THE EFFECTS OF SES ON INFANT AND MATERNAL SALIVARY CORTISOL OUTPUT

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Certificate of Approval

This is to certify that the accompanying thesis by Ariel M. Carter-Rodriguez, Al-Rahim Merali and Rachel N. Shober has been accepted in partial fulfillment of the requirements for graduation with Honors in Psychology.

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Abstract

Children growing up in low-SES environments are exposed to more cumulative environmental stressors than children who do not live in poverty. Measuring salivary cortisol is one efficient way to quantify stress in humans, and cortisol output is commonly used to examine the direct effects of low-SES environments. The purpose of the present study was to investigate the relationship between SES and salivary cortisol output for infants and mothers. We predicted that low-SES infants aged 6-12 months would display higher levels of diurnal cortisol output than high-SES infants. We also hypothesized that low-SES mothers would exhibit higher diurnal cortisol output compared to high-SES mothers. Our third hypothesis was that low-SES infants and mothers would exhibit poorer cortisol regulation over the course of the day compared to their high-SES counterparts. Finally, we hypothesized that maternal perceptions of chaos in the home would differ based on SES, and that these perceptions would be predictive of infant and maternal cortisol levels. We collected saliva samples from low and high SES infants aged 6-12 months and their mothers three times over the course of one day, while also administering a household chaos assessment. Both low-SES infant and maternal cortisol levels were marginally higher than high-SES infants and mothers over the course of one day. There were no SES-based differences in maternal perceptions of home chaos or in cortisol regulation patterns for infants or mothers. Because SES-based differences in cortisol output manifest this early in life, future research should focus on prenatal stress-reduction interventions.

The Effects of SES on Infant and Maternal Salivary Cortisol Output

Living in poverty has serious implications for the physical and psychological well-being of children and families. The United States has one of the highest rates of child poverty worldwide (UNICEF, 2012). According to the most recent Social Policy Report from the Society for Research in Child Development, there are 15.5 million children under the age of 18 currently living in poverty in the United States (Aber, Morris, & Raver, 2012). This means that 15.1% of the country's entire population and 21% of all U.S. children are poor (Aber, Morris, & Raver, 2012). Living in an environment of poverty is characterized by increased levels of psychological stress (e.g. Evans, 2004; Evans & English, 2002). The manifestation and experience of stress in low-SES homes are important in understanding the far-reaching effects of poverty on child development. The present study explored the relationship between household chaos and physiological levels of stress in low- and high-SES infants and mothers.

Low-SES families experience more stress in the form of household chaos compared to their high-SES counterparts. Chaotic homes are characterized by "environmental confusion," specifically in terms of physical indicators such as crowding, poor housing quality, and noise (Dumas, Nissley, Nordstrom, Smith, Prinz, & Levine, 2005; Matheny, Wachs, Ludwig, & Phillips, 1995). Crowding is defined as having more than one person per room (Evans, 2004). Research has shown that both crowding within the home and the availability of open, outdoor space are correlated with income levels (Myers, Baer, & Choi, 1996). In the United States, low-SES families with one or more children under age 18 are more than three times as likely to live in crowded homes than high-SES families (Children's Defense Fund, 1995), and a British survey revealed that 78% of manual laborers with children under age 18 lived in crowded housing (Davie, Butler, & Goldstein, 1972). Furthermore, a sample of low-SES 1-year-olds were more than twice as likely to live in crowded homes than high-SES infants (Liaw & Brooks-Gunn, 1994). Limited availability of outdoor space is also more prevalent in low-SES families, with low-SES neighborhoods in New York averaging 17 square yards per child and high-SES neighborhoods averaging 40 square yards (Sherman, 1994). Crowding promotes strained familial interactions and greater child maltreatment, which lead to increased neuroticism and psychological distress in children (Evans & English, 2002; Evans, 2006).

In addition to crowding, stress manifests itself in the context of household chaos through poor housing quality. Low-SES children are more than twice as likely to live in homes with structural defects, rat infestations, and heating problems compared to high-SES children (Evans, 2004). The homes of low-SES families are more likely to be considered dark, monotonous, unclean, and cluttered, whereas high-SES families are three to four times less likely to be described as such (Bradley, Corwyn, McAdoo, & Coll, 2001).

Chaos also presents itself in the physical home environment through noise. On average, low-SES children are exposed to approximately twice as much noise (5 to 10 more decibels) than high-SES children (Evans, Eckenrode, & Marcynyszyn, 2007). Increased noise levels in the home elicit physiological and psychological stress responses in children. Children living in noisy neighborhoods exhibited increased physiological stress symptoms (blood pressure, epinephrine levels, and norephinephrine levels) and decreased quality of life over a period of 26 months compared to children living in quiet neighborhoods (Evans, Hygge, & Bullinger, 1998). Living in a noisy environment also has implications for cognitive development—children exposed to chronic noise perform worse on long-term memory tasks, make more errors reading, and are less sensitive to distracting background noise (Evans, Hygge, & Bullinger, 1995).

The detrimental effects of heightened noise exposure also affect low-SES children in regard to their selective attention abilities. D'Angiulli, Herdman, Stapells, and Hertzman (2008) studied the relationship between SES and the performance of auditory selective attention by evaluating EEG readings in children. Although low and high-SES children were equally able to distinguish between different auditory stimuli, low-SES children attended to irrelevant information just as much as they attended to relevant information (D'Angiulli et al., 2008). Low-SES children operated at a maximum cognitive load, which did not allow them to effectively allocate their cognitive resources. In other words, low-SES children had to utilize more of their cognitive resources for the same task compared to high-SES children. Despite the low-SES children performing comparably to their high-SES counterparts on the behavioral task, low-SES children experienced increased stress on their cognitive systems as a result of this additional cognitive load. Noble, McCandliss, and Farah (2007) found similar cognitive deficits in a sample of low-SES first graders. Thus poor families experience higher levels of stress as a function of crowding, housing quality, and noise compared to nonpoor families (Evans 2005; Evans & English, 2002).

Additionally, low-SES families also experience stress through chaos in non-physical aspects of the home environment, particularly through lack of structure. Bronfenbrenner and Evans (2000) argue that frequent, regular interactions with the environment are necessary for healthy development, which they describe as proximal processes. Successful proximal processes promote competence, or one's perceived ability to cope with the environment, while interrupted interactions can result in difficulty in maintaining control of behavior across situations (Bronfenbrenner & Morris, 1998). Unpredictability in the daily life of poor children fosters this inconsistency, for low-SES children are more likely to be exposed to a significant number of structural stressors like family turmoil, family separation, and violence compared to their high-SES counterparts (Evans & English, 2002). Lack of structure manifests in the home through disrupted child routines, irregular work hours of poor mothers, changes in parental relationships, residential moves, and separation from parent figures (Adam, 2004; Britto, Fuligni, & Brooks-Gunn, 2002; Evans, 2004; Presser & Cox, 1997).

Household unpredictability negatively impacts psychological adjustment, academic achievement, and family satisfaction (e.g., Fiese & Parke, 2002; Repetti, Taylor, & Seeman, 2002). In a longitudinal study, Fisher and Feldman (1998) found that high school students whose households were less cohesive and orderly experienced more emotional distress six years later. Guidubaldi (1986) also found that elementary school children in households that had more routines and structure were able to adjust better emotionally and perform better in school. The lack of structure experienced by low-SES children restricts their ability to self-regulate and manage emotions and behavior, which can result in increased stress (Evans, 2005).

Physiological indicators of stress can be used to examine the direct effects of low-SES environments. One way stress can be measured physiologically is through cortisol. Cortisol is a stress hormone present in saliva and urine that is produced by the Hypothalamic-Pituitary-Adrenal (HPA) axis, also known as the stress axis (Dickerson & Kemeny, 2004; Kalman & Grahn, 2004). Cortisol production follows circadian rhythms, meaning it peaks early in the morning after awakening and continues to fluctuate during the day based on the experiences an individual encounters. The HPA axis is highly responsive to stressors and disturbances in the environment, which typically serves an adaptive function when dealing with stressful situations (Kalman & Grahn, 2004).

Generally, cortisol production in response to stressors is a beneficial coping mechanism. For example, functions to facilitate carbohydrate breakdown, therefore providing the body with "fuel" and a short-term burst of energy in stressful situations (Dickerson & Kemeny, 2004). However, maintaining chronically high levels of cortisol has been shown to contribute to a number of negative health outcomes (Miller et al., 2009; Santiago, Wadsworth, & Stump, 2011). Chronically high cortisol levels have also been linked to a variety of physical and psychological problems, including anxiety disorders, depression, somatic complaints, aggression, attention problems, cardiovascular disease, respiratory disease, and some types of cancer (Miller et al., 2009; Santiago et al., 2011). For example, elderly adults who sustained high levels of cortisol over a period of five years had significantly smaller hippocampal volume and showed deficits in hippocampus-dependent memory tasks compared to adults with normal cortisol levels (Lupien et al., 1998).

Cortisol is an accurate indicator of physiological stress even in infancy. Recent studies have successfully measured cortisol levels in infants as young as 6 months (Stenius et al., 2008; Stenius et al., 2010). Stenius et al. (2008) tested salivary cortisol levels in 6-month-old infants, mothers, and fathers three times a day. Maternal cortisol levels were significantly correlated to infant levels at each collection period, but paternal levels were not (Stenius et al., 2008). These findings suggest that infant cortisol levels are linked to maternal cortisol levels (Stenius et al., 2008).

Beyond infancy, cortisol levels are markedly higher in low-SES children. Lupien et al. (2000) studied 217 elementary school children at ages 6, 8, and 10 of high-, medium-, and low-SES backgrounds. Low-SES children produced significantly more cortisol on average than did the medium and high-SES children, and this difference was readily observable at ages 6 and 8. At age 10, significant differences in cortisol output were observed between all levels of SES (high, middle, and low) suggesting that the effects of SES on cortisol output are cumulative with age (Lupien et al., 2000). Lupien et al. (2000) found that children’s cortisol levels were also negatively correlated to family income, further demonstrating that SES is related to higher overall cortisol output. Similarly, Evans & English (2002) found that low-SES third- and fifth-graders produced significantly higher levels of cortisol than the high-SES children of the same age. The low-SES children also presented higher levels of epinephrine and higher resting blood pressure, acting as supplementary indicators of chronic stress exposure.

Significant cortisol differences between SES groups have been observed in adolescents as well. Chen, Cohen, and Miller (2010) studied cortisol levels and family chaos in a sample of 50 low- and high-SES children between the ages of 9 and 18 in Vancouver, Canada. Saliva samples were taken over a two-day period at 6-month intervals over the course of two years to follow the longitudinal patterns of cortisol output, while family chaos was determined using a questionnaire given to parents. As predicted, low-SES children exhibited significantly higher levels of cortisol across the two-year period. Low-SES children also produced nearly twice as much cortisol than high-SES children. Furthermore, both low family savings and high family chaos were predictive of high cortisol levels. Thus, the chaotic and unstructured environment of low-SES children contributed to the stress they experienced, which was also associated with higher levels of cortisol output (Chen et al., 2010).

This pattern of higher cortisol output in low-SES children and adolescents has also been observed in adults. Cohen, Doyle, and Baum (2006) studied cortisol output in adults ranging from ages 21 to 55. Socioeconomic status was calculated using income, education level, and a composite score of both. Cohen et al. (2006)

found decreasing cortisol and epinephrine concentrations with increasing levels of SES. Moreover, low-SES was associated with higher levels of cortisol output regardless of age, race, gender, and body mass (Cohen et al., 2006). Therefore, the negative effects of poverty through stress are also present not only in childhood and adolescence, but also in adulthood.

Not only does this exposure to chronic stress lead to elevated cortisol levels, but it also alters cortisol regulation. Maintaining chronically high levels of cortisol output is characterized by a dysregulated diurnal output pattern, with cortisol levels failing to decrease in the afternoon and evening (Kalman & Grahn, 2004). Research has shown that exposure to chronic stressors is associated with cortisol dysregulation (Cohen et al., 2006; Dettling, Gunnar, & Donzella, 1999). In a study by Cohen et al. (2006), low-SES adults exhibited flatter diurnal rhythms as a result of less of a decline in cortisol output in the evening. Children also demonstrated these dysregulation patterns when exposed to chronic stressors. Children aged 36-109 months that were exposed to more stressors in daycare showed consistently high levels of cortisol throughout the day compared to children who were at home and were exposed to fewer stressors (Dettling et al., 1999). Thus it is clear that exposure to chronic stress can alter cortisol regulation patterns in both children and adults.

Although exposure to chronic stressors both increases cortisol output and alters cortisol regulation patterns, living in poverty in the early years of life has also been linked to long-term elevated cortisol output even if individuals are no longer in poverty. Evans and Kim (2007) examined the relationship between poverty and cortisol output in 13-year-old children. More time spent living in poverty since birth was associated with higher cortisol levels at age 13 (Evans & Kim, 2007). Miller et al. (2009) also found similar effects in an older age group. The researchers measured the cortisol levels of over one hundred adults ages 25 to 40. Regardless of SES status at time of testing, participants who had lived in poverty at any point during the first five years of life exhibited higher cortisol levels compared to participants who had not (Miller et al., 2009). Miller et al. (2009) suggested that this finding could be evidence for a sensitive period in which basal cortisol output is determined by environmental stressors. The high cortisol output during this period is then "programmed" into the HPA axis and maintained throughout the lifespan (Miller et al., 2009). However, the exact age at which this programming might occur remains unknown.

Despite previous research on cortisol output in low-SES children, adolescents, and adults, cortisol output in low-SES infants has yet to be investigated. The purpose of the present study was to examine the relationship between poverty and chronic stress in 6-12-month-old infants, using cortisol output as a biomarker of stress exposure. A second purpose was to examine the connections between infant and maternal cortisol in low- and high-SES families, as well as maternal perceptions of household chaos. We hypothesized that (a) low-SES mothers would exhibit significantly higher average salivary cortisol levels compared to their high-SES counterparts, (b) low-SES infants would exhibit higher average salivary cortisol output compared to high-SES infants, (c) low-SES infants and mothers would exhibit poorer cortisol regulation over the course of the day than high-SES infants and mothers, and (d) low-SES mothers would report higher perceived household chaos than high-SES mothers, and these scores would be predictive of infant and maternal cortisol levels.

Method

Participants

Participants were recruited as a part of a larger study examining infant play and tool use. There were 16 high-SES mothers and infants (11 males, 5 females) and 11 low-SES mothers and infants (9 males, 2 females). Mothers indicated their infants' race/ethnicity on the included demographics form (see Appendix A). Twenty-five participants were Caucasian, two were Hispanic, and one was Indian. One high-SES infant-mother dyad was excluded from data analyses as an outlier in terms of anomalous cortisol output.

Socioeconomic status was assigned based on a needs assessment and on the level of reported maternal education, with "some college" qualifying the infant as high SES (see Appendix A). This measure of SES was used because parents generally report their education levels more accurately than income, and because maternal education is strongly correlated with both income and SES (Stevens, Lauinger & Neville, 2009).

This study was publicized through advertisements in the Walla Walla Union Bulletin, community electronic mailing lists, flyers posted in town, the Early Head Start program, and word of mouth. Participants were compensated with twenty dollars in gift cards and received a children's book.

Design

Socioeconomic status (low or high) and time of cortisol collection (morning, afternoon, or evening) were the two independent variables. SES was a between-subjects quasi-independent variable and time of collection was within-subjects. The level of salivary cortisol output and the perceived level of home chaos were the two dependent variables.

Materials

Salivary Cortisol. This study replicated the methods used by Stenius et al. (2008). Infant salivary cortisol samples were collected using commercial Salimetrics® Infant Swab (SIS) collection kits, and maternal samples were collected using Salimetrics ® Oral Swab (SOS) collection kits. Each participant kit included three SIS swabs, three SOS swabs, and 6 storage tubes, and instructions for collection.

Chaos Assessment. Maternal perceptions of home chaos were measured with the 15-item Confusion, Hubbub, and Order Scale (see Appendix B; Matheny et al., 1995). The CHAOS measure has been applied to mothers and children from different ethnic minorities and children across a variety of ages and is a valid construct of the "environmental confusion" commonly found in low-SES homes (Dumas, et al., 2005; Matheny, et al., 1995). Mothers were asked to rate how well items on the scale described their own home, with 1 being "very much like your own home" and 4 being "not at all like your own home." Scores for each item on the CHAOS scale were summed for a total score, with higher scores indicating higher perceptions of home chaos. Items included statements like "There is very little commotion in our home" (reverse scored), "The atmosphere in our home is calm" (reverse scored) and "It's a real zoo in our home".

Internal consistency (Cronbach's alpha) for the entire scale is .79 and test-retest reliability (12-month interval) for the total test score is 74. The CHAOS scale was compared with the physical and social environment codes in the Purdue Home Simulation Inventory (PHSI), which were completed by trained observers. Matheny et al. (1995) found that the PHSI physical environment codes explained 39 percent of the variance in CHAOS scores, and that the PHSI social environment codes explained 59 percent of the variance in CHAOS scores (Administration for Children & Families, n.d.).

Procedure

Salivary Cortisol. Saliva collection kits were given to mothers upon a home (n = 22) or laboratory visit (n = 4) and were picked up by a researcher on a later date. Saliva samples were collected from mothers and infants on the same day in the morning, afternoon, and evening. Morning and evening were defined as "a quarter hour after awakening and before first meal," and "before going to bed". Afternoon collection times varied between infant and mothers. For infants, it was defined as "after midday sleep" or "one hour after midday meal" if the child did not sleep. For mothers, afternoon was defined as "before dinner, or if dinner was later before 6 PM" (Stenius et. al., 2008). During sample collection, mothers were asked to hold the adult oral swab in their mouth until it was soaked with saliva (approximately 90 seconds). In order to collect the infant sample, mothers were asked to hold the infant oral swab in their infants' mouth until soaked with saliva (approx. 30-60 seconds). Samples were frozen after collection at the mothers' homes until transported to the laboratory freezer by a researcher and stored at -20°C.

Infant and maternal saliva samples were analyzed for levels of cortisol using commercial Salimetrics® 1-3002 Salivary Assay Kits and a 450 nm single plate reader (Salimetrics®, LLC). In order to prepare frozen saliva for cortisol analysis, samples were thawed for an hour in the lab and centrifuged. To increase consistency, cortisol controls and participant saliva samples were divided into duplicate subsamples. Saliva samples were then assayed for free cortisol levels using the commercially available Salimetrics® 1-3002 Enzyme Immunoassay Kit (Salimetrics®, LLC). The assay was performed by researchers in a biochemistry lab at Whitman College.

Chaos Assessment. CHAOS scales were administered to mothers during the home or lab visit and took no more than 10 minutes to complete.

Results

Maternal cortisol levels are presented in Figure 1. A 2 (SES: low vs. high) x 3 (time of day: morning, afternoon and evening) mixed ANOVA was conducted on mothers' cortisol levels (See Table 1). Results revealed a marginally significant main effect for SES, $F(1,24) = 3.17$, $p = .08$, and a statistically significant main effect for time of day, $F(2,24) = 52.01$, $p < .0001$. Low-SES mothers exhibited higher levels of cortisol than high-SES mothers and all mothers showed the typical circadian rhythm pattern for cortisol output, with highest levels in the morning and subsequent decreases throughout the day. However, there was no interaction, $F(2,24) = .708$, $p > .05$. Post-hoc t-tests (with a Bonferroni correction) revealed that across SES, maternal cortisol levels were significantly different between morning and afternoon, $t(25) = 6.95$, $p < .0001$, and between morning and evening levels, $t(25) = 8.18$, $p < .0001$. Differences in maternal cortisol levels between afternoon and evening were marginally significant, $t(25) = 1.77$, $p = .08$.

Infant cortisol levels are presented in Figure 2, and a second 2x3 mixed ANOVA was conducted on their cortisol output (See Table 2). Similar to the mothers, there was a marginally significant main effect for SES, $F(1,24) = 2.969$, $p = .09$, and a significant effect for time of day, $F(2,24) = 7.616$, $p = .0013$. Low-SES infants exhibited higher levels of cortisol than high-SES infants and all infants also showed the typical circadian rhythm pattern. As was true for mothers, the interaction was not significant, $F(2,24) = .359$, $p = .7001$. Post-hoc t-tests (with a Bonferroni correction) revealed that across SES, infant cortisol levels were significantly different between morning and evening, $t(25) = 5.51$, $p < .0001$. Differences between infant cortisol levels in the morning and afternoon were marginally significant, $t(25) = 1.84$, $p = .08$, and infant cortisol levels from afternoon to evening were not significantly different, $t(25) = 1.71$, $p > .05$.

We also hypothesized that household chaos would be predictive of cortisol levels for both mothers and infants. However, we found no SES differences in perceptions of household chaos (low SES: $M = 38.909$, $SE = .682$; high-SES: $M = 38.567$, $SE = .717$), $t(25) = .241$, $p = .8119$. To further investigate the relationship between maternal and infant cortisol levels, we ran Pearson's correlations between mother and infant levels at each time of day. There were no significant correlations between maternal and infant levels across SES in the morning ($r = .15$, $p > .05$), afternoon ($r = -.02$, $p > .05$), and evening ($r = .29$, $p > .05$). Subsequent correlations were performed on mother-infant pairs at each time of day within both high- and low-SES groups. Cortisol levels for high-SES mothers and infants were significantly correlated in the evening ($r = .63$, $p = .05$) and strongly correlated in the morning ($r = .45$, $p > .05$) and afternoon ($r = .32$, $p > .05$). Conversely, cortisol levels for low-SES mothers and infants were not significantly correlated in the morning ($r = -.10$, $p > .05$), afternoon ($r = -.12$, $p > .05$), and evening ($r = .15$, $p > .05$).

Discussion

The present study examined the effects of SES on maternal and infant salivary cortisol output. We hypothesized that both low-SES mothers and infants would exhibit higher average levels of salivary cortisol output compared to their high-SES counterparts. This hypothesis was supported. We further hypothesized that low-SES mothers and infants would exhibit poorer regulation of cortisol over the course of the day, and that this regulation would be predicted by maternal perceptions of household chaos. No SES-based differences were found in cortisol regulation or in maternal perceptions of household chaos, but there were SES-based differences in correlations between infant and maternal cortisol output throughout the day.

For our first hypothesis, we predicted that living in a low-SES environment would be associated with higher cortisol levels in mothers. Our results confirmed this prediction, for we found low-SES mothers had higher levels of cortisol output throughout the day. These findings support past research investigating cortisol output in low-income adults (Cohen et al., 2006). Low-SES families are regularly exposed to more cumulative stressors than families who do not live in poverty (Evans, 2004), and the elevated cortisol levels in low-SES mothers show the physiological reactivity that accompanies these stressors. Moreover, this increased maternal stress has negative implications for parenting. Research has shown that prenatal psychological distress in mothers can have detrimental effects on cognitive, behavioral, and psychomotor development in their infants, while postpartum psychological distress in mothers contributes negatively to cognitive and socioemotional development (Kingston, Tough, & Whitfield, 2012). Chronically high cortisol levels are thought to contribute to or even cause depression, which has also been shown to have adverse effects on parenting in mothers (Field, 2009). Depressed mothers tend to utilize less vocal and visual communication, smiling, affectionate touching, display less responsiveness and sensitivity, are less likely to continue breastfeeding, are more likely to place their infants in unsafe sleeping positions, and have more thoughts of harming their infants (Field, 2009). Thus, the high levels of cortisol in our sample of low-SES mothers could have serious implications for the interactions they have with their children.

We also predicted that low-SES infants would have higher diurnal cortisol output compared to high-SES infants. This hypothesis was also supported. Our findings indicate that this increased HPA activation appears in low-SES infants appears to be linked specifically to their poverty status. Low-SES environments are characterized by significantly more physical and psychosocial stressors such as crowding (Evans, 2004), poor housing quality, (Bradley et al., 2001; Evans, 2004) and noise (Evans et al., 2007; 2008). Therefore, our finding indicates that infants as young as six months of age are as sensitive to these environmental stressors as children (Chen et al., 2010; Evans & English, 2002) and adults (Cohen et al., 2006).

It is important to keep in mind that high cortisol levels can serve an adaptive function for short-term stressors. For example, high amounts of cortisol contributes to the fight or flight response and even in the context of poverty, having heightened cortisol can be adaptive as families face multiple stressors in their environments (Dickerson & Kemeny, 2004). However, high cortisol levels become problematic when the levels are chronically elevated (Kalman & Grahn, 2004). Children living in low-SES environments have exhibited chronically elevated levels of cortisol output over extended periods of time (Chen et al., 2010), and the fact that these differences emerge as early as 6 months of age have serious implications for permanent alterations in HPA axis activity. Previous research suggests there could be a sensitive period early in life during which cortisol output trajectories can be permanently altered (Miller et al., 2009). The results of the present study suggest that the 6-12 month old infants in our sample could potentially have permanently altered cortisol output at age 40, regardless of their SES status in adulthood (Miller et al., 2009).

In children, chronically elevated levels of cortisol are associated with increased threat responses (Chen et al., 2010), difficulties in socioemotional adjustment (Evans & English, 2002), and poorer scores on attention continuity and speed of memory tests (Maldonado et al., 2008). While there are immediate negative effects of cortisol in childhood, chronically elevated levels of cortisol can also lead to an increased susceptibility to disease. Growing up in a low-income environment has been associated with a number of health problems later in life including early mortality (Galobardes, Lynch, & Davey Smith, 2004), low resistance to infectious diseases (Cohen, Doyle, Turner, Alper, & Skoner, 2004), cardiovascular disease (Galobardes, Smith, & Lynch, 2006), diabetes (Andrew, Gale, Waler, Secki, & Martyn, 2002), obesity (Power et al., 2005), and major depression (Anisman & Zacharko, 1992). It is likely that maintaining high levels of cortisol is one of the mediating mechanisms between living in low-SES environments during childhood and adverse long-term health outcomes (Miller, Chen, & Parker, 2011).

In terms of cortisol regulation, we predicted that both low-SES infants and their mothers would show dysregulated cortisol patterns, with cortisol levels remaining high throughout the day. However, there was no evidence of SES-based differences in cortisol regulation in mothers. This finding is contrary to our hypothesis as well as previous research, which has shown that low-SES adults display flattened diurnal cortisol slopes (Cohen et al., 2006). Similarly, we did not find a dysregulation pattern in low-SES infants, which is also inconsistent with the literature on children exposed to stressful situations (Dettling et al., 1999).

The lack of differences in regulatory patterns for both low-SES mothers and infants in our sample may potentially be explained by the number of saliva samples collected throughout the day. Other studies examining cortisol regulation patterns have collected as many as six samples throughout the course of one day (Cohen et al., 2006), or have collected saliva samples over an extended period of time (Evans & Kim, 2007). Although we chose to replicate the Stenius et al. (2008) methods for this study by using three samples, it is possible that with our relatively small sample size it would have been more effective to collect a greater number of saliva samples, or collect saliva over the course of multiple days in order to get a more complete picture of cortisol regulation patterns.

It is also possible that the low-SES participants in our sample were not exhibiting cortisol dysregulation patterns. In light of the Stenius et al. (2008) findings showing infant and maternal cortisol levels having correlated regulation patterns, it is logical to assume that if the mothers did not show dysregulation, neither would the infants. A final consideration for the lack of dysregulation patterns in low-SES mothers and infants is the amount of time spent living in poverty. With regard to infants, living in poverty for only 6-12 months may not be long enough to see alterations to the HPA axis. Perhaps if their cortisol levels remain elevated, they would eventually show the expected dysregulation. Similarly, we did not ask mothers how long they had been living in poverty, or whether or not they lived in a low-SES home early in life. These considerations could potentially explain why low-SES mothers do not show cortisol dysregulation, for it is possible that they had only recently started living in poverty. Therefore it would be interesting to re-test the low-SES infants in our sample later in life, replicating Miller et al. (2009), to see whether or not their cortisol output remains chronically elevated.

Despite the lack of findings regarding dysregulation, we did find that cortisol output in low-SES mothers and infants were not significantly correlated at any time of day. In contrast, cortisol levels in high-SES mothers and infants were significantly or strongly related at each time of day. Results from our high-SES sample replicates previous literature on correlations between maternal and infant cortisol output, such as those reported by Stenius et al. (2008), which show that infant and maternal cortisol levels are correlated throughout the day. While the data for our low-SES sample does not replicate that of Stenius et al. (2008), the divergence in cortisol production patterns between low-SES mothers and their infants has been found in other studies. For example, Crockett, Holmes, Granger, & Lyons-Ruth (2013) found that maternal and infant cortisol levels were more likely to be divergent when the mother's communication with her infant was rated as severely disruptive (e.g. withdrawing from the infant, contradictory affective responses, ignoring infant cues). Given that low-SES mothers generally demonstrate less responsiveness and sensitivity in parenting (Valenzuela, 1997), it is possible that disrupted infant-maternal communication in our low-SES sample could have contributed to the absence of strong, positive correlations for cortisol.

We also hypothesized that low-SES mothers would report higher levels of perceived household chaos compared to high-SES mothers, and that these CHAOS scores would be predictive of infant and maternal cortisol levels.

Analyses revealed that there were no significant differences in perceptions of household chaos based on SES. Therefore, according to our CHAOS scale results, both low- and high-SES mothers appeared to perceive their home environments as equally stressful. Consequently these CHAOS scores could not be predictive of cortisol output, for even though there were differences in cortisol output for infants and mothers based on SES there were no differences in mothers' perceptions of home chaos. The lack of SES-based differences in CHAOS scores is surprising because low-SES home environments are characteristically more stressful than high-SES home environments (Evans, 2004). This finding suggests that there could be a discrepancy between mothers' perceptions of and physiological responses to their home environment. Alternatively, the CHAOS scale itself is also a likely cause of the relative similarity in maternal perceptions of home chaos, regardless of SES. It is possible that the CHAOS scale alone was not an adequate measure of maternal perceptions of stress, as previous studies have paired it with supplemental measures such as home visits and perceptions of threat (Chen et al., 2010; Matheny et al., 1995). However, we did not have the resources to conduct regular home visits, nor were we interested in examining perceptions of threat.

Further limitations of the present study include cortisol collection and analyses, and sample size. Participants were in charge of obtaining their own saliva samples, and samples were assayed by researchers rather than by an outside laboratory. Nevertheless, each immunoassay kit included standards that indicated if any saliva samples deviated drastically from the expected range, which is how we determined to exclude one infant-mother pair from our analyses. Furthermore, the main effects for time of day in both mothers and infants replicated previous studies on cortisol output, suggesting that cortisol collection and analyses were reliable (Stenius et al., 2008). Finally, the small sample size, especially in regard to low-SES infants and mothers, may have limited the statistical power of our results.

Despite these limitations, this is the first study to show the physiological effects of poverty in infancy, and has serious implications for the health of children living in low-SES environments. The early onset of SES-based differences in cortisol output highlights the importance of early stress-reduction interventions. Many studies have addressed this need by implementing interventions such as Attachment and Biobehavioral Catch-up (ABC), which helped 15-24 month old foster children effectively lower their cortisol levels (Dozier, Peloso, Lewis, Laurenceau & Levine, 2008). The ABC intervention aimed to enhance children's ability to regulate physiology and behavior by helping caregivers be particularly responsive to and understanding of their children's emotions (Dozier et al., 2008).

However given that cortisol differences appear as early as six months, interventions could be more effective by targeting infants and mothers even earlier. Therefore, prenatal stress-reduction interventions may be the most promising method. For example, low-SES mothers who participated in a 12-week prenatal Cognitive Behavioral Stress Management (CBSM) course had significantly lower levels of cortisol when their infants reached 6 and 18 months

(Urizar & Munoz, 2011). In addition, infants of these mothers who participated in the prenatal CBSM program also had lower cortisol levels compared to infants of low-SES mothers who did not (Urizar & Munoz, 2011). Thus, prenatal interventions can be effective at reducing cortisol levels in low-SES mothers.

It is disheartening that SES-based differences in salivary cortisol output manifest as early as six months. However, without knowing how early these effects begin, it is impossible to know the best time to intervene. The present findings suggest that effective interventions for lowering elevated cortisol levels should ideally begin prenatally. The promising results from prenatal interventions suggest that stress reduction strategies are viable for low-SES families. Future research should examine more options for effective stress-management prenatal intervention strategies.

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Table 1.

Repeated Measures ANOVA for Maternal SES, Time of day, and SES-Time of Day Interaction

Source	*SS*	*df*	*MS*	*F*	*p*
SES	.072	1	.072	3.166	.0879
Time of day	2.150	2	1.075	52.013	<.0001**
Age * Time of day	.029	2	.015	.708	.4978

Note: Significant at the p < .05 level.
* p< .05.
** p< .01.

Table 2.

Repeated Measures ANOVA for Infant SES, Time of day, and SES-Time of day Interaction

Source	*SS*	*df*	*MS*	*F*	*p*
SES	.893	1	.893	2.969	.0977
Time of day	1.290	2	.645	7.616	.0013**
SES* Time of day	.061	2	.030	.359	.7001

Note: Significant at the p < .05 level.
* p< .05.
** p< .01.

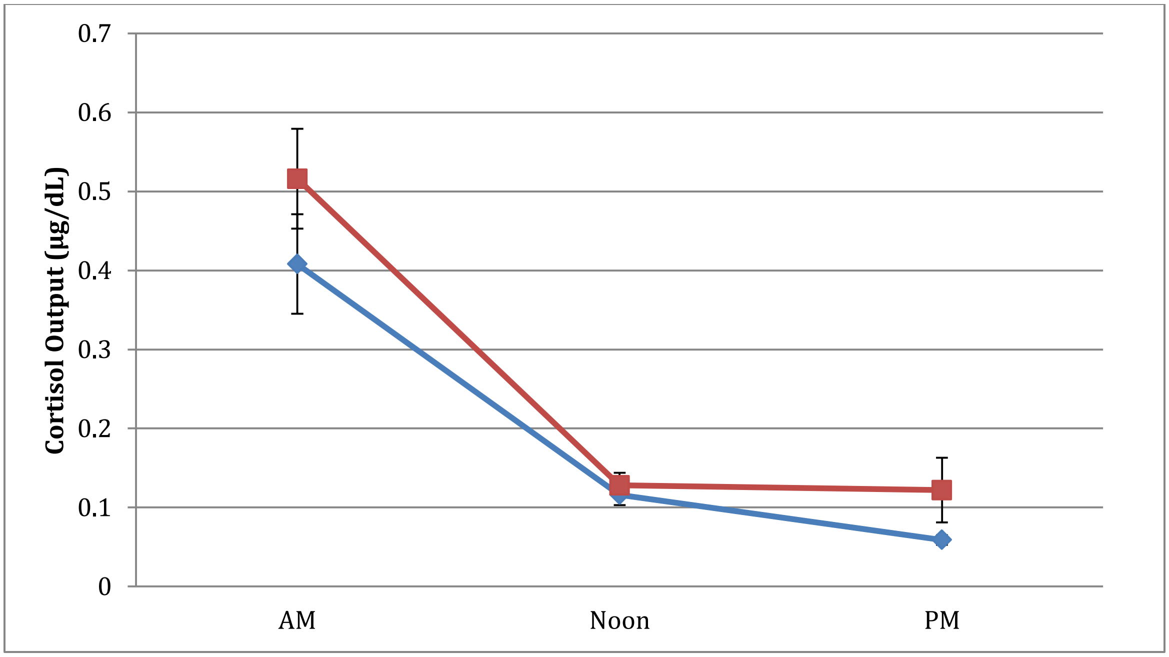

Figure 1. Average maternal salivary cortisol output.

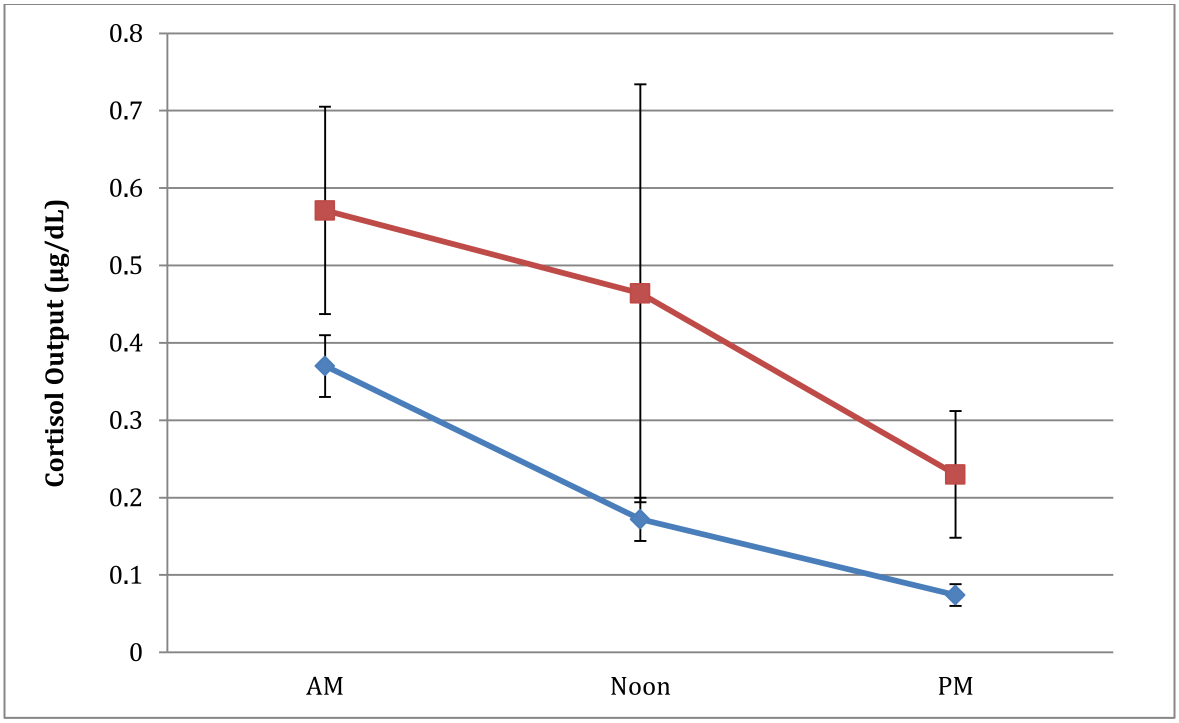

Figure 2. Average infant salivary cortisol output.

Appendix A. Needs Assessment

Participant Information Sheet
Infant Learning and Development Laboratory
Psychology Department
Whitman College
Walla Walla, WA 99362
(509)527-5599

Infant's Name: ___________________________________
Date: ________________________
Birth Date: ____________________
Sex: _________________________
Race/Ethnicity: ____________________________
Marital Status: ____________________________

Was your infant full-term (38-42 weeks)? Yes No If no, how many weeks early was your infant? ____

Motor Milestones

Next to each item, please answer yes or no, and then provide the approximate age (in months or weeks) at which the skill first appeared (if applicable).

Sitting independently (without support of parents or hands):	Yes	No	Age:
Crawling:	Yes	No	Age:
Cruising (moving/walking while holding furniture):	Yes	No	Age:
Walking independently:	Yes	No	Age:

Family Information

Mother's Education:

Some high School	High School Degree	Some College	College Degree	Post College Education

Father's Education (or education level of full-time male resident in household):

Some high School	High School Degree	Some College	College Degree	Post College Education

To what extent are the following needs being met:

Food:	My family Is frequently hungry	My family is sometimes hungry	I meet my families' needs with state help	I meet my families' needs without help
Housing:	I am homeless Or will be in 1 month	I worry that I could be homeless soon	I can afford my home with state help	I can afford my home without help
Money:	I don't have Enough money For basic needs	I meet basic needs but have no extra money	I have some extra money with state help	I have some extra money without help
Access to help:	There is no State help For me	I don't know How to get State help	I do know how to get state help and have done it	I do know how to get state help but don't need it

Appendix B. CHAOS Scale

CONFUSION, HUBBUB, AND ORDER SCALE (CHAOS), 1995

The CHAOS scale is a questionnaire filled out by parents that is designed to assess the level of confusion and disorganization in the child's home environment. The questionnaire consists of 15 statements, to each of which a parent or caregiver assigns a number between 1 and 4 that correspond to the following: 1 = Very much like your own home; 2 = Somewhat like your own home; 3 = A little bit like your own home; 4 = Not at all like your own home.

The statements are scored using a 4-point scoring system. A single score is derived from the CHAOS questionnaire by summing the responses for the 15 items. A higher score represents characteristics of a more chaotic, disorganized, and hurried home.

1. There is very little commotion in our home	1	2	3	4
2. We can usually find things when we need them	1	2	3	4
3. We almost always seem to be rushed	1	2	3	4
4. We are usually able to stay on top of things	1	2	3	4
5. No matter how hard we try, we always seem to be running late	1	2	3	4
6. It's a real zoo in our home	1	2	3	4
7. At home we can talk to each other without being interrupted	1	2	3	4
8. There is often a fuss going on at our home	1	2	3	4
9. No matter what our family plans, it usually doesn't seem to work out	1	2	3	4
10. You can't hear yourself think in our home	1	2	3	4
11. I often get drawn into other people's arguments at home	1	2	3	4
12. Our home is a good place to relax	1	2	3	4
13. The telephone takes up a lot of our time at home	1	2	3	4
14. The atmosphere in our home is calm	1	2	3	4
15. First thing in the day, we have a regular routine at home	1	2	3	4

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