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Stress contagion in the classroom? The link between classroom teacher burnout and morning cortisol in elementary school students

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A B S T R A C T

Objective: The purpose of this study was to explore the link between classroom teachers' burnout levels and students' physiological stress response. Drawing from a stress-contagion framework, we expected higher levels of teacher burnout to be related to elevated cortisol levels in elementary school students ($N = 406$, 50% female, *Mean* age = 11.26, $SD = .89$).
Method: Classroom teacher burnout was assessed with the Maslach Burnout Inventory modified for teachers. Salivary cortisol was collected as an indicator of students' hypothalamic–pituitary–adrenal (HPA) functioning. We collected salivary cortisol in children at 9 a.m., 11:30 a.m., and 2 p.m. in the classroom setting.
Results: Using Multilevel Modeling, we found that children's morning cortisol levels significantly varied between classrooms (10% variability). Higher levels of classroom teacher burnout significantly predicted the variability in morning cortisol. Teacher burnout reduced the unexplained variability in cortisol at the classroom level to 4.6%.
Conclusion: This is the first study to show that teachers' occupational stress is linked to students' physiological stress regulation. We discuss the present findings in the context of potential stress contagion in the classroom, considering empirical and practical relevance.

School classrooms are one of the environments in which children spend most of their time as they grow up. From starting Kindergarten until leaving high school, children spend at least 15,000 h in classrooms, and the experiences they have in this context are among the most critical predictors for their well-being and success in school (Eccles & Roeser, 2013; Jennings & Greenberg, 2009; Reddy et al., 2003; Ryan & Patrick, 2001). Whereas positive and supportive classroom environments can help students thrive, stressful classroom environments can jeopardize healthy child development and success in school (Hamre & Pianta, 2005; Marzano et al., 2003; Hamre and Pianta, 2006).

Teachers play a central role in establishing a positive and responsive classroom environment that is conducive to social, emotional, and academic growth (Hamre and Pianta, 2010; Jennings & Greenberg, 2009). Unfortunately, heavy workloads, lack of support, and the pressure of high stakes testing have become a common concern in public education. Many teachers face occupational stress and burnout, experience difficulties to form close relationships with their students, and lack the required support and capacity to create a positive learning environment (Collie et al., 2012; Jennings & Greenberg, 2009; Marzano et al., 2003; Osher et al., 2008; Shen et al., 2012). Although the connection is evident, there is a paucity of research that has examined the relationship between the classroom environment created by teachers and elementary school students' stress and well-being in school (Milkie & Warner, 2011).

The goal of our study was to investigate the link between levels of classroom teachers' burnout and elementary school students' salivary cortisol levels as a biological indicator of stress. The present study is important for several reasons. To our knowledge, this is the first study to assess students' stress regulation objectively at a biological level in relation to teachers' emotional exhaustion and feelings of depersonalization from their students. This connection is plausible in the context of stress-contagion theory (Wethington, 2000), where stressful experiences can spillover from one stressed individual to another within a shared social setting (McLeod & Lively, 2003; Milkie & Warner, 2011). Considering pathways in

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which classroom teacher burnout could relate to stress in students, researchers have theorized the existence of a "burnout cascade" in which teachers' and students' stressful experiences are connected in a cyclic manner. Specifically, as teachers feel overworked while lacking support and resources, they increasingly experience occupational stress and tend to use fewer responsive and more reactive and punitive classroom management strategies. This leads to deterioration in classroom climate in which the emotional needs of students are not met. As a result, students exhibit increased troublesome behaviors which ultimately leads to increases in stress for students and teachers, steadily contributing to teacher burnout and a negative classroom environment (Jennings & Greenberg, 2009; Marzano et al., 2003; Osher et al., 2008).

The present study draws from personality-stress contagion theory (McLeod & Lively, 2003; Milkie & Warner, 2011; Wethington, 2000), and builds on theorized links between teacher burnout and increasing sources of stress in the classroom (Jennings & Greenberg, 2009). Furthermore, it expands on previous research demonstrating that students in more negative classroom environments in which material resources are scarce and teachers experience a lack of respect, exhibit more behavioral adjustment problems (Milkie & Warner, 2011). We draw from a student sample of 4th to 7th grade students – a developmental period in the lifespan in which students are undergoing significant cognitive, social, emotional, and physical changes as they traverse the transition from middle childhood to early adolescence (Eccles, 1999). Socially, this is a time during which children begin to shift their focus away from the family toward other ecological contexts, such as the school, and teachers gain an increasingly important role in early adolescents' life (Oberle et al., 2014).

1. Linking teachers' occupational stress to classroom and student characteristics

Occupational stress among teachers has risen dramatically over the past decade, and burnout is presumed to be highest in teachers compared to other professions (Aloe et al., 2014). Burnout is likely the leading cause for teachers' early dropout of their profession, with up to 40–50% of new American teachers leaving their job as educators within the first three years (Ingersoll & Smith, 2003; Steinhardt et al., 2011). The alarming rate of teacher burnout is not limited to North America; occupational stress among teachers has been a global concern (Aloe et al., 2014), affecting a large number of European countries, Australia, and China among others (e.g., Liu & Wang, 2004; Parker et al., 2012; Stoeber & Rennert, 2008).

Common experiences of long-term occupational stress in teachers include feelings of emotional exhaustion, depersonalization from students, and a lack of accomplishment in their work in the classroom (Maslach et al., 1996). Emotional exhaustion is signaled by feelings of fatigue, and feeling drained of emotional and physical resources; depersonalization occurs when teachers feel negative, irritable, and cynical towards students (Maslach et al., 2001). Teachers who score higher on those dimensions of burnout also report higher stress levels, less effective classroom management, less satisfaction in their work place, and less efficacy in teaching (Aloe et al., 2014; Brouwers & Tomic, 2000; Fisher, 2011; Klassen et al., 2011; Steinhardt et al., 2011). Several research studies have identified lack of support in the work place, lack of resources, time pressure, and challenging relationships with disruptive students to be key contributors to teachers' stress and burnout (Aloe et al., 2014; Fernet et al., 2012; Grayson & Alvarez, 2008; Hastings & Bham, 2003; Maslach et al., 1996). Assets that help teachers cope with occupational stress include a strong sense of self-efficacy, supportive relationships with colleagues and school leaders, and access to high quality professional development opportunities (Kyriacou, 2010; Schwerdtfelder et al., 2008).

Whereas most research has viewed troublesome student behavior and lacking efficacy in classroom management as an originator of teacher burnout, the reverse relationship can also been assumed. Classrooms in which a higher number of students exhibit behavioral problems and disruptiveness can be a major source of teacher stress (Hastings & Bham, 2003). At the same time, stressed and burned out teachers experience more challenges in managing classrooms effectively, have fewer resources to form nurturing and supportive relationships with students, and tend to be less responsive to students' needs (Brouwers & Tomic, 2000; Hamre & Pianta, 2006; Jennings & Greenberg, 2009). Positive and supportive relationships with teachers play a central role in all students' social, emotional, and academic adjustment in school (Crosnoe et al., 2004; Hamre & Pianta, 2006). Especially for students at risk, research has identified that positive student–teacher relationship can be a protective factor for school failure, whereas a disconnection between student and teacher can aggravate the risk (Ladd & Burgess, 2001).

In sum, classroom teachers play a critical role in pre- and early adolescents' adjustment and well-being at school (Eccles, 1999; Pianta & Hamre, 2009; Wentzel, 2002). Unfortunately, an alarming number of teachers report high levels of occupational stress and burnout, which jeopardizes their ability to support students academically, socially, and emotionally (Aloe et al., 2014; Brouwers & Tomic, 2000; Dicke et al., 2014; Hastings & Bham, 2003; Jennings & Greenberg, 2009; Maslach et al., 1996). It is conceivable that teachers' occupational stress, emotional exhaustion, and feelings of depersonalization from students affect their ways of interacting with students, and contribute to less positive and more stressful classroom environments.

2. Cortisol regulation as an indicator of stress and well-being in children

School-related stress is an important concern in pre- and early adolescence. Higher levels of stress in the school and classroom environment relate to more mental health problems, adjustment problems in school, and lower academic achievement (Kaplan et al., 2005; Kenny et al., 2002; Windle & Windle, 1996). In the past few years, research on school-related stress has expanded and included biological markers of stress in connection with stressful experiences. Biological stress reactivity is frequently assessed via the reactivity of the hypothalamic–pituitary–adrenal (HPA) axis, a homeostatic system that follows a circadian rhythm and is activated in response to cognitive (e.g., fear, excitement, anxiety) or non-cognitive (e.g., infections) stressors (Jessop & Turner-Cobb, 2008).

Cortisol levels found in saliva or blood can be used as an indicator for HPA axis activity. Integrity of the HPA axis is essential to human health. In a typical diurnal HPA-axis regulation pattern, cortisol levels rise within 20–45 min after waking and then gradually decline across the day. Inappropriately low or elevated levels of cortisol can compromise HPA axis functioning (Jessop & Turner-Cobb, 2008). In addition, a flat cortisol slope (often associated with high cortisol secretion throughout the day and a lack of downward regulation) indicates dysregulation and has been associated with mental health problems in children and adults (Miller et al., 2007; Shirtcliff & Essex, 2008). Prolonged exposure to stress is one of the reasons that can result in dysregulation of the HPA axis, affect the metabolic, immune, and nervous systems, and pose a significant risk to health outcomes (Miller et al., 2007). For example life stress that involves a major loss has been found to predict the onset of a major depression; it has been argued that the underlying mechanism is activation of the HPA axis to continuously secrete cortisol (Miller et al., 2007; Kendler et al., 2003).

Neuroendocrine regulation of cortisol has been used as a biological indicator for children's stress-related experiences in the classroom in a growing number of research studies in past years. Research conducted in the preschool setting has found that higher levels of teacher–child conflict predicted an increase in children's cortisol levels during interactions with the teacher, whereas lower conflict levels predicted a decrease in cortisol level (Lisonbee et al., 2008). Further, in a study conducted with adolescents, those who were at the bottom of the scholastic hierarchy in the classroom, characterized by less academic success and more troublesome behaviors, were found to have higher cortisol levels (West et al., 2010). Considering the importance of peer relationships in the school setting, a recent study found that 4th grade students who were excluded by their peers had elevated cortisol levels throughout the day, and a flatter cortisol slope indicating poorer regulation of cortisol from morning to afternoon (Peters et al., 2011). Similarly, male adolescents exposed to occasional bullying by peers in the school setting have been found to exhibit higher levels of cortisol over time, whereas the opposite effect was found for females (Vaillancourt et al., 2008).

Higher cortisol levels in 5th grade students have also been linked to more mental health problems in grade seven (Shirtcliff & Essex, 2008). The authors suggest that the transitional years between grades five and seven can be a stressful time that marks the shift out of elementary school, and the adjustment to middle school. They theorized that higher cortisol levels may indicate children's stronger biological sensitivity to their context; children who are more sensitive to contextual stressors and challenging transitions tend to have higher cortisol levels, and are also more likely to respond to the stressful transitional time from elementary to middle school with mental health challenges (Ellis et al., 2005; Shirtcliff & Essex, 2008).

Although neuroendocrine regulation is highly complex and it is unclear what represents an objectively healthy cortisol level in childhood and adolescence (e.g., due to the neuroendocrine changes resulting from day-to-day influences, and due to developmental changes during puberty), assessing students' neuroendocrine regulation in the school setting has proven to be a valuable and important measure that can indicate biological stress levels from preschool-age through to adolescence (Jessop & Turner-Cobb, 2008; Lisonbee et al., 2008; Peters et al., 2011). Both hypocortisolism signalizing low cortisol levels (Alink et al., 2008; Fisher & Stoolmiller, 2008; van Goozen et al., 2007) and hypercortisolism signalizing high cortisol levels (Bevans et al., 2008; Boyce & Ellis, 2005) have been indicative of social, emotional, and behavioral problems in children and adolescents, and more research is needed to identify the association between hypothalamic functioning and stress-related experiences in specific domains throughout different stages of child development (Jessop & Turner-Cobb, 2008).

Despite research on neuroendocrine functioning in relation to classroom experiences being at an emerging stage, several studies have suggested that higher cortisol output throughout the day in normally developing children might be related to being part of a school and classroom environment characterized with more stressful experiences (Peters et al., 2011; Shirtcliff & Essex, 2008; Vaillancourt et al., 2008; West et al., 2010). To our knowledge there are no studies that have investigated whether classroom teachers' burnout levels can predict cortisol levels in pre- and early adolescent students.

3. Summary and hypotheses

Teacher burnout is a growing concern in schools around the world. Teachers who experience high levels of occupational stress and burnout often feel emotionally exhausted, disconnected from their students, and have difficulties to manage their classroom and teach effectively (Aloe et al., 2014; Brouwers & Tomic, 2000; Maslach et al., 1996; Steinhardt et al., 2011). Especially during the early adolescent years it is critical to have a responsive, supportive, and efficacious classroom teacher (Eccles, 1999; Hamre & Pianta, 2006; Jennings & Greenberg, 2009; Oberle et al., 2014).

The goal of the present study was to investigate the so far unexplored link between classroom teachers' burnout levels and students' cortisol levels as an indicator for stress and well-being in the school context. Based on stress contagion theory (McLeod & Lively, 2003; Milkie & Warner, 2011), and previous research that has identified increased cortisol levels in students with stressful experiences at school (Peters et al., 2011; Shirtcliff & Essex, 2008; West et al., 2010), we hypothesized that higher burnout levels in teachers – an indicator for less positive, supportive, and connected teacher–student relationships, higher levels of emotional exhaustion, and more stressful classroom environments – would predict higher cortisol levels in students.

4. Method

4.1. Participants

Participants were 406 4th to 7th grade students (50% female) and their classroom teachers. This presents 88% of all students who were invited to participate and received parental consent. Students were drawn from 17 classrooms located in 13 elementary schools in a large urban public school district in Vancouver, Canada. Regarding socioeconomic characteristics, the median family income in the schools' neighborhoods ranged from $64,859 (CAD) to $120,413 (CAD) (*Mean* = $89,190, *SD* = $23.17) (Statistics Canada, 2013). Twenty-two students were in 4th grade, 77 students in 5th grade, 194 students were in 6th grade, and 113 students were in 7th grade. Students' age ranged from 8.80 to 12.94 years (*Mean* = 11.27 years; *SD* = .89). Seventy-two percent of students reported English to be their first language learned at home, 18% reported Cantonese or Mandarin, and the remaining students reported other languages representative of the cultural and ethnic variety in the district. Seventy-six percent of students lived with both parents, 15% lived with either their mother or father, and the remaining lived with other adults, such as grandparents, relatives, or in foster care. Ethics approval to conduct this research was obtained from the Behavioral Research Ethics Board (BREB) of the University of British Columbia and from the Vancouver School District.

Among the 17 classroom teachers, four were male and 13 were female. Their age ranged from 34 to 65 years (*Mean* = 48.59 years; *SD* = 14.20). All teachers had completed a certified, university-based teacher education program in the past; seven teachers held an additional graduate degree (M.Ed., M.A., or M.Sc.). Teaching experience ranged from 6 to 39 years with an average of 13.5 years (*SD* = 8.17). All participating teachers provided consent.

4.2. Measures

4.2.1. Student measures

Demographics. A demographic questionnaire was administered to all students to gather information about their age, gender, family composition, and first language learned at home.

Cortisol. HPA axis activity as an indicator for students' stress reactivity was assessed by measuring free cortisol in saliva at 9 a.m., 11:30 a.m., and 2:00 p.m. in the classroom setting on one day. Participants were instructed to avoid food and drink intake, and high physical activity prior to the saliva collection to avoid an artificial incline of cortisol. Research assistants were present throughout the school day to provide hands-on assistance with cortisol sampling and ensured that students followed the outlined protocol (i.e., avoiding physical activity and food intake prior to collection). Samples were shipped to Clemens Kirschbaum's laboratory at the Dresden University of Technology in Germany for analyses of salivary cortisol. They were stored at −30 °C until all samples had been received. Upon completion of the study, samples were thawed, centrifuged and free cortisol concentrations in saliva were measured using a commercial chemiluminescence immunoassay (CLIA; IBL-Hamburg, Germany). This assay has a sensitivity of 0.16 ng/ml and intra- and interassay coefficients of variation less than 12%. For further analyses, data were log-transformed. Area under the curve to the ground (AUCground) was computed as an indicator of total cortisol concentration throughout the day (Pruessner et al., 2003). AUCground incorporates all time points of cortisol measurement, and combines them to one single indictor of total cortisol output. We used the formula they provided, and adapted it for calculation of data based on three time points in the day with equal timing between collections (Pruessner et al., 2003):

$AUC = (m_2 + m_1)/2 + (m_3 + m_2)/2$ (m indicates cortisol measurement). The average AUC was 1.54 (SD = .40).

We also collected information on students' wake-up time on the day of data collection. The HPA axis activity follows a diurnal rhythm with cortisol levels typically peaking shortly after wake-up, following downward regulation for the remainder of the day. Therefore, morning cortisol levels tend to be higher closer to wake-up time after the initial morning peak has occurred (Jessop & Turner-Cobb, 2008). The variable "time since awaking" was computed based on wake-up time (1 = .25 h, 2 = .75 h, 3 = 1.25 h,…. 7 = 3.25 h since awaking) and used as a control variable in subsequent analyses. Descriptive statistics for all continuous variables in this study appear in Table 1.

Students self-reported their medication intake on the morning of cortisol collection. Several children reported various forms of vitamin supplements. One child reported Asthma medication. One child reported ADHD medication. Two children reported Advil and Tylenol. We individually screened those children's cortisol levels; given that their cortisol output was within the normal range around the sample mean, data were included in subsequent analyses.

4.2.2. Teacher measures

Demographics. Teachers completed a short demographic survey, collecting information about their age, sex, educational background, and teaching experience.

Teacher Burnout. We assessed teacher burnout with the depersonalization subscale (5 items) and the emotional exhaustion subscale (9 items) of the Maslach Burnout Inventory modified for teachers (Grayson & Alvarez, 2008; Maslach et al., 1996; Maslach & Jackson, 1981). Higher scores on depersonalization and emotional exhaustion indicate higher burnout levels (Maslach et al., 2001). Feelings of depersonalization and emotional exhaustion were assessed on a 7-point-scale ranging from 1 = *Never* to 7 = *Every day*. Example items for emotional exhaustion are: "How often do you feel used up at the end of the workday?" and "How often do you feel burned out from your work?" Example items for depersonalization are "How often do you feel that you treat some students as impersonal objects?" and "How often do you feel that you don't really care what happens to these students?"

In general, having a depersonalization score at or above 13, and an emotional exhaustion score at or above 27 is considered a cut off for "being burned out" (Maslach et al., 1996). On average, teachers in the present study had a moderate depersonalization score (*Mean* = 8.18, *SD* = 4.66) and a high emotional exhaustion score (*Mean* = 29.99, *SD* = 11.81) (Maslach et al., 1996). Because the two subscales were significantly correlated ($r = .77$, $p < .0001$), and to capture a wider array of burnout characteristics in teachers, we formed a burnout composite by averaging scores on the two subscales. This is also supported by previous research in which depersonalization and emotional exhaustion loaded on the same factor (Walkey & Green, 1992). Validity and reliability of this measure has been established in previous research (Grayson & Alvarez, 2008; Maslach & Jackson, 1981; Roeser et al., 2013). We found the internal consistency to be high in the present study (emotional exhaustion: $\alpha = .92$, depersonalization: $\alpha = .80$, burnout composite: $\alpha = .93$). Readers should note that the results of the analyses in this study remained stable when using each of the burnout subscales individually rather than a burnout composite.

4.3. Procedure

All data were collected by research assistants in the classroom setting within 8 weeks of the new school year in October 2011. Prior to data collection, students were told that they were taking part in a study about student experiences in the school setting. They were informed about their research rights (e.g., confidentiality, voluntary participation) and asked to provide assent to participate. Student survey questions were read out loud in the classroom to control for any differences in reading abilities. Cortisol samples were collected via oral cotton swab in the beginning of a class-period at three different occasions throughout the school day. To complete the teacher survey during school hours, teachers were provided with a substitute teacher so that they could complete their survey in privacy. As a sign of appreciation, teachers were also given a monetary gift card, and we arranged a pizza delivery for all students in the classroom upon completion of the study.

5. Results

Preliminary analyses were conducted to identify missing data and to confirm that assumptions were met for subsequent analyses. There were relatively few missing data points in the present study,

Table 1
Means, *standard deviations*, and *range* of all variables.

	N	*Mean*	*SD*	*Range*
Student age	406	11.27	.89	8.8– 12.94
Time since awaking[a]	389	1.75	.62	.25–3.25
Student morning cortisol[b]	394	.92	.27	–.19–2.07
Student midday cortisol[b]	397	.73	.26	–1.00–1.90
Student afternoon cortisol[b]	393	.69	.26	–.54–2.78
Total cortisol release (AUCground)	390	1.54	.40	–.89–4.09
Teacher burnout	[n = 17 classrooms]	19.09	7.84	9.50–38.50

[a] Reported in hours; lower numbers indicate a later wake-up time and less time between awaking and cortisol collection.
[b] Measurement unit = g/dl.

ranging from $N = 17$ (4%) to $N = 0$ across the different measures. Missing data were equally distributed across the classrooms with no more than $N = 3$ data points missing within one classroom. Missing data were excluded listwise. Considering the range of cortisol, we identified $N = 4$ outliers; their cortisol levels was within four standard deviations of the sample mean. We analyzed data with and without those outliers; given that results did not change, we included data of those students in our analyses. Descriptive data are reported in Table 1. Intercorrelations among variables are reported in Table 2. Our main variable of interest – teacher burnout – was significantly and positively related to morning cortisol and total cortisol output (AUCground) in students, but not to midday or afternoon cortisol. Even though there was an initially significant correlation between total cortisol release and burnout levels, further analyses revealed that total cortisol could no longer be significantly predicted by teacher burnout after controlling for children's demographics and their wake up time. Hence, considering space limitations, subsequent analyses are reported predicting morning cortisol only.

A multilevel modeling (MLM) approach was used to analyze students' cortisol levels at the student-level and the classroom-level. Gender, age, and time since awakening were used as control variables in the analysis because their relation to cortisol levels has been established in previous research (Jessop & Turner-Cobb, 2008). Grand mean centering was applied to the teacher burnout variable in order to improve interpretability of the results. We first tested an unconditional model, identifying student-level and classroom-level variability in cortisol levels. Next, we added student-variables (gender, age, time since awakening) and teachers' reports of burnout, and tested the full model. Detailed results of the analyses are reported in Table 3. All analyses were conducted using SPSS 18.0; we followed Hayes' (2006) and Peugh's (2010) guidelines and recommendations for MLM.

$$\begin{aligned}\text{Full model:}\quad &\text{Level 1(individual):}\quad Y_{ij} = \beta_{0j} + \beta_{1j}\left(\text{Age}_{ij}\right) + \beta_{2j}(\text{Gender}_{ij}) + \beta_{3j}(\text{tsa}_{ij}) + r_{ij}\\ &\text{Level 2(school):}\quad \beta_{0j} = \gamma^{00} + \gamma^{01}(\text{Teacher Burnout}_j) + u_{0j}\\ &\beta_{1j} = \gamma^{10}\\ &\beta_{2j} = \gamma^{20}\\ &\beta_{3j} = \gamma^{30}\end{aligned}$$

5.1. *Variability in morning cortisol levels between students and classrooms*

Using MLM, a basic unconditional means model was built to test the proportion of variation in morning cortisol occurring between classrooms.

$$\begin{aligned}\text{Unconditional model:}\quad &\text{Level 1 (individual):}\quad Y_{ij} = \beta_{0j} + r_{ij}\\ &\text{Level 2 (school):}\quad \beta_{0j} = \gamma^{00} + u_{0j}\end{aligned}$$

The cortisol score of the student i in classroom j (Y_{ij}) was modeled as function of the mean cortisol score for classroom j (β_{0j}), plus a residual term reflecting individual student differences around the mean of classroom j (r_{ij}). The mean cortisol score for classroom j (β_{0j}) was modeled as a function of the grand mean of cortisol in the sample ($\gamma00$) plus a classroom-specific deviation from the grand mean (u_{0j}). An overview of all parameter estimates along with the results of the hypotheses tests can be found in Table 3. Analysis of the unconditional model suggested statistically significant student-level variability in morning cortisol scores within classrooms ($\sigma^2 = .067$; $Z = 13.69$, $p < .001$), as well as variability between classrooms ($\tau_{00} = .007$, $Z = 2.01$, $p = .04$). The intercorrelation coefficient (ICC; Bickel, 2007), computed as an indicator for the proportion of variability that exists between Level 2 units, was .099, which indicated that 10% of variability in morning cortisol occurred at the level of the classroom in which students were embedded. An *ICC* of 10% supports the addition of possible classroom level predictor variables in order to explain variability between classrooms (Hayes, 2006).

The full model predicting students' morning cortisol contained students' age, gender, and time since awaking (tsa) as student-level variables, and teacher burnout as a classroom-level variable.

The purpose of this model was to estimate morning cortisol as a linear function of student *i*'s age, gender, and time since awaking in classroom *j*, and the classroom teacher's burnout score in classroom *j*. We found that among the student level predictors, less time since awaking significantly predicted higher cortisol levels in students [$\gamma30 = -.158$, $t(376.93) = -7.806$, $p < .001$]. In addition, after controlling for student-level variables, higher levels of teacher burnout as a classroom-level variable significantly predicted higher cortisol levels in students [$\gamma01 = .009$, $t(14.989) = 3.69$, $p = .002$].

Table 2
Intercorrelations of all variables.

	1	2	3	4	5	6	7
1. Student Age	–						
2. Student Gender[a]	.064	–					
3. Time since awaking[b]	–.057	.056	–				
4. Student Morning Cortisol[c]	.135**	–.064	–.351***	–			
5. Student Midday Cortisol[c]	.075	.139**	.054	.239***	–		
6. Student Afternoon Cortisol[c]	.124*	.050	.024	.336***	.402***	–	
7. Total Cortisol Release (AUCground)	.134**	.094	–.085	.603***	.866***	.704***	–
8. Teacher Burnout	.315***	.021	.051	.248***	.090	.082	.174**

*$p < .05$; **$p < .01$; ***$p < .001$.
[a] Male = 1; Female = 2.
[b] Reported in hours; lower numbers indicate a later wake-up time and less time between awaking and cortisol collection.
[c] Measurement unit = g/dl.

Table 3
Multilevel modeling analysis predicting students' morning cortisol levels.

		Model 1	Model 2
Fixed components			
Intercept	$\gamma 00$	.926***	1.070***
Age	$\gamma 10$		.015 (ns)
Gender	$\gamma 20$		−.026 (ns)
Time since awaking	$\gamma 30$		−.158***
Teacher Burnout	$\gamma 01$		.009**
Variance of random components			
	τ_{00}	.007*	.003 (ns)
	σ^2	.067***	.058***
Deviance (−2 LL)		76.877	40.073

The *ICC* of .046 in the full model indicated that by adding teacher burnout to the model, the classroom-level variability in students' morning cortisol had been reduced significantly from 10% to 4.6%. The variability of cortisol between classrooms was no longer significant in the full model ($\tau_{00} = .003$, $Z = 1.411$, $p = .158$). Adding students' gender, age, and time since awaking to the model accounted for 12.5% of student-level variance in morning cortisol (*Pseudo* $R^2 = .125$). Significant student-level variability in cortisol remained in the model after the addition of gender, age, and time since awaking ($\sigma^2 = .058$; $Z = 13.48$, $p < .001$).

6. Discussion

Teacher burnout is a concern that affects personal health, education systems, and societies around the world. Teachers who experience higher levels of burnout report to be more stressed, less effective in teaching and classroom management, less connected to their students, and less satisfied with their work (Aloe et al., 2014; Brouwers & Tomic, 2000; Dicke et al., 2014; Maslach et al., 1996). Occupational stress affects the health and well-being of educators (Parker et al., 2012), and it can also have an impact on the students they interact with on a daily basis (Hamre & Pianta, 2006; Jennings & Greenberg, 2009). The aim of the present study was to establish a link between classroom teachers' experiences of depersonalization and emotional exhaustion − two core indicators of burnout − and students' physiological stress levels in the classroom context. This study is an important contribution in the field; it is the first of its kind connecting teachers stress-related experiences to students' stress physiology in a real-life setting.

As expected, we found that after adjusting for differences in cortisol levels due to age, gender, and time of awaking, higher morning cortisol levels in students could be significantly predicted from higher burnout levels in classroom teachers. In fact, before considering the predictive role of teacher burnout in the present sample, we found an initial 10% of variability in morning cortisol levels between classrooms. Thus, morning cortisol levels not only significantly differed among individual students, but could also be predicted from the particular classroom where lessons took place. The significant differences in cortisol levels due to the classroom setting provided strong rationale for identifying classroom-indicators to predict students' cortisol levels. We found that classroom-specific variability was significantly reduced by more than 50%—from 10% to 4.6%—when considering the role of teacher burnout in relation to students' morning cortisol levels. This finding is new and important: It extends the field of school-based experiences and cortisol activity as an indicator of stress regulation in students, and links teachers' stressful occupational experiences to students' biological stress levels.

Several explanations can be employed for the present finding; because data were cross-sectional, causality cannot be inferred. First, it is possible that higher levels of occupational stress in classroom teachers transfer to students in the classroom. This explanation is in line with stress contagion theory, which argues that within a shared social setting can cross over from one person to another (McLeod & Lively, 2003; Milkie & Warner, 2011). Specifically, Milkie and Warner (2011) found that elementary school children who are part of stressful classroom environments, partly characterized by teachers who received less respect from colleagues, exhibited more behavioral and adjustment problems in school. Considering that classroom teachers can take on many roles for elementary school students, including mentor, role model, and parental roles, it is possible that spending most of the school day in interaction with a stressed and burned out teacher is taxing for students and can affect their physiological stress profile. Second, previous research has argued that stressed and burned out teachers have less capacities and personal resources to manage classrooms and student behaviors in a responsive and positive way (Aloe et al., 2014). It is conceivable that being part of a generally tense, less organized, and high-conflict environment is a stressor for students and effects their well-being in the classroom (Milkie & Warner, 2011; Torsheim & Wold, 2001).

The cyclical relationship Jennings and Greenberg (2009) have illustrated between teachers' stress levels, their ability to manage student behavior positively, and students' adjustment in the classroom also supports the link between teachers' burnout and students' increases in cortisol. However, this cyclical relationship also offers a reverse explanation: it is possible that classrooms in which students exhibit higher cortisol levels might be indicative of more stressful and challenging work environments for teachers; teachers of those classrooms might therefore have more troubling interactions with students, experience more occupational stress, and consequently experience higher rates of burnout (Hastings & Bham, 2003). Because data were collected within the first 2 months of the school year, however, it is unlikely that teachers' burnout scores in the present study stem only from their work in the current year's classroom. Students cortisol levels, on the other hand, can fluctuate in response to immediate, short-term, and long-term stressors (Jessop & Turner-Cobb, 2008), and could therefore be influenced by their recent and short-term experiences in the classroom.

The finding that teacher burnout was predictive of students' morning cortisol in the present study aligns with previous research that has found that higher cortisol levels seem to be related to the presence of stressors in the school environment (Lisonbee et al., 2008; Peters et al., 2011; Shirtcliff & Essex, 2008; West et al., 2010). However, it is not clear why the midday and early afternoon cortisol levels were not related to teacher burnout in the present study. In general, researchers have noted that the understanding of cortisol levels, and patterns in generally healthy people in daily life, in the absence of an acute stressor is still emergent (Saxbe, 2008). Especially cortisol activity in children and in school settings is only in its beginnings, and further research is needed to identify if and how certain school-related experience are linked to cortisol outcomes (Gunnar & Quevedo, 2007; Jessop & Turner-Cobb, 2008).

The present study has several practical implications for the field of health promotion within educational settings. It further highlights the importance of positive and nurturing student–teacher relationships in student well-being (Hamre & Pianta, 2006). In addition, it emphasizes the importance of preventing teacher burnout and promoting well-being among teachers by offering the necessary support, resources, and professional development opportunities teachers may need (Darling-Hammond, 2005).

6.1. Limitations and future directions

Although the present study has several strengths, limitations need to be considered. The findings of the present study are based on a one-time cortisol collection. Ideally, future research will collect cortisol at each time point over the course of several days, and use averaged cortisol levels at each time point in subsequent analyses. This method can provide a more accurate measure of individuals' HPA system activity, and control for the fluctuations due to unrepresentative events and experiences (e.g., if cortisol was assessed right after a student was involved in a fight). Due to the high expense of collecting cortisol data in 17 classrooms at three time points in the day, it was not possible for us to collect data on multiple days. Similarly, due to budget limits, the present study was conducted in 17 classrooms only; with respect to MLM, it is a small sample size and including a larger number of classrooms would have been beneficial. With a larger sample of classrooms, we could have included more predictor variables at both the student level (e.g., self reported stress, conflict with peers and teachers in the classroom, coping skills) and the classroom level (e.g., perceptions of classroom management, socioeconomic characteristics of the school in which classroom is based). We believe that future research needs to replicate and expand on this new finding, and investigate potential moderating and mediating factors when linking teacher burnout to students' cortisol levels. In addition, future research needs to explore links between further indicators of cortisol regulation (i.e., slope, total cortisol release) and contextual characteristics. Research also needs to investigate contextual variables at the school level (e.g., school climate, students' sense of school belonging, perceived safety in the school) in relation to cortisol activity.

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