Cortisol Production Patterns in Young Children Living With Birth Parents vs Children Placed in Foster Care Following Involvement of Child Protective Services

Kristin Bernard, MA; Zachary Butzin-Dozier; Joseph Rittenhouse; Mary Dozier, PhD

Objective: To examine differences in waking to bedtime cortisol production between children who remained with birth parents vs children placed in foster care following involvement of Child Protective Services (CPS).

Design: Between-subject comparison of cortisol patterns among 2 groups of children.

Setting: Children referred from the child welfare system.

Participants: Three hundred thirty-nine children aged 2.9 to 31.4 months who were living with birth parents (n=155) or placed in foster care (n=184) following CPS involvement as well as 96 unmatched children from low-risk environments.

Main Exposures: Involvement by CPS and foster care.

Main Outcome Measure: Salivary cortisol samples obtained at waking and bedtime for children on 2 days.

Results: Child Protective Services–involved children who continued to live with birth parents and CPS-involved children placed in foster care differed in cortisol production, with children living with their birth parents showing flatter slopes in waking to bedtime values.

Conclusions: Continuing to live with birth parents following involvement of CPS is associated with greater perturbation to the diurnal pattern of cortisol production than living with foster parents. Foster care may have a regulating influence on children's cortisol among children who have experienced maltreatment.


The functioning of the hypothalamus-pituitary-adrenal (HPA) axis is vulnerable to the effects of early adversity. Experimental studies with rodent and nonhuman primate young as well as correlational studies (or natural experiments) with young children have shown that neglect and separation from caregivers are associated with perturbations to the functioning of the HPA axis. In particular, experiences of neglect and separation from caregivers affect the production of glucocorticoids (cortisol among humans), an end product of the HPA axis. Alterations to the diurnal pattern of cortisol production have been seen among children living with their birth parents following maltreatment and among neglected children placed in foster care. In previous studies, it has not been possible to discern whether children who continue to live with their birth parents or those placed in foster care have shown greater perturbations in HPA functioning following involvement of Child Protective Services (CPS). Our study addresses this question.

A typical daytime cortisol pattern is characterized by a high waking value (peaking about 30 minutes after waking), followed by a rapid decline and then a slow drop-off across the day, reaching a nadir at bedtime. This pattern begins to emerge in the first 2 months of life, with mature functioning emerging by 5 to 6 years of age. Young children who have experienced neglect often differ from children from low-risk environments in showing a more blunted pattern of cortisol production across the day. Morning levels of cortisol have been shown to be lower with a flatter waking to bedtime slope than for other children.

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These findings have emerged for neglected children living with their birth parents and for neglected children placed in foster care. In the studies conducted to date, high-risk children (neglected children living with birth parents or with
foster parents) have been compared with children with no known risk factors.3-5 To our knowledge, no study has contrasted HPA functioning of children living with birth parents vs HPA functioning of children living with foster parents following involvement of CPS.

The primary aim of this study was to examine daily cortisol production patterns among maltreated children following involvement of CPS. Specifically, we were interested in whether there were differences in daily cortisol production between CPS-involved children who continued to live with their birth parents and children who were placed into foster care. We included data from a third group of unmatched children from low-risk conditions to provide an estimate of typical levels of cortisol among children of this age. We hypothesized that, relative to children placed into foster care, CPS-involved children who continued to live with their birth parents would show a more perturbed pattern because they were likely experiencing ongoing neglect from caregivers.

### METHODS

#### PARTICIPANTS

Primary participants included 339 children, ranging in age from 2.9 to 31.4 months (mean [SD], 12.9 [6.9] months). All children were involved with CPS and referred for participation in ongoing longitudinal studies assessing the effectiveness of an attachment-based parenting intervention; only children’s pre-intervention data were included in this study. Following involvement of CPS, 155 of the children continued to live with their birth parents and 184 of the children were placed in foster care. For those placed in foster care, it was the first placement for 138 children (75%), the second placement for 42 (23%), the third placement for 2 (1%), and the fourth placement for 2 (1%). The duration with the current foster parent at the time of enrollment in our study ranged from 0.1 to 18.1 months (mean [SD], 3.6 [3.6] months). Secondarily, 96 children from low-risk environments were included. Participants in the low-risk group were recruited from a university-based child care center. Table 1 shows demographic characteristics of each group.

#### PROCEDURES

The study had institutional review board approval and involved informed consent regarding research participation. Parents collected saliva samples from children at waking and bedtime for 2 consecutive days as part of the preintervention data collection for the larger study. Saliva samples were obtained by placing the end of a dental cotton roll in the child’s mouth.

Table 1. Child Demographic Characteristics

<table>
<thead>
<tr>
<th>Group</th>
<th>Sex</th>
<th>Race/Ethnicity</th>
<th>Age, Mean (SD), mo</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>White</td>
</tr>
<tr>
<td>CPS-involved, stayed with birth parents (n=155)</td>
<td>38 (54)</td>
<td>33 (46)</td>
<td>8 (11)</td>
</tr>
<tr>
<td>CPS-involved, placed in foster care (n=184)</td>
<td>69 (57)</td>
<td>52 (43)</td>
<td>32 (27)</td>
</tr>
<tr>
<td>Low-risk environment (n=96)</td>
<td>46 (54)</td>
<td>39 (46)</td>
<td>49 (58)</td>
</tr>
</tbody>
</table>

Abbreviation: CPS, Child Protective Services.

For children older than 12 months, flavored beverage crystals (cherry-flavored drink mix; Pathmark, Montvale, New Jersey) were provided to facilitate sampling. Parents were instructed to first wet the cotton in the child’s mouth, then dip the cotton in a cup containing 0.8 g of the flavored crystals and place it back in the child’s mouth until the cotton was soaking wet. Recent controlled studies have reported that flavored crystals only minimally affect cortisol levels when radioimmunoassay is used.3,10 The saturated cotton roll was returned to a prelabeled vial and stored in the freezer until it was picked up by a research assistant. Waking samples were collected between 5:00 AM and 12:00 PM (mean, 8:03 AM) and bedtime samples were collected between 6:30 PM and 12:47 AM (mean, 8:48 PM).

#### CORTISOL DATA PREPARATION

Following procedures commonly used in previous studies,11 cortisol values 3 SDs above the mean were considered outliers and excluded from analyses. Each child could have up to 4 cortisol values (ie, 2 waking and 2 bedtime samples). Of 1740 possible cortisol values, 31 outliers were removed and 126 samples were missing due to an inadequate volume of saliva or because no sample was taken, representing approximately 1% of the data. Missing data patterns were comparable across groups, with children living with birth parents missing 11% and 16%, children living with foster parents missing 14%, and children from low-risk environments missing 10% (Table 2). Log10 transformation was used to normalize the distribution of cortisol values owing to a positive skew.

#### PRELIMINARY ANALYSES

Demographic variables were examined to determine whether child characteristics were associated with log-transformed cortisol values. Child age, sex, and minority status were not associated with cortisol values at any of the time points (P > .05). Time of sample collection was also not associated with cortisol values at any of the time points (P > .05). Despite these findings, child age and sampling time were included in primary

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analyses as both have been significantly related to cortisol levels in previous studies.\textsuperscript{5,6,11}

**DATA ANALYTIC STRATEGY**

Group differences in cortisol levels at waking and bedtime as well as change in cortisol levels across the day were analyzed using hierarchical linear modeling.\textsuperscript{2,12} Hierarchical linear modeling treats repeated observations as nested within individuals, allowing for separate estimates of within-subject (level 1) and between-subject (level 2) variation. This nesting accounted for the nonindependence of multiple samples from the same child. Rather than aggregating across days to create an average waking cortisol level and an average bedtime cortisol level for each child (resulting in only 2 data points per child), the average estimated log cortisol level at waking for CPS-involved children living with foster parents, controlling for child’s age; $\beta_3$ is the difference in the waking log cortisol value between the CPS-involved children living with foster parents and the CPS-involved children living with birth parents (ie, the group
dummy coded 1); \(\beta_0\) is the regression coefficient representing the effect of the child's age (grand centered at the mean); CPS-birth represents the dummy-coded group status (with 0 representing children living with foster parents and 1 representing children living with birth parents); child's age represents the child's age in months; and \(r_{00}\) is the between-child individual differences left unexplained by the level 2 predictors. The equations for linear change (ie, \(\pi_i\)) also included the group status variable to compare cortisol change across the day between the groups.

In the second analysis, the same level 1 was specified, this time including data from the children in low-risk environments. A similar model was identified at level 2, with group status dummy coded to allow for comparisons among individuals of any 2 groups against a selected reference group—the low-risk sample in this case. The resulting level 2 model can be represented as follows:

\[
\pi_i = \beta_{00} + \beta_{01}(\text{CPS-foster}) + \beta_{02}(\text{CPS-birth}) + \beta_{03}(\text{child's age}) + r_{0i}
\]

\[
\pi_i = \beta_{10} + \beta_{11}(\text{CPS-foster}) + \beta_{12}(\text{CPS-birth}) + \beta_{13}(\text{child's age}) + r_{1i}
\]

\[
\pi_{2i} = \beta_{20}
\]

where the term \(\beta_{00}\) represents the average estimated log cortisol waking level for the low-risk comparison group; \(\beta_{01}\) is the difference between the low-risk comparison group and the CPS-involved children living with foster parents (ie, the group dummy coded 1 in the first group dummy code) at waking; and \(\beta_{03}\) is the difference between the low-risk comparison group and the CPS-involved children living with birth parents (ie, the group dummy coded 1 in the second group dummy code). Other terms are similar to those described earlier for the first level 2 model.

### RESULTS

To examine group-related differences in the diurnal pattern of cortisol production, we examined whether group status predicted the waking level of cortisol (intercept) and the change in cortisol level from waking to bedtime (slope). Results of the first model are summarized in Table 3. When controlling for sample collection time (at level 1) and child's age (at level 2), the log cortisol waking level differed significantly between CPS-involved children placed in foster care and CPS-involved children who continued to live with birth parents, with children living with birth parents showing a lower waking level of cortisol (Table 3).

The model was rerun with the bedtime sample as the intercept, indicating that CPS-involved children living with their birth parents had significantly higher cortisol levels at bedtime than children living with foster parents (\(\beta_{01} = .20\); \(P < .001\)). Furthermore, the change in cortisol level across the day differed significantly between the groups, with CPS-involved children living with their birth parents showing a more blunted pattern (ie, flatter slope) than children living with foster parents (Table 3).

The secondary analysis including the low-risk children as the reference group indicated that both CPS-involved children living with their birth parents and those living with foster parents differed significantly from the low-risk children in terms of their waking cortisol levels and slope across the day (Table 4). Whereas CPS-involved children living with birth parents also differed from low-risk children in their bedtime cortisol levels (\(\beta_{02} = .26\); \(P < .001\)), children placed in foster care did not differ (\(\beta_{01} = .05\); \(P = .46\)). Comparison of the magnitude of differences between low-risk children and CPS-involved children indicates that CPS-involved children living with their birth parents showed the most blunted pattern of diurnal cortisol production. The Figure presents the estimates of the waking and bedtime values for each group.

### COMMENT

Consistent with previous studies, our results indicate that CPS-involved children, who have typically experienced maltreatment, differ from low-risk children in showing lower waking cortisol values and flatter patterns of cortisol production from waking to bedtime. The findings go beyond prior studies to show that CPS-involved children who continue to live with their birth parents appear to have the greatest perturbation to their systems. Children living with their birth parents have lower waking cortisol values than both CPS-involved children living with foster parents and children living from low-risk environments, and they have flatter slopes from waking to bedtime than other children.

Although foster care involves disruptions in children's relationships with parents, children are better able to regulate their neuroendocrine systems when living with foster parents than when they continue to live with ne...
Blunted cortisol patterns and hyperreactivity of the hypothalamic-pituitary-adrenal (HPA) system have been associated with psychopathy and substance abuse. These findings, however, come from studies of individuals who experienced maltreatment in early life and were referred to care, and therefore a third variable (or variables) could contribute to these group differences. Clarifying possible explanatory factors may help target interventions for children at risk for biological dysregulation.

A blunted pattern of cortisol production appears to confer risk for later psychiatric disorders, most especially psychopathy and substance abuse problems. For example, blunted patterns of cortisol production are predictive of increases in aggressive behavior over time and characterize adolescents with conduct disorder and adults with antisocial personality disorder and substance use disorder.14,17 Shirtcliff and colleagues17 have argued that HPA hyporeactivity is central to the development of callous behavioral traits. The impaired neural circuitry of individuals with blunted or hyporeactive HPA systems leaves them underaroused by the distress of others and thus vulnerable to behaving in callous ways. Although it is premature to suggest specific implications for neglected children, the findings are concerning.

These and other findings suggest the plasticity of the HPA system in early development. On the one hand, conditions of neglect adversely affect children’s HPA system functioning. On the other hand, interventions such as foster care and specialized services can remediate the system’s functioning.18-21 For example, 2 randomized clinical trials have shown that specialized training for foster care and birth parents results in children showing more normative cortisol patterns.20-21 These results emphasize the importance of prevention for young children exposed to early adversity given that neural circuitry and associated developmental trajectories become less plastic over time.

The greatest limitation of this study is that it did not use an experimental design. It is not possible to randomly assign children to conditions of neglect or foster care, and therefore a third variable (or variables) could account for the findings. Indeed, we expect that the 2 groups of children who experienced maltreatment differ from the comparison children perhaps in ways that are important to HPA regulation. Nonetheless, the 2 groups of CPS-involved children (those who continued to live with birth parents and those placed in foster care) provide reasonable comparisons for one another. Differences in prenatal histories would likely be expected to favor children living with birth parents, making it unlikely that obtained differences between these 2 groups are attributable to prenatal factors.

Accepted for Publication: January 21, 2010.
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Author Contributions: Study concept and design: Bernard and Dozier. Acquisition of data: Bernard, Butzin-Dozier, and Rittenhouse. Analysis and interpretation of data: Bernard, Butzin-Dozier, Rittenhouse, and Dozier. Drafting of the manuscript: Bernard, Butzin-Dozier, Rittenhouse, and Dozier.

Table 4. Multilevel Modeling Coefficients of Group Effects on Diurnal Cortisol Production With Low-Risk Children as Reference Group

<table>
<thead>
<tr>
<th>Effect</th>
<th>β Coefficient (SE)</th>
<th>t Statistic</th>
<th>df</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, β₀₀</td>
<td>−.49 (.04)</td>
<td>−11.12</td>
<td>411</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>CPS-foster, β₁₁</td>
<td>−.18 (.05)</td>
<td>−3.27</td>
<td>411</td>
<td>.002</td>
</tr>
<tr>
<td>CPS-birth, β₀₂</td>
<td>−.26 (.06)</td>
<td>−4.71</td>
<td>411</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Child’s age, β₀₃</td>
<td>−.00 (.00)</td>
<td>−0.84</td>
<td>411</td>
<td>.40</td>
</tr>
<tr>
<td>Sample slope, β₁₀</td>
<td>−.67 (.14)</td>
<td>−4.72</td>
<td>411</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>CPS-foster, β₁₁</td>
<td>.22 (.07)</td>
<td>3.41</td>
<td>411</td>
<td>.001</td>
</tr>
<tr>
<td>CPS-birth, β₀₂</td>
<td>.52 (.07)</td>
<td>7.76</td>
<td>411</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Child’s age, β₀₃</td>
<td>−.00 (.00)</td>
<td>−0.60</td>
<td>411</td>
<td>.55</td>
</tr>
<tr>
<td>Time slope, β₁₀</td>
<td>−.00 (.01)</td>
<td>−0.18</td>
<td>1345</td>
<td>.86</td>
</tr>
</tbody>
</table>

Abbreviation: CPS, Child Protective Services.

αβ₀₀ and β₁₁ represent the waking level of cortisol and the slope of cortisol production across the day, respectively, for low-risk children. β₀₂ and β₁₁ represent the difference in the waking level of cortisol and the slope of cortisol production across the day, respectively, between low-risk children and CPS-involved children living with foster parents. β₀₀ and β₁₁ represent the difference in the waking level of cortisol and the slope of cortisol production across the day, respectively, between low-risk children and CPS-involved children living with their birth parents.

Figure. Cortisol patterns for Child Protective Services (CPS)–involved children who stayed with birth parents, CPS-involved children placed in foster care, and low-risk children. Cortisol levels were measured as micrograms per deciliter (to convert to nanomoles per liter, multiply by 27.588). Error bars indicate SE.

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house, and Dozier. Critical revision of the manuscript for important intellectual content: Bernard and Dozier. Statistical analysis: Bernard. Obtained funding: Dozier. Study supervision: Dozier.

Financial Disclosure: None reported.

Funding/Support: This work was supported by grants R01MH052135, R01MH074347, and R01MH084135 from the National Institute of Mental Health (Dr Dozier).

Disclaimer: The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute of Mental Health or the National Institutes of Health.

REFERENCES


