the perceived stress scale score, LES negative impact score, and the material deprivation score.

2.3.4 Parental Internalizing Symptoms

Depression: Parental depressive symptoms were measured using the 9-item Patient Health Questionnaire (PHQ-9; Kroenke et al., 2001). The PHQ-9 is a self-report measure of depression based on the Diagnostic and Statistical Manual (DSM) criteria for major depressive disorder (MDD). Participants are asked to indicate how often in the past 2 weeks they have been bothered by depressive symptoms using a 4-point scale ranging from 0 (*not at all*) to 3 (*nearly every day*). Participant responses are then summed to create a total score, with higher total scores indicating greater depressive symptoms (α = .836). The PHQ-9 has

well-established internal consistency, test-retest reliability, and validity (Kroenke et al., 2001; Lee et al., 2007) .

Anxiety: Parental anxiety symptoms were measured using the Beck Anxiety Inventory (BAI; Beck and Steer, 1990). The BAI is a 21-item self-report measure of physiological and cognitive anxiety symptoms. Participants are asked to indicate how often in the past week they were bothered by anxiety symptoms using a 4-point scale ranging from 0 (*not at all*) to 3 (*severely/could barely stand it*). Participant responses are then summed to create a total score with higher scores indicating greater anxiety symptoms (α = .912). The BAI has strong internal consistency, test-retest reliability, and concurrent validity (Beck and Steer, 1991).

2.3.5 Child Internalizing Symptoms—The Revised Child Anxiety and Depression Scale – Parent Version (RCADS-P; Chorpita et al., 2005) is a 47-item parent-report measure of child anxiety and depression. It has been used for children aged 6–18 years. Parents are asked to rate items on a scale ranging from 0 (*never*) to 3 (*always*). The RCADS-P has been found to have adequate internal consistency and validity (Ebesutani et al., 2015). Child anxiety symptoms were measured using the anxiety total score (α = .915) and child depression symptoms were measured using the depression subscale (α = .564).

The Child Behavior Problems Index (BPI; Peterson and Zill, 1986) is a 30-item parent-report scale measuring internalizing and externalizing symptoms in children aged 4–17 years. It has been used in large national studies such as the National Longitudinal Survey of Youth and the Panel Study of Income Dynamics. Child behaviors are rated using a 3-point scale ranging from 1 (*not true*) to 3 (*very often true*). Internalizing symptoms were measured by summing scores on 13 items pertaining to internalizing symptoms (α = .865) as was done in the Panel Study of Income Dynamics (The Child Development Supplement to the Panel Study of Income Dynamics User Guide: Release 1997).

Thus, child measures of internalizing symptoms included separate measures of child anxiety and depressive symptoms as well as an overall measure of internalizing symptoms.

2.4 Analysis Plan

Associations between SES and HCC: We first used regression analysis to examine whether parental education and family income were related to parental HCC. Next, we used regression analysis to examine whether parental education and family income were associated with children's HCC, after controlling for parents' HCC.

Associations between HCC and internalizing symptoms: We then used regression analysis to investigate whether HCC in parents and children were independently associated with internalizing symptoms in parents and children, respectively, after controlling for socioeconomic indicators and parental perceptions of stress.

Mediation models: SES, HCC, and internalizing symptoms: Finally, we examined whether SES disparities in internalizing symptoms were mediated by HCC and parental perceptions

of stress. The INDIRECT macro was used to generate bias corrected confidence intervals from bootstrap mediation models (Preacher and Hayes, 2008).

All analyses controlled for either parent or child age, sex, and race as appropriate. Our current analyses were limited to the 35 parents and 28 children for whom parent or child HCC data were available. Analyses including both child and parent HCC were restricted to a subsample of 26 parent-child dyads for whom these data are available. Given these small sample sizes, power was sufficient to detect effects in the medium to large range. Analyses of child internalizing symptoms were restricted to the subset of 22 children for whom these data were available. Analyses were conducted with SPSS Statistics Version 22.

3. Results

3.1 Descriptive Statistics

Consistent with our sampling plan, parental education ranged from 6.5 – 20 years (M = 14.4, SD = 3). Family income-to-needs ratio, defined as family income divided by the federal poverty level for a family of that size, ranged from .32 to 14.08 (M = 2.91, SD = 2.73), which included families below the poverty line as well as very high-income families. Parent and child demographic characteristics are present in Table 1.

3.2 Associations between SES and HCC

Parents: Lower parental education was linearly associated with higher parent HCC ($\beta = -.602$, $p = .004$) (Figure 1). Lower family income-to-needs ratio was associated with higher parental HCC. Here, the logarithmic function was the best fit for the data ($\beta = -.445$, $p = .025$), suggesting that the greatest differences in cortisol were seen at the lowest income levels (Figure 2). Parent age, sex, and race were unrelated to HCC in both of the models.

Children: Lower parental education was linearly associated with higher child HCC ($\beta = -.675$, $p = .009$) when controlling for parent HCC and child characteristics (Figure 3). Family income was not significantly related to child HCC in either a linear or logarithmic pattern. Being Hispanic/Latino was also associated with lower child HCC ($\beta = -.551$, $p = .05$). Child age, sex, and parent HCC were unrelated to child HCC.

3.3 Associations between HCC and Internalizing Symptoms

Parents: We next examined whether parental HCC was independently associated with parent internalizing symptoms after controlling for socioeconomic factors and parental perceived stress. As shown in Table 2 (Model A), higher parental HCC ($\beta = .25$, $p = .047$) was associated with higher parental anxiety symptoms, independent of family income and parental perceptions of stress. Higher parental perceived stress was associated with higher parental anxiety symptoms ($\beta = .586$, $p < .001$). The same pattern of results was found when parental education was substituted for family income.

As shown in Table 2 (Model B), parental HCC ($\beta = .109$, $p = .423$) was not significantly associated with parental depression symptoms after accounting for family income and parental perceptions of stress. Parental perceived stress was associated with higher parental

depressive symptoms (β = .514, p = .001). The same pattern of results was found when parental education was substituted for family income.

Children: We then examined whether child HCC was independently associated with internalizing symptoms after controlling for socioeconomic factors and parental perceived stress. As shown in Table 3, child HCC was not significantly associated with any measure of children's internalizing symptoms. Higher parental perceptions of stress were associated with higher internalizing symptoms in children as measured by the BPI (β = .485, p = .035) when income was used as the measure of SES (Model C). The same pattern of results was found when parental education was substituted for family income.

As shown in Table 3, higher parental perceptions of stress were associated with higher levels of child anxiety symptoms as measured by the RCADS (β = .478, p = .047) when family income was used as the measure of SES (Model D), but this relation was only marginally significant when parental education was used as the measure of SES.

As shown in Table 3, higher parental perceptions of stress were associated with higher levels of child depression symptoms as measured by the RCADS (β = .515, p = .044) when family income was used as the measure of SES (Model E), but this relation was only marginally significant when parental education was used as the measure of SES.

3.4 HCC and Parental Perceptions of Stress as Mediators of Socioeconomic Differences in Internalizing Symptoms

Preliminary analysis indicated that parental HCC and parental perceptions of stress were not significantly related to each other (r = .274, p = .112).

Parents: Family income to needs ratio (β = −.613, p = .001; β = −.567, p = .001) and parental education (β = −.574, p = .005; β = −.542, p = .006) were both significantly inversely associated with parental anxiety and depressive symptoms, respectively (even after controlling for parent age, sex, and race), raising questions about potential mediating factors. We used bootstrap mediation models to examine whether parental perceptions of stress and parental HCC mediated relations of family income and parental education to parental internalizing symptoms.

The association of family income with parent anxiety was significantly mediated by parental perceptions of stress (95% CI: [−7.199, −.958]) and marginally mediated by parent HCC (90% CI: [−4.126, −.051]).

The association of parental education with parent anxiety was significantly mediated by parental perceptions of stress 95% CI: [−2.832, −.307] and marginally mediated by parent HCC 90% CI: [−1.537, −.024].

The association of family income with parent depression was significantly mediated by parental perceptions of stress 95% CI: [−3.251, −.251] but not by parent HCC.

The association of parental education with parent depression was significantly mediated by parental perceptions of stress 95% CI: [−1.261, −0.098] but not by parent HCC.

Children: In regression models, family income and parental education were unrelated to internalizing symptoms. There were no significant indirect effects of family income or parental education on any measure of child internalizing symptoms through parental perceived stress or child HCC.

4. Discussion

This is the first study to examine socioeconomic differences in HCC of children and their parents and to examine the ways in which HCC and parental perceptions of stress may mediate relations between SES and internalizing symptoms in both parents and children. Our results indicated that lower parental education and lower family income were related to higher HCC among parents. Interestingly, the relation between family income and parental HCC was logarithmic such that differences in HCC were more pronounced among those at the lower end of the income distribution. This finding is consistent with a large body of research indicating that incremental differences in income have the largest effects at the lowest income levels (Duncan and Magnuson, 2003; Noble et al., 2015).

Additionally, we found that lower parental education was related to higher HCC in children, which is consistent with two prior studies (Vaghri et al., 2013; Vliegenthart et al., 2016), but contrasts with three studies reporting null relations (Groeneveld et al., 2013; Karlen et al., 2013; Liu et al., 2016). These three studies, however, had restricted ranges of parental education, which may have made it more difficult to detect an effect. Importantly, the relation of parental education to child HCC was robust to controlling for parental HCC. Although prior work has suggested that HCC may be heritable (Karlen et al., 2013), no studies to date have controlled for parent hair cortisol when examining SES differences in children's HCC. By controlling for parent HCC, our results suggest that parental education may have unique effects on children's cortisol that are independent of familial heritable differences in stress physiology. Interestingly, family income was not associated with child HCC, consistent with prior work (Vaghri et al., 2013).

We did not hypothesize *a priori* that only parental education, and not family income, would predict children's HCC. One possible explanation for this finding comes from a large literature suggesting that parental education may be particularly associated with the quality of parenting that children experience, whereas family income may be more highly associated with children's experience of material resources (Duncan and Magnuson, 2003). It is thus possible that characteristics of parenting, such as warmth and harshness, affect children's stress physiology more directly than access to material goods. For parents, on the other hand, it is possible that both low income and low education may lead to increased stress as parents are faced with the tasks of paying for food, housing, utilities, and other daily expenses as well as with the tasks of organizing and managing their families' lives. Future work would benefit from including more specific measures of parenting and parenting related stress, such as the Parenting Stress Index (Abidin, 1995), in order to examine these pathways in more detail.

After having established relations between SES factors and both parental and child HCC, we were next interested in extending these findings to examine the role that HCC might play in socioeconomic disparities in anxiety and depression. Among parents, higher education and higher family income were both associated with lower anxiety and lower depressive symptoms, consistent with a large body of work demonstrating SES disparities in internalizing symptoms (Alegria et al., 2000; Callan et al., 2015; Hudson, 2005; Lorant et al., 2003). After controlling for family income or education, both higher parental perceptions of stress and parent HCC were significantly related to anxiety symptoms. Only parental perceptions of stress were related to depressive symptoms. This is consistent with two prior studies, which found no relations of HCC to depression diagnosis or symptoms (Dowlati et al., 2010; Ouellette et al., 2015). In the present study, the magnitudes of the effects of HCC were moderately large, and the magnitudes of the effects of parental perceptions of stress were large with a one standard deviation difference in parental perceived stress accounting for over half (.514 – .657) of a standard deviation difference in anxiety or depressive symptoms. These findings add to an emerging body of literature examining relations of HCC to internalizing problems in adults. More broadly, the findings illustrate the importance of considering both physiological and psychosocial aspects of stress, as both of these components were significantly associated with parental anxiety symptoms. Moreover, the finding that these two components were unrelated to each other further highlights the importance of considering both physiological and psychosocial aspects. We did not hypothesize that the psychosocial measure of stress would be more strongly related to anxiety symptoms than would HCC, but it is possible that the strength of this association is in part driven by the fact that both of these measures were assessed through the same method (i.e., parent self-report).

Our formal tests of mediation demonstrated that parental perceptions of stress significantly mediated associations of family income and parental education to both parental depressive and anxiety symptoms. This finding is consistent with a broader body of work, which has suggested that the SES disparities in health are in part explained by greater exposure to stressors (Evans and Kim, 2010; Evans and Cassells, 2014; Matthews et al., 2010). We hypothesized that physiological stress as measured by HCC would also play a role in explaining the SES disparities in anxiety and depression. However, HCC only marginally mediated relations of family income and parental education to parent anxiety, and did not play a role in parent depression. This marginally significant result suggests that examining this pathway in a larger sample may be a productive direction for future research.

For children, we found some evidence that parental perceived stress was related to internalizing symptoms, which was consistent with our adult findings. It is possible that events and circumstances perceived as stressful by parents are also perceived by their children to be stressful. Alternatively, or in conjunction, parental perceived stress may be transmitted to children through differences in parenting behaviors or other facets of the home environment. In contrast to our findings for parents, however, we did not find any associations between SES or HCC and internalizing symptoms. The lag in time between the measurement of HCC and the measurement of internalizing symptoms, however, may have played a role in this null result. Unfortunately, measures of children's internalizing symptoms concurrent to HCC measurement were not available. Given evidence linking early

experiences of stress with psychopathology in adolescence (Grant et al., 2004), it is highly possible that early chronic stress as measured by HCC could be related to later internalizing symptoms. However, the very small sample for this analysis made it impossible to detect all but large effects. Moreover, it may be that internalizing symptoms associated with early life stress would not appear until children approach adolescence. Future work examining concurrent measures of HCC and internalizing symptoms will help to clarify some of these possibilities.

Finally, although not hypothesized *a priori*, we found that Hispanic/Latino ethnicity was associated with lower depressive and anxious symptoms among adults and children and with lower HCC in children. This finding is consistent with epidemiological work demonstrating a lower lifetime prevalence of anxiety and depressive disorders among Latinos as compared to non-Latino whites (Alegria et al., 2008). This body of work, however, has also shown that prevalence of these disorders differs by sub-ethnicity and immigrant status, which are two factors that should be considered in future work aiming to clarify the effects of Hispanic ethnicity on HCC and internalizing symptoms.

4.1 Limitations

Overall, the study was limited by its relatively small sample size. The purposeful recruitment of participants from diverse SES backgrounds, however, likely strengthened the ability to detect significant associations between SES factors and HCC, despite the small number of participants. Additionally, the analyses of internalizing symptoms in children were particularly limited by an even smaller sample size than the other analyses and by an average lag in time of two years between the time when SES and hair cortisol were measured and when internalizing symptoms were assessed. As such, these analyses should be viewed as exploratory. Given the positive findings in adults, future work should continue to examine these associations in larger samples of children where the measurement of physiological and perceived stress are contemporaneous with the measurement of children's internalizing symptoms. Moreover, including child report of internalizing symptoms (for children 8 years of age and older) could be a productive direction for future work.

4.2 Conclusions

This study demonstrates important links between family SES and HCC in both parents and children. Importantly, it is the first study to show that the association between SES and child HCC is independent of parent HCC. Moreover, this is the first study to examine HCC as a mediator of SES disparities in internalizing symptoms. Our finding that HCC and parental perceived stress were independently associated with parents' internalizing symptoms suggests that it is important to simultaneously consider multiple aspects of stress in order to understand the emergence of internalizing symptoms.

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Highlights

- Parents with lower family incomes had higher hair cortisol concentration (HCC)
- Relation between HCC and income was strongest among the most disadvantaged parents
- Lower parental education was associated with higher HCC in parents and children
- Perceived stress mediated socioeconomic disparities in parents' anxiety symptoms
- HCC marginally mediated socioeconomic disparities in parents' anxiety symptoms

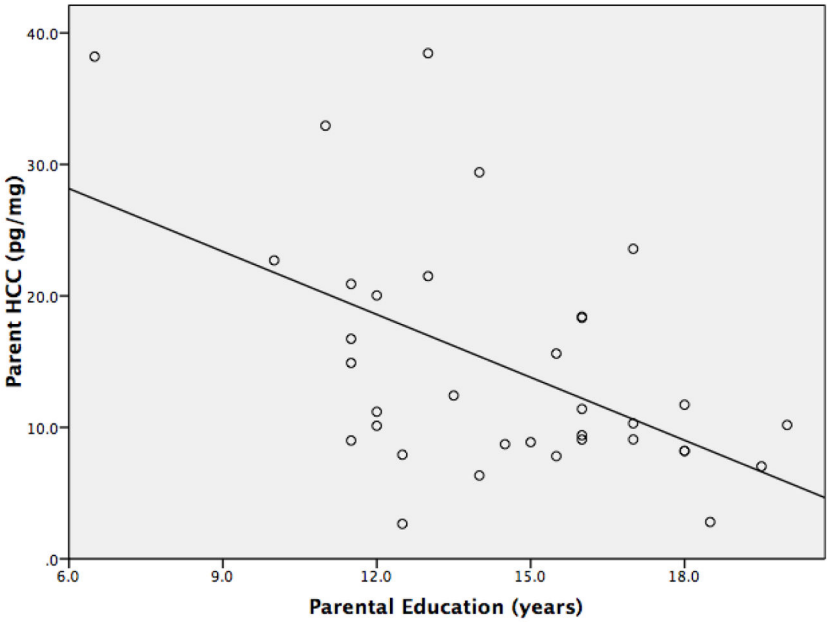

Figure 1.

Parental education is inversely linearly associated with parents' hair cortisol concentration (HCC). Figure depicts unadjusted bivariate association.

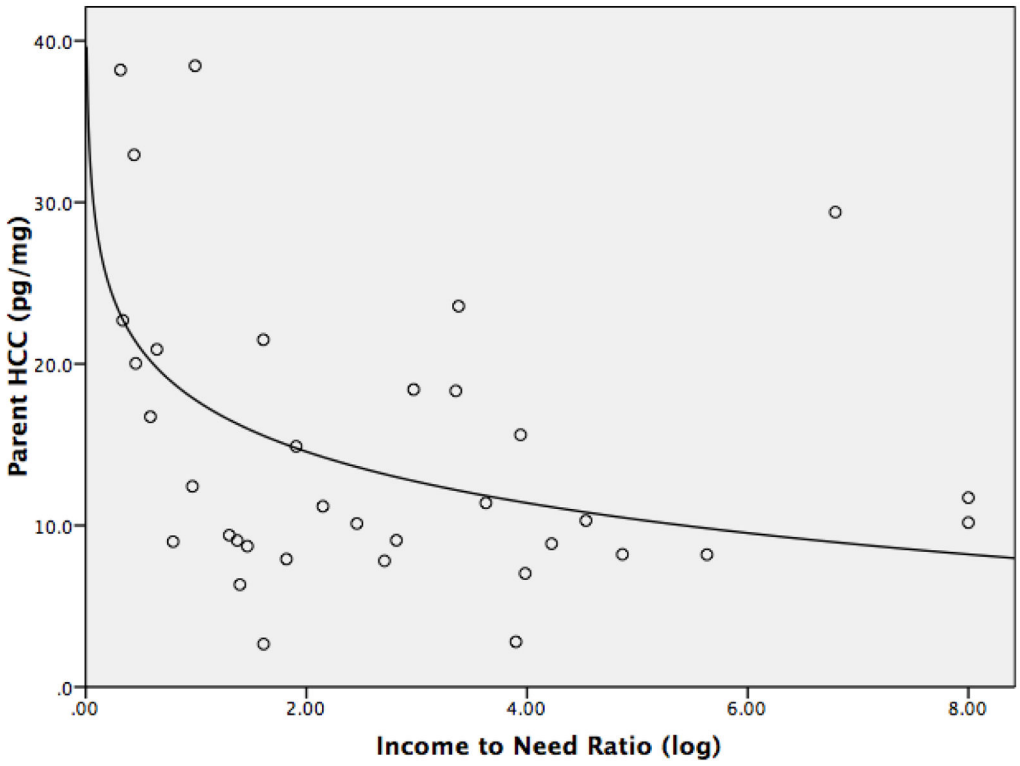

Figure 2.

Parental income is logarithmically associated with parents' hair cortisol concentration (HCC). Figure depicts unadjusted bivariate association.

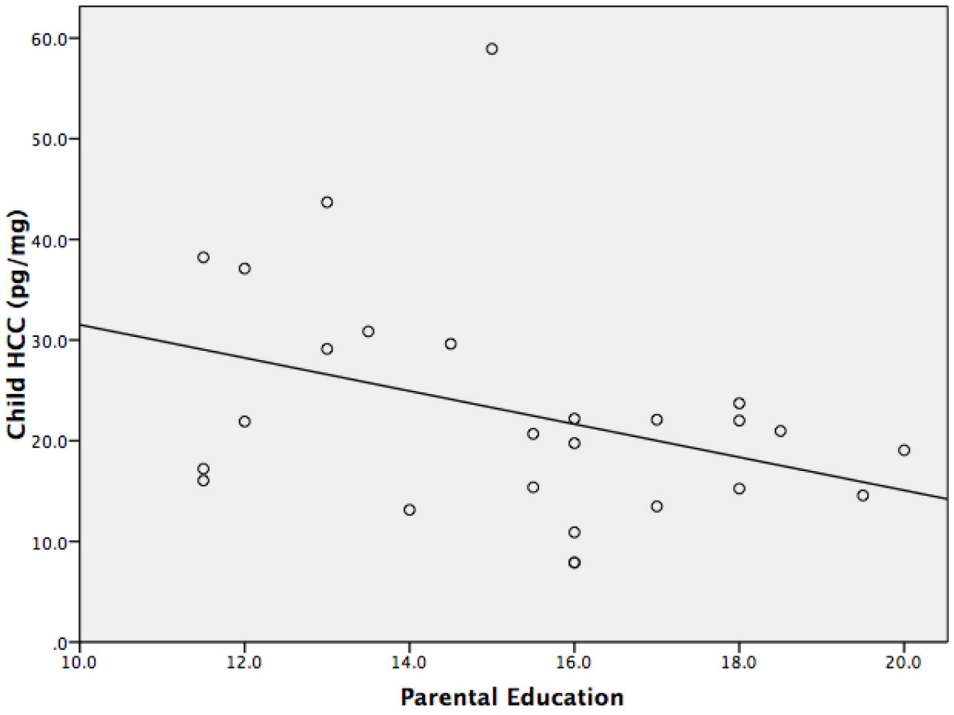

Figure 3.

Parental education is inversely linearly associated with children's hair cortisol concentration (HCC). Figure depicts unadjusted bivariate association.

Table 1

Descriptive Statistics

Parents (n = 35)	**Number**	**Mean**	**S.D.**	**Range**
Parent age (years)		34.9	7.3	(23 – 51)
Sex (male =1)	4			
African American, non-Hispanic/Latino	8			
Hispanic/Latino	19			
White, non-Hispanic/Latino	7			
Other	1			
Family income-to-needs ratio		2.91	2.73	(.32–14.08)
Parental education (years)		14.44	3.00	(6.5–20)
Parent HCC (pg/mg)		14.69	9.14	(2.7–38.5)
Children (n = 28)	Number	Mean	S.D.	Range
Child age (months)		76.2	9.0	(60–90)
Sex (male =1)	6			
African American, non-Hispanic/Latino	4			
Hispanic/Latino	15			
White, non-Hispanic/Latino	7			
Other	2			
Family income-to-needs ratio		3.28	2.91	(.45–14.08)
Parental education (years)		15.20	2.50	(11.5–20)
Child HCC (pg/mg)		23.35	11.88	(7.9 – 58.9)

Note. HCC, hair cortisol concentration

Table 2

Associations of SES and stress with parent anxiety and depression.

Parent Anxiety	**Model A**		
	Beta	**t**	**p-value**
Income-to-Needs Ratio	−0.219	−1.482	.150
Age	−0.125	−0.873	.390
Sex	−0.147	−1.218	.234
African American	−0.206	−1.357	.186
Hispanic/Latino	−0.548	−3.170	.004
HCC	0.250	2.079	.047
Perceptions of Stress	0.586	4.523	< .001
Parent Depression	Model B		
	Beta	t	p-value
Income-to-Needs Ratio	−0.271	−1.652	.110
Age	−0.309	−1.947	.062
Sex	−0.137	−1.025	.314
African American	−0.052	−0.307	.761
Hispanic/Latino	−0.563	−2.934	.007
HCC	0.109	0.813	.423
Perceptions of Stress	0.514	3.570	.001

Note. HCC, hair cortisol concentration

Table 3

Associations of SES and stress with child internalizing symptoms.

BPI Internalizing	**Model C**		
	Beta	**t**	**p-value**
Income-to-Needs Ratio	−0.153	−0.695	.499
Age	0.252	1.108	.286
Sex	0.617	2.796	.014
African American	−0.345	−1.284	.220
Hispanic/Latino	−0.847	−3.329	.005
Child HCC	−0.243	−1.252	.231
Parental Perceptions of Stress	0.485	2.341	.035
RCADS Anxiety	Model D		
	Beta	t	p-value
Income-to-Needs Ratio	−0.249	−1.067	.304
Age	0.364	1.509	.154
Sex	0.350	1.498	.156
African American	−0.512	−1.797	.094
Hispanic/Latino	−0.587	−2.180	.047
Child HCC	−0.280	−1.361	.195
Parental Perceptions of Stress	0.478	2.178	.047
RCADS Depression	Model E		
	Beta	t	p-value
Income-to-Needs Ratio	−0.035	−0.140	.891
Age	−0.153	−0.599	.559
Sex	0.582	2.351	.034
African American	0.053	0.175	.863
Hispanic/Latino	−0.613	−2.150	.050
Child HCC	0.049	0.226	.824
Parental Perceptions of Stress	0.515	2.215	.044

Note. HCC, hair cortisol concentration; BPI, Behavior Problems Index; RCADS, Revised Child Anxiety and Depression Scale.