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Cortisol Predicts Behavioral Dysregulation and Length of Stay Among Children Admitted for Psychiatric Inpatient Treatment

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Individual differences in behavioral regulation system (BRS) and stress response system (SRS) functioning may reflect greater biological sensitivity to context. The current study tested whether children’s cortisol, a measure of the SRS, was related to observed dysregulated behavior, an indicator of the BRS, in a sample of children admitted for acute psychiatric inpatient care. In addition, cortisol and dysregulated behavior were tested as unique predictors of length of hospitalization over and above demographic factors, prior treatment history, and caretaker-reported psychiatric symptoms. The latter variables were tested as potential moderators of the relations of BRS and SRS functioning to length of hospitalization. Plasma cortisol was collected on the morning following hospital admission for 544 children (ages 6–12; 73% boys; 61% ethnic minority). Dysregulated behavior was operationalized as the mean number of timeouts administered by staff for noncompliant behavior per day of hospitalization. Caretakers reported on youth internalizing and externalizing symptomatology. Higher cortisol was modestly associated with greater dysregulated behavior. In a model including both cortisol and dysregulated behavior, each predicted longer hospitalization. Cortisol was positively related to length of stay only for children previously hospitalized, and the relation of dysregulated behavior to length of stay was stronger for older children. Dysregulated behavior and cortisol are related but independent predictors of acute psychiatric hospitalization duration. Direct measures of the SRS can add to the clinical picture regarding hospitalization in ways that observed behavior and caretaker report alone cannot.

Admission to an acute-care child psychiatric inpatient facility is typically reserved for children experiencing severe and frequent psychological, emotional, or behavioral disturbances not easily managed in less restrictive treatment settings (e.g., outpatient treatment). Although the goal of such facilities is timely assessment, diagnosis, stabilization, and referral to a less restrictive setting, inpatient treatment is costly (Ringel & Sturm, 2001) and often results in considerable emotional

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burden for children and parents. Identification of factors associated with increased length of stay (LOS) could lead to treatment modifications that prevent extended and costly hospitalizations. To date, multiple psychosocial risk factors (e.g., individual, familial, socio-cultural) have been shown to predict poorer response for children seeking treatment for serious emotional and behavioral disturbances (Leon, Snowden, Bryant, & Lyons, 2006). Regarding inpatient treatment, those who are younger, are boys, have a history of previous hospitalizations, or have higher parent-reported illness severity are each more likely to experience longer LOS, an indicator of poor treatment response for hospitalized youth (Leon et al., 2006; Pavkov, George, & Czapkowicz, 1997). Ethnicity findings are mixed, with some studies showing longer LOS for ethnic minority populations compared to European-Americans (Leon et al., 2006; Pavkov et al., 1997), whereas others show longer LOS for European American compared to African American and Hispanic youth (Mason & Gibbs, 1992; Pottick, McAlpine, & Andelman, 2000). Beyond these variables, however, variation in two different biobehavioral regulatory systems may also contribute to children’s treatment response and LOS: the behavioral regulation system (BRS) and the stress response system (SRS).

Some have suggested that dysregulated BRS and SRS functioning may be two separate indicators of a greater biological sensitivity to context (Ellis, Boyce, Belsky, Bakermans-Kranenburg, & Van Ijzendoorn, 2011). Children who are more biologically sensitive, as evidenced through neurobiological processes and behavioral displays, are theorized to be more susceptible to their environments. In supportive environments, children who are biologically sensitive thrive and demonstrate the best developmental outcomes. On the other hand, and particularly relevant to the current study, those same highly sensitive children who experience adverse environments demonstrate the worst outcomes. Initial empirical work supports this model with regard to mental and physical health symptoms (e.g., Boyce, Essex, & Ellis, 2005; Essex, Armstrong, Burk, Goldsmith, & Boyce, 2011), but relations to clinical outcomes like LOS have not been tested. In addition, although behavioral indicators are posited to be the result of neurobiological processes (Del Guidice, Shirkchiff, & Ellis, in press), it is unclear if (a) different indicators of sensitivity are independent or correlated, and (b) whether these separate indicators predict subsequent clinical outcomes (e.g., LOS) in a unique, additive, or interactive manner. Thus, the primary purpose of the current study was to examine whether cortisol, a marker of the SRS, was related to dysregulated behavior during psychiatric inpatient hospitalization, and whether behavioral dysregulation and cortisol contributed uniquely or interactively to LOS.

BEHAVIORAL REGULATION SYSTEM

Behavioral regulation has been defined as one’s ability to modulate behavior in order to adhere to situational demands (Kochanska, Coy, & Murray, 2001; Kopp, 1982). For children, one primary facet of behavioral regulation is compliance with caregivers’ directions and commands, which requires control over both behavior (e.g., refraining from impulsivity) and emotion (e.g., controlling anger, inhibiting crying; Kopp, 1982; Kuczynski & Kochanska, 1995). Behavioral dysregulation, then, may be observed when children display non-compliance or disinhibited behavior, especially in novel or socially stressful situations (Kopp, 1982).

Unless broadened as suicidal behavior or dangerousness (Leon et al., 2006; Pavkov et al., 1997), behavioral dysregulation has been infrequently studied in relation to inpatient LOS for children. In one study, Gold, Shera, and Clarkson (1993) found that violent tantrums during hospitalization predicted LOS in a sample of children ages 4 to 12 years. Dysregulated behavior, however, also relates to other adverse outcomes, such as problems adjusting to a new classroom, peer conflict, and externalizing-spectrum problem behaviors (Eisenberg et al., 2000; A. L. Miller, Gouley, Seifer, Dickstein, & Shields, 2004). Certainly, being admitted to a psychiatric inpatient unit is a novel and socially stressful experience for a child that places considerable demands on a child’s ability to regulate behavior. The child is away from primary caretakers, expected to follow a strict set of milieu rules requiring compliance, and surrounded by unfamiliar adults and peers. Discharge timing decisions, however, are often largely based on the emotional and behavioral control exhibited by a child during inpatient treatment. It would not be surprising, then, to find that those youth who exhibit higher levels of dysregulated behavior (e.g., non-compliance to a behavioral modification program) would remain hospitalized longer. As such, an association among behavioral dysregulation and increased LOS would be expected.

STRESS RESPONSE SYSTEM

A second system that may influence clinical outcomes is the SRS. In general, scant attention has been paid to physiological indicators of poor treatment response (e.g., LOS) for children receiving psychiatric inpatient treatment. This is surprising in light of the fact that physiological measures (e.g., blood pressure, complete blood count) are routinely administered during initial hospital admission processes. A lack of research in this area stands in stark contrast to the recent surge in studies examining the role of the SRS in the development
of emotional and behavioral problems in youth. Functioning within one component of the SRS, the Hypothalamic Pituitary Adrenal (HPA) axis, is associated with emotional and behavioral processing (Smidt et al., 2002). Exposure to new, uncertain, or stressful situations triggers HPA axis activation, which, via a chain of events, ultimately culminates in the release of the hormone cortisol. This response is universal, adaptive, and related to coping when well regulated; dysregulated HPA functioning, however, relates to various maladjustment outcomes (Gunnar & Quevedo, 2007).

Several studies have shown that both hyper- and hypoactivation of the HPA axis relate to adverse outcomes, namely, psychopathology. Generally, studies have found that children’s internalizing problems are associated with higher cortisol levels (El-Sheikh, Erath, Buckhalt, Granger, & Mize, 2008; Goodyer, Park, & Herbert, 2001; though see Granger et al., 1998), whereas lower cortisol appears to be related to externalizing behavior (e.g., Shirtcliff, Granger, Booth, & Johnson, 2005; van de Wiel, van Goorzen, Matthys, Snoek, & van Engeland, 2004; though see Kruesi, Schmidt, Donnelly, Hibbs, & Hamburger, 1989; Scerbo & Kolko, 1994). In some studies, higher cortisol has been related to externalizing behavior, especially when youth are in novel contexts (Dettling, Gunnar, & Donzella, 1999; van Bokhoven et al., 2005). The few studies that consider co-occurring internalizing and externalizing problems in relation to HPA-axis functioning are also mixed, with some finding increased basal cortisol related to shared externalizing and internalizing distress (Shirtcliff & Essex, 2008), whereas others find no additive effect of comorbidity on HPA functioning (e.g., Marsman et al., 2008; Oosterlaan, Geurts, Knol, & Sergeant, 2005; Shirtcliff et al., 2005).

Rather than examining cortisol’s relation with symptomatology, what remains untested is whether SRS functioning predicts unique clinical outcomes. Emerging evidence suggests that, at least in the realm of disruptive behavior disorders, HPA functioning may be predictive of differential treatment effectiveness (van de Wiel et al., 2004). Morning cortisol levels may be particularly informative for understanding adverse clinical outcomes. Cortisol tends to be at its highest volume in the morning and then decreases throughout the day, and higher morning cortisol volumes have been associated with general life stress and adverse family functioning (Chida & Steptoe, 2009; Cutuli, Wiik, Herbers, Gunnar, & Masten, 2010). In particular, acute stress seems to be related to higher morning cortisol, and it increases children’s vulnerability to a host of subsequent negative emotional and behavioral outcomes (G. F. Miller, Chen, & Zhou, 2007; Ruttle et al., 2011). Likely, high morning cortisol would be indicative of youth having a more difficult time adjusting to an acute stressor such as being admitted to an inpatient psychiatric care facility. In turn, poorer clinical outcomes (i.e., longer LOS) for these children would be expected.

RELATIONS AMONG BEHAVIORAL DYSREGULATION, CORTISOL, AND LOS

In assessing relations of LOS with either behavioral dysregulation or cortisol, it is important to also consider the relation between behavioral dysregulation and cortisol to understand whether unique or perhaps interactive effects might occur in predicting LOS. In general, little empirical work has considered BRS and SRS functioning in the same study. Somewhat surprisingly, studies typically find no relation of cortisol to observable indicators of dysregulated behavior despite relations to questionnaire measures of behavior (Alink et al., 2008; Dabbs, Jurkovich, & Frady, 1991). The majority of these studies, however, have (a) occurred in samples of young children (2–7 years old), (b) used a laboratory stress-reactivity paradigm to measure cortisol reactivity and observed behavior, or (c) used small sample sizes despite expecting small effects (Bagner, Sheinkopf, Vohr, & Lester, 2010; Granger et al., 1998; Gunnar, Kryzer, Ryzin, & Phipps, 2010; Pérez-Edgar, Schmidt, Henderson, Schulkin, & Fox, 2008; Spinrad et al. 2009). In contrast with these studies, behavioral dysregulation in novel, stressful peer settings has been positively associated with increased cortisol levels (Gunnar et al., 2010; Dettling et al., 1999; Gunnar, Sebanc, Tout, Donzella, & van Dulmen, 2003). Further, Essex and colleagues (2011) recently demonstrated that BRS functioning (measured as mean arterial pressure across a stress protocol) and BRS functioning (measured as temperamental disinhibition) each uniquely moderated the relation between a stressful environment and later mental health symptom severity. Taken together, and in line with biological sensitivity to context theory, a modest, positive association would be expected between behavioral dysregulation and cortisol, but these indicators likely would be unique predictors of LOS as well. To our knowledge, no study has examined if these two biobehavioral systems might interact to predict LOS.

POTENTIAL MODERATORS

Aside from a potential interaction among behavioral dysregulation and cortisol predicting LOS, previous literature warrants investigation of other possible moderating variables. First, as mentioned previously, age, sex, previous history of hospitalization, and psychiatric symptoms each affect LOS (Leon et al., 2006; Pavkov et al., 1997). These same attributes may also influence
the relation of BRS or SRS functioning to LOS. Second, age and sex have been found to moderate the separate relations of behavior dysregulation and cortisol to other maladaptive outcomes. For instance, the relation of cortisol to externalizing problems is stronger in school-aged children than young children or adolescents (Alink et al., 2008), and some studies have shown that relation to be true only for boys (Shirtcliff et al., 2005). Likewise, the relation of behavioral dysregulation to adverse outcomes such as problematic home or school behaviors and psychopathology tend to be stronger for older children, and depending on the study, stronger for one gender or the other (Buckner, Mezzacappa, & Beardslee, 2009; Eisenberg et al., 2000; Kalpidou, Power, Cherry, & Godfried, 2004). Finally, age and sex have been found to moderate the relation between the BRS and SRS themselves. For example, Gunnar et al. (2010) found cortisol related to dysregulated behavior for boys but not for girls, and age moderated the relation of cortisol to behavior in nonhome contexts (Watamura, Donzella, Alwin, & Gunnar, 2003).

THE CURRENT STUDY

The high emotional and monetary costs associated with inpatient psychiatric care is a significant challenge faced by clinicians and families alike. Research examining both behavioral and physiological factors that predict poorer clinical outcomes may inform new or better ways to decrease costs through development of more effective and targeted treatments. Demographic factors, treatment history, and symptom severity have been found to relate to a host of treatment-efficacy issues including poorer treatment outcome, younger age at inpatient admission, and risk of readmission (Fite, Stoppelbein, Greening, & Dhossche, 2008; Leon et al., 2006). Testing whether functioning in two different biobehavioral regulatory systems, the BRS and SRS, independently predict LOS has important implications for improving treatment selection and cost reduction (both monetary and emotional). Therefore, we investigated first whether morning cortisol was associated with dysregulated behavior while statistically controlling for demographic factors, treatment history, and parent-reported psychopathology in a sample of children admitted to acute psychiatric inpatient care. Dysregulated behaviors were defined as those that elicited a “timeout” administered to children by direct-care staff. As two indicators of biological sensitivity to context, we expected that higher levels of cortisol would be modestly related to receiving more timeouts per day of hospitalization. The second goal of the study was to assess the extent to which dysregulated behavior and cortisol were independently associated with children’s LOS. Again, we hypothesized that more dysregulated behavior and elevated cortisol levels would each be related to longer LOS. Further, we expected an interactive effect, such that children demonstrating high reactivity in both the BRS and SRS domains would experience the longest LOS. Finally, we examined if demographic variables, treatment history, and psychopathology symptoms moderated the relations previously described. Given the limited past work from which to draw, specific moderation hypotheses were not generated a priori.

METHODS

Participants

Participants included 586 children admitted consecutively to an acute child psychiatric inpatient facility providing treatment for children ages 4 to 12. Exclusion criteria for participation included (a) a history of traumatic brain injury, an acute medical condition, or a diagnosis of either psychosis or autism; (b) children in the Department of Human Services’ custody lacking a reliable informant regarding the child’s history; and (c) children younger than 6 years old. Of the 586 children, two parents declined participation and 22 met one or more exclusion criteria. Also, due to potential delays in treatment initiation and multidisciplinary team review, children admitted on Saturday (n = 13) or Sunday (n = 5) were excluded from analyses. Thus, the final sample included 544 participants. Compared to those included, the 42 youth excluded from analyses did not differ on sex, $\chi^2(1) = .30, p = .58$; ethnicity, $\chi^2(1) = 1.16, p = .28$; mean age, $t(584) = -1.20, p = .23$; or mean LOS, $t(584) = -0.35, p = .73$.

Of those included, 397 were boys (73%) and 147 were girls (23%), ranging from 6 to 12 years old ($M = 9.11, SD = 1.91$). On average, boys ($M = 8.97, SD = 1.88$) were slightly younger than girls ($M = 9.47, SD = 1.98$), $t(542) = -2.69, p < .01$. For all participants, data come from their first hospitalization at this particular facility. However, 30.6% of youth had been previously hospitalized elsewhere for psychiatric concerns. Only caretakers who maintained legal guardianship over the child participated in the study. Caretakers who completed measures were primarily mothers (78%), followed by grandparents (7%), fathers (6%), and aunts or uncles (2%). An additional 7% identified as “other” legal guardians, and 1% of caretakers did not complete the item identifying their relation to the child. For simplicity, all caretakers are referred to as “parents” from here forward. Parent-identified race/ethnicity of the sample was mostly African American (58%), with 39% Caucasian, and 2% biracial. Two participants identified as Hispanic (0.4%), one participant as Asian American (0.2%), and
one as “Other” (0.2%). Although specific information regarding socioeconomic status of individual participants was unavailable, 84% of children admitted to this particular facility are covered by Medicaid.

For the unit, discharge diagnoses were made by treatment team consensus. Most children were diagnosed with at least one externalizing disorder (e.g., attention deficit hyperactivity disorder, disruptive behavior disorder; 88.9%), with fewer being diagnosed with at least one internalizing disorder (e.g., depression, anxiety; 17.3%) or another psychiatric condition (e.g., Tourette’s syndrome, learning disorders; 32.0%). Most participants (78.3%) were diagnosed with more than one disorder.

**Measures**

*Internalizing and externalizing symptoms.* Parents completed the Child Behavior Checklist for Ages 6 to 18 (Achenbach & Rescorla, 2001). Parents rated on a 3-point scale (0 = not true, 1 = sometimes true, 2 = very true) how true each of 120 problem items was for their child. T scores for externalizing (α = .90) and internalizing (α = .88) syndrome scales were calculated. The externalizing scale consists of 35 items that assess rule-breaking and aggressive behavior, whereas the internalizing scale consists of 32 items assessing anxious, depressed, and withdrawn behavior, as well as somatic complaints. Higher scores indicate more distress in these domains. Previous studies find high test-retest reliability (r_{ext} = .92, r_{int} = .91) and internal consistency (α_{ext} = .94, α_{int} = .90; Achenbach & Rescorla, 2001).

In the current sample, 88.2% of participants were in the clinical range (4.5% in the borderline range) on the Externalizing subscale (M = 73.40, SD = 8.37). Similarly, 69.9% of youth scored in the clinical range (10.1% in the borderline range), on the Internalizing subscale (M = 66.83, SD = 10.03). As in other studies (e.g., Shirtcliff & Essex, 2008), internalizing and externalizing symptoms were strongly correlated (r = .43, p < .001). To prevent multicollinearity problems in primary analyses that include both sets of symptoms, separate severity and directionality scores were calculated following procedures outlined by Essex and colleagues (Essex, Klein, Cho, & Kraemer, 2003). Severity was calculated as the mean of standardized externalizing and internalizing scores, whereas directionality was calculated as the difference between standardized externalizing and internalizing scores divided by 2, representing the relative preponderance of externalizing to internalizing symptoms. For directionality, a positive score indicated greater externalizing symptomatology, whereas a negative score indicated greater internalizing symptomatology. Severity and directionality were orthogonal (i.e., r = .00).

**Timeouts.** As a measure of dysregulated behavior, the mean number of timeouts administered to each participant per day of their hospitalization was used for analyses. Upon admission to the inpatient unit, children were immediately enrolled in a behavior modification program in which they earned incentives for following unit rules (e.g., speaking respectfully to others, following directions) and received consequences for engaging in noncompliance. When milieu rules were broken (e.g., verbal threats to others, failing to follow staff commands) or children displayed significant context-inappropriate behavior (e.g., uncontrolled crying, yelling), and subsequently did not respond appropriately to staff redirection, they were administered a timeout. Timeouts involved being removed from the stimulating environment and having to remain quiet during the duration of their timeout (typically, 1 min per child’s age in years). All timeouts were recorded by staff in the child’s medical records.

The behavioral modification program was implemented prior to the start of the current study (i.e., the program was not created solely for this study) and represents typical hospital protocol. Staff were provided initial training upon their hire and engaged in regular continuing education sessions to maintain the program fidelity. All staff underwent a manualized training program that explained the basic tenants of behavior therapy, the use of reinforcement and punishment to promote and extinguish various behaviors, and the appropriate use of a standard behavioral program consisting of a sticker/reward program and use of timeouts. Following training, new staff members shadowed a senior staff member for 2 weeks before implementing the program on their own. They were provided with an additional week of one-to-one training with a senior staff member as they took the lead in implementing the program for the children.

**Plasma cortisol.** A fasting blood draw was obtained before breakfast (approximately 12 hr since the child last ate) between 6:00 a.m. and 7:30 a.m. on the morning following each child’s admission. All blood was drawn using a VACUTAINER blood collection set within 20 min of the child awakening, and samples were used for biological assays to inform clinical care including cortisol level. Concentrations of cortisol were determined using a chemiluminescence procedure (ECI instrument, Ortho Clinical Diagnostics). The interassay and intra-assay coefficients of variation were 0.9% and 3%, respectively. The assay sensitivity was < .11 μg/dL.

**Length of stay.** The number of days a child was admitted to the unit was calculated as the difference between hospital admission and discharge dates.
Procedure

All procedures received hospital Institutional Review Board approval. Upon each child’s admission to the hospital, parents were asked if their child’s clinical data, collected per typical hospital admissions protocol, could be used for the current study. Parents were informed that their child’s clinical care would not be contingent upon or be affected by participation. Once written consent was obtained, parents completed a standard questionnaire battery. LOS and number of timeouts administered were obtained from children’s medical records following their hospital discharge.

RESULTS

Preliminary Analyses

One-way analyses of variance were performed to ensure that there was no mean difference in symptoms scores based on type of informant (e.g., mother, father). All F values were nonsignificant (Fs range from 0.29 to 1.42), suggesting no differences among reporters. Thus, all caretakers were included in our sample. In addition, hospital staff do not typically meet to discuss treatment planning during weekend days. Potentially, LOS data may be artificially inflated for children admitted to the unit on a Friday, for example, because full treatment planning would likely not commence until the following Monday. A one-way analysis of variance indicated, however, that day of week for admission was not associated with LOS, F(4, 539) = 2.25, p > .05. As such, day of admission was not considered further in analyses.

Means, standard deviations, and intercorrelations for cortisol, psychiatric symptom severity and directionality, timeouts, and LOS are presented in Table 1. Also included are potential covariates (i.e., sex, ethnicity, age, and history of psychiatric hospitalization) that have been linked in previous studies to psychopathology severity, behavioral dysregulation, and LOS. At the bivariate level, both cortisol and parent-reported preponderance of externalizing psychopathology were significantly, positively related to timeout frequency and experiencing longer LOS. Further, timeouts per day was related to longer LOS. Severity of psychopathology was unrelated to the number of timeouts children received per day and LOS.

Certain demographic variables were related to outcomes of interest. Specifically, boys received more timeouts, on average, than girls. LOS was unrelated to sex. Also, as children’s age increased, the number of timeouts and overall LOS decreased. Having a history of prior hospitalization was related to longer LOS. Age and sex of children as well as history of prior hospitalizations were therefore included as covariates in primary analyses. Child ethnicity was not associated with any

<table>
<thead>
<tr>
<th>TABLE 1</th>
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<tr>
<td>Intercorrelations, Means, Standard Deviations, and Ranges for Covariates, Cortisol, Psychopathology Symptom Severity and Directionality, Timeouts, and LOS</td>
</tr>
<tr>
<td>1. Sex&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>2. Ethnicity&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>3. Age</td>
</tr>
<tr>
<td>4. Hospitalization&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>5. Cortisol</td>
</tr>
<tr>
<td>6. Severity&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>7. Directionality&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>8. Timeouts per Day</td>
</tr>
<tr>
<td>9. Days on Unit</td>
</tr>
<tr>
<td>M</td>
</tr>
<tr>
<td>SD</td>
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<td>Range</td>
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</table>

Note: N = 544. Because sex, ethnicity, and past hospitalizations are dichotomous variables, correlation coefficients that include these constructs represent point-biserial correlations. Age is presented in years. Cortisol values are presented as μg/dL. Severity is the mean score of standardized Child Behavior Checklist (CBCL) Externalizing and Internalizing T scores. Directionality is presented as one half difference between CBCL Externalizing and Internalizing T scores, with positive score reflecting a relative preponderance of externalizing symptoms and negative scores reflecting a preponderance of internalizing symptoms. LOS = length of stay.

<sup>a</sup>Boys = 0, girls = 1.
<sup>b</sup>Caucasian = 0, minority = 1.
<sup>c</sup>Hospitalization = previous psychiatric hospitalization; No = 0, one or more previous hospitalizations = 1; for this variable only (N = 540).
<sup>d</sup>Severity = parent-reported psychopathology severity.
<sup>e</sup>Directionality = parent-reported preponderance of either externalizing or internalizing symptoms.

*p < .05. **p < .01.
TABLE 2
Regression Results of Demographic Variables, Symptomatology, and Cortisol Predicting Timeouts per Day

<table>
<thead>
<tr>
<th>Predictors</th>
<th>b</th>
<th>SE</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.51</td>
<td>.14</td>
<td>10.62*</td>
</tr>
<tr>
<td>Sex</td>
<td>−.11</td>
<td>.02</td>
<td>−.28</td>
</tr>
<tr>
<td>Age</td>
<td>−.14</td>
<td>.07</td>
<td>−6.78**</td>
</tr>
<tr>
<td>Past Hospitalization</td>
<td>.09</td>
<td>.06</td>
<td>1.41</td>
</tr>
<tr>
<td>Severity</td>
<td>.00</td>
<td>.03</td>
<td>0.07</td>
</tr>
<tr>
<td>Directionality</td>
<td>.18</td>
<td>.06</td>
<td>2.28**</td>
</tr>
<tr>
<td>Cortisol</td>
<td>.01</td>
<td>.00</td>
<td>2.00</td>
</tr>
</tbody>
</table>

Note. N = 544. Overall model fit, $F(6, 533) = 14.26$, $p < .001$. $R^2 = .14$. For sex, boys = 0, girls = 1. Age is calculated in years. For past hospitalization, none = 0, one or more = 1. Severity and directionality are Z scores. Cortisol values are calculated in μg/dL.

* $p < .05$, ** $p < .01$.

criterion variables, and thus not included as a covariate in analyses.

Primary Analyses

Our first aim was to examine if cortisol was associated with behavior dysregulation, operationalized as the average number of timeouts per day of admission, over and above parent-reported severity of psychopathology while controlling for common demographic variables (i.e., sex, age, past hospitalizations). Because four participants were missing data on presence or absence of past hospitalizations, regression analyses included 540 participants. The overall model was significant, and regression coefficients, standard errors, and $t$ values are displayed in Table 2. Cortisol was significantly, positively related to number of timeouts received per day by participants controlling for parent-reported severity and directionality of symptoms, child sex, age, and past hospitalizations. The relation of cortisol to timeouts, albeit significant, was small, suggesting a large degree of independence among stress regulation and behavioral regulation. Holding all other variables in the model constant, for every 10 μg/dl increase in a child’s cortisol, an additional one timeout per day of admission would be expected.

Considering other variables in the model, directionality of symptoms were positively associated with timeouts, indicating that children displaying a preponderance of externalizing symptoms were given a larger number of timeouts. Symptom severity was unrelated to timeouts. Regarding covariates included in the model, child’s sex predicted timeouts, with boys receiving more timeout than girls, and age was negatively associated with timeouts. Whether a child had been previously hospitalized for psychiatric distress was unrelated to timeouts. Given our primary interest in the association of stress responsivity to behavioral dysregulation, moderation analyses were conducted to test if the direct effect of cortisol on timeouts was moderated by demographic factors or psychiatric symptoms. No significant interactions emerged.

A second regression analysis, with LOS as the criterion variable, was used to test whether cortisol and behavioral dysregulation (i.e., timeouts) contributed unique variance over and above each other after controlling for age, sex, presence or absence of previous hospitalization, and symptom severity and directionality. The overall model was significant, and regression coefficients, standard errors, and $t$ values are displayed in Table 3. As expected, both behavioral dysregulation and cortisol were uniquely related to LOS. Holding other variables in the model constant, for every additional timeout per day received, children’s LOS was predicted to increase by 1.13 days. Likewise, for every 1 μg/dl increase in cortisol, children’s LOS was predicted to increase by .07 days. More intuitively, a 14.3 μg/dl increase in cortisol predicted an increase of 1 full day on the unit. In addition, past hospitalizations significantly predicted increased LOS, whereas age predicted decreased LOS. Sex, symptom severity, and directionality were unrelated to LOS.

We also tested if the direct effects of cortisol or timeouts on LOS were moderated by demographic factors or psychiatric symptoms (see Table 3). In contrast to our hypothesis, the interaction of cortisol and timeouts per day did not significantly predict LOS. Two significant interactions, however, did emerge. First, cortisol significantly interacted with past hospitalization to predict LOS. Follow-up analyses probed the simple effect of cortisol within each level of hospitalization, indicating a significant relation for those youth who had been previously hospitalized ($N = 165, b = .21, \beta = .22, t = 2.97, p = .003$), but not for those youth for whom this was their first psychiatric hospitalization ($N = 375, b = .02, \beta = .03, t = 0.64, p = .52$). For those previously hospitalized, a 4.5 μg/dl increase in cortisol predicted an increase of 1 day on the unit. Second, the number of timeouts significantly interacted with age to predict LOS. To probe this interaction, we tested the simple slope of timeouts predicting LOS at the mean age in our sample (approximately 9 years), as well as at 1 standard deviation below (roughly age 7) and 1 standard deviation above (roughly age 11) the mean. As shown in Figure 1, the effect of timeouts per day on LOS became stronger for older youth.

DISCUSSION

The goal of the current study was to test whether individual differences in children’s BRS and SRS...
functioning were associated with or independent of one another, and whether these two systems uniquely predicted length of acute psychiatric hospitalization over and above common demographic factors, treatment history, and parent-reported internalizing and externalizing symptomatology. Whereas many studies have examined BRS and SRS functioning as separate risks for or markers of symptomatology, the current study went one step further to examine if these two biobehavioral systems predict LOS, a potential marker of clinical need. In particular, we focused on observed noncompliance and disinhibition as our measure of BRS and morning cortisol as our measure of SRS. Our findings extend previous research by examining the simultaneous role of both systems as predictors of a clinically relevant outcome. Not surprisingly given how discharge decisions are made, dysregulated behavior predicted increased LOS, and this relation was stronger for older children. On the other hand, a single assessment of child cortisol also provided unique information about behavior not available from observed behavior or parent report of youth’s psychopathology. Increases in cortisol predicted greater number of timeouts per day and longer LOS, though the latter was only true for those children with a history of past hospitalizations.

Before discussion of results regarding primary aims, brief comment regarding the relations of cortisol to psychiatric symptoms is warranted. Although the emerging consensus in the literature is that, by middle childhood, low levels of basal cortisol are associated with externalizing disorders (Alink et al., 2008) and high levels with internalizing disorders (El-Sheikh et al., 2008), most studies have compared clinical versus control groups rather

### TABLE 3

| Predictors          | Direct Effects Analyses |  | Moderation Analyses |  |
|---------------------|-------------------------|  |                    |  |
|                     | b  | SE  | β   | T   | b  | SE  | β   | t  |
| Intercept           | 8.96 | .85 | —   | 10.57** | 8.77 | .84 | —   | 10.39** |
| Sex                 | .04  | .37 | 0.00 | 0.10  | .14  | .38 | 0.02 | 0.38  |
| Age                 | −.18 | .09 | −.09 | −2.00* | −.15 | .09 | −.07 | −1.63 |
| Hosp.               | 1.43 | .36 | .16  | 3.94** | 1.40 | .36 | .16  | 3.89* |
| Severity            | .11  | .20 | .02  | 0.54  | .11  | .21 | .02  | 0.51  |
| Direction           | .61  | .32 | .08  | 1.92  | .62  | .33 | .08  | 1.88  |
| Cort.               | .07  | .03 | .09  | 2.26* | .22  | .15 | .31  | 1.46  |
| TO                  | 1.13 | .25 | .20  | 4.55** | −1.72 | 1.22 | −.30 | −1.41 |
| A Priori Two-Way Interactions |  |  |  |  |  |  |  |  |
| Cort. × Sex         |  |  |  |  |  |  |  |  |
| Cort. × Age         |  |  |  |  |  |  |  |  |
| Cort. × Hosp.       |  |  |  |  |  |  |  |  |
| Cort. × Severity    |  |  |  |  |  |  |  |  |
| Cort. × Direction   |  |  |  |  |  |  |  |  |
| TO × Sex            |  |  |  |  |  |  |  |  |
| TO × Age            |  |  |  |  |  |  |  |  |
| TO × Hosp.          |  |  |  |  |  |  |  |  |
| TO × Severity       |  |  |  |  |  |  |  |  |
| TO × Direction      |  |  |  |  |  |  |  |  |
| TO × Cort.          |  |  |  |  |  |  |  |  |

Note: N = 540. Overall model fit, Direct Effects: \( F(7, 532) = 10.09, p < .001. \) \( R^2 = .12; \) Moderation: \( F(18, 521) = 5.31, p < .001. \) \( R^2 = .16. \) For sex, boys = 0, girls = 1. Age is calculated in years. For past hospitalization, none = 0, one or more = 1. Severity and directionality are Z scores. Cortisol values are calculated in \( \mu g/dL. \) Timeouts are calculated as the mean number per day of hospitalization. Hosp. = past hospitalization; Direction. = symptom directionality; Cort. = cortisol; TO = timeouts.

\*p ≤ .05. \**p ≤ .01.

### FIGURE 1

Interaction of age and timeouts per day predicting length of stay on a psychiatric inpatient unit (\( N = 540 \)). Note: As age increases, so too does the strength of the relation of timeouts to length of stay.
than examining individual differences in cortisol and clinical symptoms. In addition, few studies examine the HPA functioning of children experiencing comorbid internalizing and externalizing symptoms (Fox, Hane, & Pérez-Edgar, 2006). Given that a majority of children in our sample experienced both clinically significant internalizing and externalizing symptoms, it was important to investigate cortisol’s relation to both shared distress and unique externalizing- and internalizing-typical symptoms. In our sample, morning cortisol levels were unrelated, bivariately, to either severity of symptomatology or to relative expression (i.e., directionality) of externalizing versus internalizing symptoms. Our findings are in line with studies indicating no additive effect of comorbidity on HPA functioning (Marsman et al., 2008; Oosterlaan et al., 2005; Shirtcliff et al., 2005). However, our severity result contrasts Shirtcliff and Essex’s (2008) finding of a positive relation of cortisol to shared symptom severity (though, like the current study, no relation to directionality was found in that study either). Our use of a clinical sample of youth with severe emotional and behavioral disturbances may have resulted in a restricted symptom range compared to Shirtcliff and Essex’s community-based sample.

As two indicators of biological sensitivity to context, but at different levels of analysis, BRS and SRS functioning are theorized to be correlated (Ellis et al., 2011). The few studies examining cortisol’s link to observed behavior, however, typically show no relation (Dabbs et al., 1991). Compared to past studies utilizing observed behavior that were limited by use of smaller samples, our larger sample size provided the power needed to detect small to modest effects. In our sample, even within a small and structured window of observation (i.e., an acute hospitalization), cortisol levels were bivariately associated with the number of timeouts children received per day and continued to explain additional variance in timeouts over and above demographic factors, treatment history, and parent-reported levels of symptomatology. Given that cortisol is thought to regulate later ability to engage in the fight/flight response in reaction to stress (Gunnar & Quevedo, 2007), children exhibiting elevated levels may be more sensitive to the behavioral demands placed upon them while hospitalized. The end result of this sensitivity was a greater likelihood of engaging in dysregulated behavior as an expression of perceived stress. Caution should be taken when interpreting this finding because although SRS functioning was significantly associated with dysregulated behavior, this effect was quite small. In fact, Essex and colleagues’ (2011) joint examination of behavioral disinhibition and a different SRS indicator than used in the current study (i.e., autonomic nervous system functioning) found no bivariate relation among the two. Clearly, more work is needed, but BRS and SRS functioning may best be considered separate and largely independent indicators of biological sensitivity.

As expected, the number of timeouts that children received per day during their hospitalization was strongly associated with their LOS. Naturally, one’s actual behavior while hospitalized influences treatment decisions regarding potential danger to self/others and, in turn, whether youth are adequately stabilized for discharge. Yet, before now, predictors of hospital behavior were primarily limited to past medical history or caretaker report of prior behavior (e.g., Pfeffer, Solomon, Plutchik, Mizruchi, & Weiner, 1985). Our finding directly supports past work showing that increased tantrums, another form of dysregulated behavior, contributes to extended LOS (Gold et al., 1993). In addition, age moderated this relation such that the effect was stronger for older children. Developmentally speaking, greater behavioral regulation is expected as children grow (Kochanska et al., 2001). In support of this in our sample, age was inversely related to the number of timeouts per day received. Consistent with studies showing a stronger relation for older children between dysregulated behavior and other adverse outcomes (Kalpidou et al., 2004), when older youth behave in way that is deemed by direct care staff to be inappropriate (i.e., dysregulated) given their age, the more likely such youth are to be viewed as not ready for discharge and experience costly extended LOS.

A major finding of our study was that basal cortisol was uniquely related to increased LOS, though this relation was qualified by treatment history. Despite evidence that various patient-level (e.g., demographics, illness severity) and facility-level (e.g., hospital specialty) factors influence LOS (Leon et al., 2006; Pavkov et al., 1997), to our knowledge, our finding is among the first to show that a biological indicator also predicts variation in LOS over and above previously established predictors (i.e., age, sex, past treatment, illness severity) and dysregulated behavior while hospitalized. Despite their small association and individual relations with LOS, and in contrast to our hypothesis, no significant interaction between timeouts and cortisol was found. Surprisingly, the relation of cortisol to LOS was found only for those who had been previously hospitalized. At first glance, this finding seems counterintuitive given that a stronger SRS response is expected in situations that are novel or unpredictable for children (Del Giudice et al., 2011). However, our data come from the first admission to this particular inpatient unit, with its milieu-specific rules, for all children. Rather than as a marker of situational familiarity or predictability, a history of past hospitalizations may reflect greater cumulative environmental stress, adversity, or instability. Consistent with biological sensitivity to context theory, more reactive children are expected to show the worst
outcomes (i.e., longer LOS) given greater environmental adversity and more abrupt life transitions (Boyce & Ellis, 2005). In sum, our study suggests that SRS functioning, and in particular cortisol levels, may provide a new piece to understanding clinical outcomes. Once tests of diagnostic validity and cost-effectiveness are conducted, such functioning may guide treatment decisions for hospitalized youth.

Strengths of this research include our use of multiple methods (e.g., caretaker report, observable behavior, biological indicators), an ethnically diverse middle-childhood sample, and use of a fasting-blood draw for collection of cortisol. As mentioned, our large clinical sample also provided the power to detect small effects. Given the multiple contextual influences on actual behavior and the logistical and systemic factors that often impact treatment decisions (i.e., hospital discharge; Leon et al., 2006), it was unsurprising that effects were small in our study. In the literature, the most consistent and strongest effects emerge in studies of HPA functioning in clinical samples of youth compared to nonpsychiatric control groups. Yet our study suggests that even within a population of children with severe psychopathology, individual differences in both BRS and SRS functioning relate to meaningful outcomes and warrants additional study.

Our study’s results should be interpreted in light of four limitations. First, timeout behaviors were heterogeneous. Inability to regulate crying and refusal to follow directions were just two of the many behaviors that garnered a timeout. Unfortunately, data on specific behaviors precipitating timeouts were unavailable. Likewise, this measure represents a frequency of dysregulated behavior, rather than intensity. A child who engages in many minor disruptive acts many garner a larger sum of timeouts than a child who engages in one extremely dysregulated behavior and earns only one timeout. Future work is needed to parse the effects of HPA functioning on specific type, frequency, and intensity of behaviors. Second, we used only a single assessment of cortisol. Although morning cortisol is thought to be more reflective of trait HPA functioning and less influenced by environmental stressors (Wüst, Federenko, Hellhammer, & Kirschbaum, 2000), the extent to which values reflected basal levels or were influenced by the acute stressful nature of having just spent the first night hospitalized without a parent present is unclear. Ideally, though not possible given the constraints of clinical data collected, multiple assessments of cortisol would have allowed us to parse out variance due to trait factors and variance due to situational effects of hospitalization (Shirtcliff et al., 2005). Also, given such small effects found for cortisol, simultaneous assessment of other psychobiological processes (i.e., allostatic load) may evince stronger effects with dysregulated behavior, maladjustment, and clinical outcomes. Third, neither number nor recency of past hospitalizations was known for participants. The effect of cortisol on LOS may be qualified even further when considering past environment in more nuanced ways. Finally, although a hospital setting provided an excellent opportunity to monitor specific behaviors, generalizability of findings to naturalistic settings is unknown. The setting’s structure imposed behavioral constraints that may have been unfamiliar to many of the children and may have elicited altered behavioral patterns that influenced subsequent relations with SRS functioning. Behavioral observation of clinical samples in home or school contexts is needed. Likewise, use of other reporters (e.g., teachers, self) of psychopathology symptoms and behavior may provide unique information compared to only using parents as was done in the current study.

Implications for Research, Policy, and Practice

Additional examinations of the individual and joint effects of BRS and SRS functioning on clinical outcomes are needed. Although both accounted for unique variance in the prediction of LOS, it remains to be seen if these biobehavioral indicators of sensitivity to context differentially predict other important clinical and developmental outcomes or function uniquely within certain environmental contexts. Of course, a true test of the biological sensitivity to context model also requires examination of BRS and SRS functioning in supportive and enriching environments as well. This was not feasible in the current study. As such, our findings could also be interpreted as supporting a diathesis-stress model. Our results do suggest, however, that direct measures of the psychobiology of stress can add to the clinical picture of youth in ways that parent-report and even observed dysregulated behavior alone cannot. Although the science has a considerable way to go, preliminary evidence in the disruptive behavior disorders literature suggests that individual differences in biological stress reactivity may be associated with treatment effectiveness (van de Wiel et al., 2004). Given that cortisol collection may already be standard procedure in hospital settings for identifying extreme hypo- or hypercortisolism, our findings suggest expanded utility for considering individual variability within “typical” ranges of cortisol functioning. Knowing which children might be at increased risk for displaying dysregulated behavior and extended LOS may guide treatment decisions (e.g., modifications to behavior programs, use of combined pharmacological and psychological approaches; van de Wiel et al., 2004) that reap cost savings for treatment facilities and reduce the emotional strain that accompanies psychiatric hospitalization for children and caregivers.
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