

Child's Stress Hormone Levels Correlate with Mother's Socioeconomic Status and Depressive State

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Background: *Individuals with lower socioeconomic status report greater exposure to stressful life events and a greater impact of these events on their lives than individuals with higher socioeconomic status, and this relationship between socioeconomic status and health begins at the earliest stages of life. To extend on these results, we performed a psychoneuroendocrine study of 217 children and 139 mothers.*

Methods: *Salivary cortisol levels and cognitive function were assessed in children, and a semistructured phone interview measuring symptoms of stress and depression was conducted with their mothers.*

Results: *Children with low socioeconomic status present significantly higher salivary cortisol levels than children with high socioeconomic status, and this socioeconomic status effect emerges as early as age 6. We also report that a child's cortisol level is significantly correlated with his or her mother's extent of depressive symptomatology.*

Conclusions: *These results offer a neurobiological determinant to the well-known association between socioeconomic status and health that begins early in life.* Biol Psychiatry 2000;48:976–980 © 2000 Society of Biological Psychiatry

Key Words: Children, socioeconomic status, cortisol, depression

Introduction

It is well known that individuals from more advantaged backgrounds enjoy better physical and mental health than do individuals from disadvantaged environments (for a review, see Adler et al 1994). Differential exposure to stress (allostatic load; McEwen 1998) as a function of socioeconomic status (SES) has been invoked as a possible pathway for the relationship between SES and health (Anderson and Armstead 1995). Indeed, individuals with lower SES report greater exposure to stressful life events and greater impact of these events on their lives than do

individuals with higher SES, and this relationship between SES and health begins at the earliest stages of life (Dohrenwend 1973).

Physiologic response to environmental stimuli that are perceived as stressful are mediated by catecholamines and by glucocorticoids. Although short-term glucocorticoid responses to stress serves an adaptive function (McEwen 1998), chronic exposure to elevated glucocorticoid concentrations contributes to the onset of physical pathologies and is associated with depressive symptomatology (Anderson and Armstead 1995; Lupien et al 1998; Rubin and Mandell 1966; Sachar et al 1973).

To assess whether differences in stress hormone levels attributable to SES exist in children of various ages, we measured basal morning salivary cortisol levels in children with low, medium, and high SES, ranging from 6 to 10 years of age. The second goal of this study was to assess whether scores of children's mothers on a measure of stress and depression (the Derogatis Stress Profile; DSP; Derogatis and DellaPietra 1994) would differ with regard to SES and whether these scores would be related to their child's cortisol levels.

Methods and Materials

Two hundred seventeen children (random selection of 6-, 8-, and 10-year-olds) with low, medium, and high SES were tested (Table 1). High SES was defined as families with an income higher than \$50,000. In Quebec, Canada, the average family income is between \$30,000 and \$35,000 (Can \$). Children from homes with incomes greater than \$100,000 were not tested, given that the majority of these children are placed in private schools, which are not part of the school board from which students were recruited.

Recruitment of the population as a function of SES was done in two ways. First, the entire population of children was gathered using the school system, within only one school board commission (Commission des Ecoles Catholiques de Montréal [CECM]). This was done to ensure similar schooling procedures and environments for all children. The CECM governs the majority of French-speaking schools in the Montréal Urban Community. With the help of census data and in conjunction with the CECM, we chose schools for the study according to the SES levels of the neighborhoods in which the schools are located (low-, medium-, or high-SES areas). The CECM uses a criterion for SES using parents' income, occupation, and education level,

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Table 1. Demographic Data on Parents of Children from Low-, Medium-, and High-SES areas in Montréal

	Low SES	Medium SES	High SES
Salary	\$22K or less	Between \$30K and \$45K	\$50K or more
Education level	11.7 \pm 5 years	13.5 \pm 7 years	19.6 \pm 1 years
Occupation	Occasional or clerical	Technician	Professional
No. children	2 \pm 1	2 \pm 1	2 \pm 1

Data obtained on 139 families. SES, socioeconomic status.

and this criterion has been shown to be reliable for description of the socioeconomic background of children (CECM 1989; Dutton and Levine 1989). A school was chosen for the study only if it included children from elementary grades one, three, and five. This way, each school contributed a unique SES (low, medium, or high) but the same three elementary grades (one, three, and five). Within each of these schools, students were sampled randomly within grade levels from a list provided by the school. We studied 217 children with low, medium, and high SES, and there were no significant differences between ages of children from same grades, but different SES. Second, we confirmed children's SES during a semistructured phone interview with the mothers (see below). This was done to ensure that the SES criterion used by the school board was valid. Table 1 presents the SES characteristics of the gathered population as confirmed after the semistructured phone interview. Every child was in good general health as reported in school records. The only exclusion criteria for our study was the presence of asthma, the use of corticosteroids, or both.

Written consent was obtained from each child's mother. Consenting mothers also were asked if they would be interested in participating in a 40-min phone interview in which they were asked to answer questions relative to demography and items from a questionnaire (the DSP; Derogatis and DellaPietra 1994) measuring environmental and family stressors. Mothers had two choices: to participate in the study in conjunction with their child or to refuse to participate but consent to their child's participation. The demographic information gathered during the interview was used to confirm SES for each child.

The DSP consists of 77 items that are divided into 11 subscales or domains that measure the salient aspects of each of the three principal stress domains (environmental events' subscale = vocation and work, family, health; personality mediators' subscale = time pressure, driven behavior, attitude posture, relaxation potential, role definition; emotional response subscale = hostility, anxiety, depression). The DSP has demonstrated acceptable reliability coefficients. Test-retest coefficients range from .92 to .72, and internal consistency for the three principal domain scores ranged from .88 to .83.

Child's Cortisol Levels

Saliva samples for cortisol level determination were taken in groups of children during regular class hours, at 8 and 9 AM, following a protocol that has been described extensively elsewhere (Lupien et al 1997, 1998). The average of the two morning data was used as a measure of basal morning cortisol levels and took into account intra- and intersubject variability in salivary

cortisol samplings (Lupien et al 1998). Moreover, recent data tend to show that these morning cortisol levels are highly correlated with personality variables in adults (Steptoe et al 2000), and other data report a significant relationship between salivary cortisol levels in children and temperament (Davis et al 1999; Dettling et al 1999; Kagan et al 1988).

Results

First, confirmation of SES status was obtained in 139 mothers (see distribution across SES and age in Table 2), with significant differences between the three groups of SES for annual family income ($p = .0001$), education level of both the mother ($p = .001$) and father ($p = .001$), and employment type ($p = .0001$) of both parents. Significant SES group differences were obtained for the children's cortisol levels at each age (Figure 1). Preliminary analyses were performed to test the existence of gender differences. No differences between boys and girls were observed for any variables tested (main gender effect as well as interaction with SES or age were all nonsignificant), so data were collapsed across subsequent analyses. The multivariate analysis of variance performed on the gender-collapsed cortisol levels revealed significant main effects of SES [$F(2,207) = 23.2, p < .0001$], Age [$F(2,207) = 3.4, p < .03$], as well as a significant interaction between these two factors [$F(4,207) = 3.9, p < .005$]. We broke this interaction as a function of age using univariate analyses of variance and a posteriori Tukey comparisons of means. Results revealed significant SES

Table 2. Distribution of Sample across SES and Age

SES	Grade	N total	Age (M/SD)	Ratio F/M	N parents	Participation (%)
Low	1	36	6.8 \pm .5	22/14	22	61.1
	3	25	8.9 \pm .6	9/16	11	44.0
	5	35	11.1 \pm .9	23/12	22	62.8
Medium	1	26	6.7 \pm .5	12/14	17	65.3
	3	24	8.7 \pm .5	7/17	17	70.8
	5	25	10.9 \pm .7	12/13	15	60.0
High	1	13	6.7 \pm .7	6/7	10	76.9
	3	18	8.5 \pm .6	11/7	12	66.7
	5	15	10.3 \pm .6	12/3	12	80.0
Total		217			138	63.6

SES, socioeconomic status; F, female; M, male.

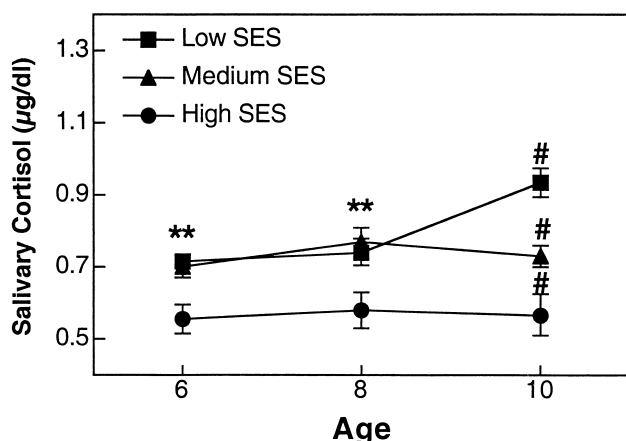


Figure 1. Morning basal cortisol levels ($\mu\text{g/dL} \pm \text{SEM}$) in children aged 6, 8, and 10 years and with low, medium, and high socioeconomic status (SES). **Significantly different from high SES. #All between-group differences significant.

differences at each age. At both ages 6 and 8, children with high SES presented significantly lower cortisol levels than did children with low and medium SES. At age 10, medium-SES children presented cortisol levels between that of low- and high-SES children (all $p < .01$), suggesting that the socioeconomic gradient of SES as a function of stress hormone levels appears between the age of 8 and 10.

Mothers did not differ on the 11 subscales of the DSP as a function of SES. Partial correlations between the scores obtained by the mothers on the 11 subscales and their child's cortisol levels were performed using child's age as a covariate (to control for a possible effect of child's age on mother's DSP scores) and a Bonferroni correction leading to an a priori significance level of $p < .005$. The only correlation coefficient that reached significance was that between the depressive score of the mother on the DSP and her child's cortisol levels ($r = .22$, $p = .004$), showing that the higher the score of the mother on the DSP depression subscale, the higher the cortisol levels of her child (Figure 2). To assess whether family income (as a marker of SES) had any impact on the significant association between the mother's depressive score and her child's cortisol levels, we performed bivariate as well as partial correlations using family income in the model. First, we showed that family income correlated negatively with both mother's depressive score ($r = -.25$, $p = .001$) and child's cortisol levels ($r = -.31$, $p = .001$), suggesting that family income is also a significant predictor for both mother's depressive score and child's cortisol levels. Second, we showed that when income was partialled out of the association between mother's depression and child's cortisol levels, the correlation decreased from .22 to .148 ($p = .08$). This later result suggests that although family

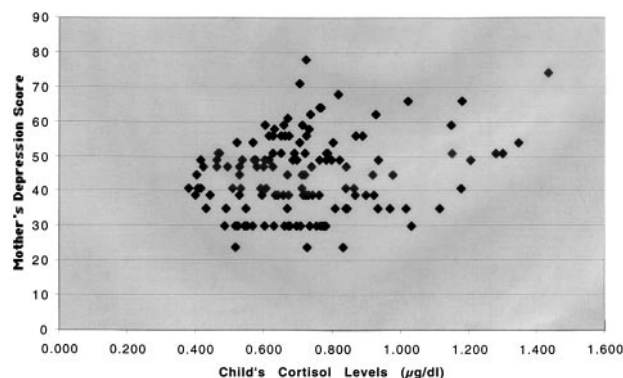


Figure 2. Correlation between mother's score on the depressive subscale of the Derogatis Stress Profile and child's cortisol level.

income has an impact on the association between mother's depressive score and her child's cortisol levels, it is not the only factor explaining this relationship.

Discussion

In our study, we report for the first time significant differences in stress hormones as a function of SES in children from an urban area, and we show that these differences gradually develop over time, with the largest SES differences appearing around the age of 10. Another study measured salivary cortisol levels in children from different social environments (Flinn and England 1997), and this study was undertaken in a rural Dominican village. Flinn and England (1997) and Flinn (1999) reported that children living in stable family environments had significantly lower cortisol levels than children living in unstable environments. Our results extend Flinn's data and show that SES differences occur in children from urban areas and that these differences develop over time. Given that our study was cross-sectional rather than longitudinal, one cannot predict whether duration of poverty is significantly related to hypersecretion of glucocorticoids in children or to risk for psychopathology later in life. Clearly, only a longitudinal follow-up of these children could serve to answer this question.

The observed SES differences in children's cortisol levels could be due to the school environments. A study performed by Tennes and Kreye (1985) on children's adrenocortical responses to classroom activities reported that in second graders, cortisol levels are influenced by social interactions with peers and teachers at school. In our study, however, children from all ages were tested in the same school; significant SES differences still emerged as a function of age in medium-SES children. This would suggest that if school environment plays a significant role in cortisol differences as a function of SES, its impact is concomitant with other environmental variables associated

to age. Second, the SES differences could be due to the neighborhood environments in which children are exposed as a function of SES (for a review, see Bureau of Labor Statistics 1967). It is known that for individuals with lower status in the SES hierarchy, residential choices become more limited; many of the environments in which these individuals live are associated with increased mortality rate and crime (Haan et al 1989). There is much evidence that individuals who live in "inner-city" areas reside in an environment that exhibits sharply lower attainment levels and, in addition, that repeatedly manifests higher rates of crime, divorce, unemployment, and population density than outer-city areas (Bureau of Labor Statistics 1967). It has been suggested that these differences in environments vary objectively in chronic exposures to stressor events (Harburg et al 1973). Although low-SES areas in the Montréal area are known to be safer and less violent than low-SES areas of other countries in the Americas, it is nonetheless possible that children from low-SES areas are exposed to greater environmental stress than children with high SES.

We also found that high cortisol levels in children from all socioeconomic backgrounds is significantly related to their mother's depressive symptomatology. Given previous studies that report a higher prevalence of depression in mothers with low SES (Hirschfeld and Cross 1982) and the observed significant relationship between mother's depressive score and family income, we can suggest that this significant correlation was moderately induced by mothers with low SES. This is further supported by the tendency of mothers with low SES to have higher scores on the depression subscale of the DSP (low SES: 46.31 ± 11.6 ; medium SES: 43.88 ± 12.2 ; high SES: 43.0 ± 7.9).

The association between depressive symptomatology in the mother and stress hormone levels in her child extends previous studies that have reported behavioral (Weintraub et al 1978) as well as cognitive (Billing and Moos 1983; Cohler et al 1977; Weissman et al 1987) impairments in children of depressed mothers (for a complete review, see Radke-Yarrow et al 1998). Nonetheless, the positive relationship between depressive symptomatology in the mother and her child's basal cortisol levels could be explained by a variety of scenarios. First, children may be reactive, in terms of adrenocortical activation, to the family environment in which they live. The frequent presence of discord and disorganization in families with a depressed parent is well known (Brown and Harris 1978). This finding has led to numerous investigations measuring the importance of parental diagnosis and family stress on the child's psychopathology (Emery et al 1982; Fendrich et al 1990; Hammen et al 1987). Such a relationship may well explain our results.

Second, children's cortisol levels may solely be associ-

ated with SES and have no clear relationship to mother's depressive symptomatology. This would suggest that both mothers and children should present cortisol levels that are related to SES and that depressive symptomatology in the mother is an artifact when associated with her child's cortisol levels. Clearly, the absence of cortisol measurement in the mothers, and the possibility that the relationship between mother's depressive score and low SES follow a curvilinear function rather than a linear one, does not currently permit an answer to this question. Third, children's cortisol levels may reflect a propensity for depression, transmitted pre- or postnatally from mother to child (Goodyer et al 1991; Nurnberger et al 1986). Again, the absence of a depression measure in the child does not permit assessment of the validity of this hypothesis at this point. Finally, it is possible that the child's temperament, being related to SES, basal cortisol levels, or both, has a direct influence on the mother's mood. Studies that report the presence of mood and cognitive changes in children following exposure to high glucocorticoid levels (Bender et al 1988) would correspond to this suggestion.

Although our study does not permit us to determine the exact origin of the association between a child's cortisol levels, the mother's depressive symptomatology, and SES, it remains a potentially important association, given the well-known detrimental effects of chronically elevated cortisol in both animals and humans (for a review, see Lupien and McEwen 1997; McEwen 1998). Indeed, cumulative exposure to high levels of cortisol in humans has been related to depression, cognitive deficits, and atrophy of brain structures involved in learning and memory (Lupien et al 1998). It remains to be seen whether childhood differences in cortisol are the precursors of later life gradients of mental health across SES.

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