Stress and Diurnal Cortisol Among Latino College Students:

A Multi-Risk Model Approach

by

Jeri Sasser

A Thesis Presented in Partial Fulfillment
of the Requirements for the Degree
Master of Arts

Approved January 2022 by the
Graduate Supervisory Committee:

Leah Doane, Chair
Jinni Su
Kevin Grimm

ARIZONA STATE UNIVERSITY

May 2022

ABSTRACT

The transition to college is a time of increased opportunity and stress that spans across multiple domains (e.g., social life, academic workload, finances). Adolescents who encounter significant stress during the transition to college may be vulnerable to adverse outcomes, due to a "wear and tear" of physiological systems, including the hypothalamic-pituitary-adrenal (HPA) axis. Latino students may be particularly at-risk for heightened stress exposure, as minority youth often experience both minority-specific stressors and general life stress. Despite this, the majority of research on Latino students is limited to the examination of singular forms of stress, and little is known regarding the cumulative impact of multiple forms of stress on Latino students' HPA axis functioning. The present study employed a "multi-risk model approach" to examine the additive, common, and cumulative effects of multiple types of stress (general, academic, social, financial, bicultural, discrimination) on HPA axis functioning in Latino college students (N = 209; 64.4% female; M_{age} = 18.95). Results from three-level growth curve models indicated that, in the additive model, no stressors were associated with the CAR, but general stress was associated with a flatter diurnal cortisol slope (DCS) and bicultural stress was linked with a steeper DCS. In the common model, the college stress latent factor was related to a reduced cortisol awakening response (CAR), but not the DCS. In the cumulative model, cumulative risk was linked with a lower CAR, but not the DCS. These findings highlight the physiological correlates of various stressors experienced by Latino college students.

ACKNOWLEDGMENTS

Firstly, I would like to thank Dr. Leah Doane for her dedicated mentorship throughout my Master's thesis, and in graduate school more generally. Her support and excitement for this project was a motivating force that made this process genuinely fun, and her expertise in the area taught me countless lessons about the "mysteries" of stress and cortisol, which I had initially embarked on this project to discover. In addition, I am extremely grateful for the time and knowledge of my committee members. Specifically, I am thankful for Dr. Jinni Su's critical insight and offerings into the conceptualization of stress, which helped immensely in the framing and interpretation of my thesis findings. Further, I am grateful for Dr. Kevin Grimm's guidance, ideas, and strategies regarding best practice for methodological and statistical procedures, which underlie some of the most nuanced and exciting findings in my thesis.

I would also like to thank the incredible support system that helped me achieve this milestone. My parents, Keven and Linda, for making my education possible and always supporting me in my endeavors. My sister, Katie, who has pushed me to do my best since, well, forever. My husband, Harry, for the countless walks spent listening to me talk about this project, the constant encouragement along the way, and of course, for helping me write the Python code to create my thesis figures. My ASU family, whom have become some of my best friends that I hope to know forever, for the numerous pep talks, study breaks, and validations. The ASAE Lab team, who remind me why I fell in love with research and encourage me daily.

Lastly, I am grateful to the amazing participants of the *Transiciones* study, who made this research possible.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

The transition into college is a time of opportunity and stress, consisting of both developmental (e.g., into emerging adulthood) and ecological change (e.g., into new social contexts; Seidman & French, 2004). Adolescents who encounter significant stress during the transition to college may be particularly at-risk for adverse outcomes, due to a "wear and tear" of physiological systems. Evidence suggests that Latino[1] students may encounter greater stress during the transition to college, as minority youth often experience cumulative perceptions of both minority-specific stressors and general life stressors (Phinney & Haas, 2003; Wei et al., 2011). Importantly, Latino students represent the largest ethnic/racial minority group in higher education (McFarland et al., 2017), but are also the minority group least likely to graduate from a four-year institution (Snyder et al., 2019). Alterations in typical stress responsive systems may serve as a potential mechanism underlying academic and health inequalities among Latino students. However, there is a lack of research disentangling the effects of different types of stress simultaneously (i.e., alongside each other) on physiological outcomes in Latino college students. Thus, the proposed study will investigate multiple forms of stress (e.g., general, college-related, minority-specific) as they relate to Latino college students' diurnal cortisol. Further, in an effort to disentangle the complex associations between stress and

[1] The word "Latino" is used here to refer to an individual who is of Latin American origin or ancestry. We use this term, rather than the non-binary "Latinx," to honor the self-identification of the study participants who self-selected into the study based on Hispanic/Latino descent.

cortisol, I will implement a three-strategy-approach to best characterize perceptions of stress[2] during the first year of college.

Significance and Overview of Study

Latino adolescents represent a large and rapidly growing population in the U.S. that are entering higher education at annually increasing rates (e.g., 22 to 37 percent from 2000-2015; McFarland et al., 2017). It is expected that these numbers will continue to rise, as Latino individuals are projected to make up 27% of the overall U.S. population by 2060 (compared to 18% in 2018; U.S. Census Bureau, 2017). Despite this, research examining psychosocial influences on Latino college students' physiological functioning is scarce (Sladek et al., 2020; Sladek et al., 2021). Whereas prior literature has identified racial/ethnic differences in stress response systems among adolescents (i.e., minority youth more likely to exhibit physiological patterns generally associated with negative health outcomes; DeSantis et al., 2007), there is more evidence to suggest this is the case for African American adolescents, and evidence for Latino youth is more mixed (Martin et al., 2012). Currently, the most commonly explored stressor to explain ethnic/racial disparities in physiological stress systems are experiences of discrimination or mistreatment (Huynh et al., 2016; Skinner et al., 2011; Zeiders et al., 2014; Zeiders et al., 2018). Yet, the effects of alternative forms of stress (e.g., bicultural stress, financial stress) that may also explain these disparities have been less extensively studied. The

[2] For the purposes of this paper, perceptions of stress will be referred to broadly as "stressors." However, it should be noted that because we are using self-report data, it is likely that some of the constructs we are examining may better capture students' *perceptions* of stress (e.g., academic stress, social stress).

present study harnessed the strengths of an ethnically-homogenous design to identify *within-group* differences (i.e., meaningful variability) in stress perceptions and physiological stress processes among Latino college students (García Coll et al., 1996).

This project will address multiple gaps and inconsistencies in the literature by implementing a "multi-risk model approach" to studying associations between stress and physiological processes. With this approach, I seek to investigate the effects of multiple forms of stress (general, academic, social, financial, bicultural, and discrimination) on physiological functioning by characterizing stress in three different ways. Specifically, I will examine the effects of each stressor independently (additive model), the common and/or "shared" influence of stress (common model), and the cumulative impact of experiencing multiple stressors (cumulative model; see Figure 1). To my knowledge, this "multi-risk" approach has not yet been tested in psychobiological research, and no prior work has investigated the potential physiological correlates of each of these individual stressors concurrently.

Theories of Stress and Health

Allostatic load theory. A prominent theory in the examination of stress exposure as it relates to biological functioning is allostatic load (AL; McEwen, 1998). *Allostasis* refers to the body's adjustment of biological responses in an attempt to meet the demands of acute stressors (e.g., psychosocial stress; McEwen, 1998). Whereas this process is adaptive under normal levels of stress exposure, individuals who undergo chronic and/or ongoing perceptions of stress often experience the cumulative "wear and tear" of the body's biological systems, wherein the chronic over-activation of these systems results in diminished biological functioning (McEwen, 1998). One biological system that is particularly influenced by the experience of psychosocial stress is the hypothalamic-pituitary-adrenal (HPA) axis. Measured by its end product hormone cortisol, the HPA axis has been hypothesized as a key physiological mechanism in AL (McEwen & Seeman, 1999). Similar to the concept of allostasis, immediate activation of the HPA axis in response to an acute stressor is adaptive at the short-term level, as the initial release of cortisol helps the body manage stress and affects biological processes essential for daily functioning (e.g., increasing heart rate and blood pressure, regulating metabolism via flooding of glucose, reducing inflammation; Kirschbaum & Hellhammer, 2000; Oakley & Cidlowski, 2013). However, a constant activation of the HPA axis (i.e., chronic stress) can cause a counterregulatory response in which cortisol levels begin to drop below normal (Adam, 2012; Miller et al., 2007). This HPA axis dysregulation has been linked to numerous negative outcomes, including risk for mental and physical health problems (Adam et al., 2017). Thus, it is paramount that research examines predictors of HPA axis functioning among populations that are known to experience high levels of chronic and/or cumulative stress, such as minority students transitioning to college.

Minority stress model. The minority stress model (Meyer, 2003) posits that minority groups experience unique and chronic stressors that may go on to influence health disparities among these populations. Chronic stress, including age and ethnicity-related stressors, have been linked to an increased risk for numerous adverse outcomes in minority adults, including poorer perceived physical health, increased risk for diabetes, hypertension, smoking, and coronary heart disease (Gallo et al., 2014; Garcia et al., 2017). Importantly, individuals who experience the *cumulative* effects of multiple stressors may be particularly vulnerable to later negative health outcomes, as mediated through various psychological and biological processes (e.g., HPA axis; Myers, 2009). Given that minority adolescents often experience the chronic burden of minority-specific stressors *in addition* to the normative stress associated with college (e.g., Wei et al., 2010; Wei et al., 2011), it is plausible that Latino college students may experience diminished HPA axis activity as a result of cumulative stress. Guided by theories of minority stress and health (Meyer, 2003; Myers, 2009), the present study examines the degree to which cumulative perceptions of stress evince unique patterns on physiological functioning.

Stress and the HPA Axis

The HPA axis is one of the body's major stress response systems that, once activated, leads to the eventual release of cortisol, a hormone that helps the body manage stress and affects biological processes essential for daily functioning (e.g., metabolism; Kirschbaum & Hellhammer, 2000). Whereas prior research has frequently focused on the immediate response to psychosocial stress (e.g., cortisol reactivity; Dickerson & Kemeny, 2004), the chronic effects of stress may be better understood by the basal activity of the HPA axis (i.e., measured in naturalistic settings; Adam, 2006; Adam, 2012). Cortisol follows a typical diurnal rhythm, with high levels upon waking, a 50-65% increase approximately 30 minutes after waking (cortisol awakening response; Stalder et al., 2016), and an overall decrease throughout the day with lowest levels at midnight (Adam & Kumari, 2009). Two parameters commonly used to characterize the diurnal pattern are the diurnal cortisol slope (DCS; decline in cortisol levels across the day) and the cortisol awakening response (CAR).

There is robust evidence that chronic stress is associated with a flatter DCS (Miller et al., 2007), a pattern that results from deviations below or above the typical diurnal rhythm (e.g., low cortisol in the morning and/or high cortisol in the morning and evening) and that is linked with numerous adverse health outcomes in adolescents and adults (for review see, Adam et al., 2017). In contrast, findings regarding associations with the CAR have been more inconsistent (Clow et al., 2004), with chronic stress linked to both an increase and decline in cortisol output (e.g., Chida & Steptoe, 2009). It has been hypothesized that a higher CAR than normal can be adaptive in the short-term by helping individuals prepare to meet the demands of the day (e.g., "boost hypothesis"; Adam et al., 2006); however, when these short-term elevations are chronically experienced, a heightened CAR can confer risk for negative outcomes (e.g., major depressive disorder; Adam et al., 2010). Conversely, a lower CAR may reflect HPA axis dysregulation resulting from prior overactivation (i.e., due to exhaustion of physiological systems) and has been associated with conditions such as fatigue or burnout (Chida & Steptoe, 2009; Pruessner et al., 1999).

Previous reviews suggest that numerous characteristics of stress may help explain whether individuals will exhibit increased or decreased HPA axis activation, including both the *type* of stressor (i.e., nature and/or controllability) as well as the *timing* of the stressor (i.e., how recently it occurred; Chida & Steptoe, 2009; Miller et al., 2007).

Type of stressor. Specificity hypotheses suggest that different *types* of stress may play a large role in determining how HPA axis activity is impacted (Miller et al., 2007). Specifically, different forms of stress often require discrete adaptational demands that are differentially regulated via the HPA axis, pointing to a need to examine multiple forms of stress. For example, general life stress has been frequently associated with a heightened CAR (Miller et al., 2017; Morin-Major et al., 2016), which may be indicative of metabolic support that prepares adolescents to cope with these daily stressors. In addition, a large body of evidence suggests that social stressors (i.e., that pose social threat to self) are particularly influential on HPA axis reactivity (Dickerson & Kemeny, 2004), and may also have implications for diurnal patterns. In particular, prior work found that positive perceptions of family relationships in adolescence were associated with higher waking cortisol and a steeper DCS in young adulthood (Shirtcliff et al., 2017). Among early adolescents, greater average peer problems were linked to a flatter DCS, whereas day-to-day increases in peer or academic problems were associated with greater morning cortisol (Bai et al., 2017). Further, another study observed that first-year graduate students' CAR was flatter in Spring, as opposed to the start of classes in Fall, whereas the CAR remained stable for community comparisons (McGregor et al., 2016). This may suggest that first-year graduate students are facing stressors unique to that context that are linked with changes in diurnal cortisol patterns, which may also occur for undergraduate students.

Importantly, a growing body of evidence suggests that minority-specific stressors, or additional forms of stress that are unique to members of marginalized communities, are associated with biological functioning (Doane et al., 2018; Flentje et al., 2019; Meyer, 2003). Numerous studies have examined the physiological correlates of perceived discrimination and HPA axis activity in adolescence and young adulthood, among them being greater overall cortisol output, lower waking cortisol, and a flatter DCS (Huynh et al., 2016; Skinner et al., 2011; Zeiders et al., 2012; Zeiders et al., 2014). In addition, more subtle forms of discrimination (e.g., microaggressions) have been linked to increases in diurnal cortisol among Latino and African American young adults (Zeiders et al., 2018), highlighting the impact of both subtle and severe minority stressors on HPA axis functioning. Notably, less work has been done examining stressors that relate to cultural adaptation (e.g., acculturation, biculturalism) and diurnal cortisol among Latino adolescents. A recent study by Gonzales et al. (2018) found that youth reporting higher biculturalism (i.e., high on both Anglo and Mexican orientations) exhibited greater cortisol reactivity, suggesting that there may be evidence for potential linkages between culturally-specific stressors (e.g., bicultural stress) and diurnal cortisol. However, to date, no known study has examined the impact of ethnic/racial minority specific stressors on diurnal cortisol patterns while controlling for general or adolescent-specific stressors, pointing to the importance of the present study.

Timing of stressor. The time frame in which stress is measured is also critical to the examination of diurnal cortisol, given that a chronic activation of the HPA axis (i.e., hypercortisolism) can eventually result in diminished HPA activity (i.e., hypocortisolism; Adam, 2012; Miller et al., 2007). Accordingly, stressors that are more recent and/or immediate may evince greater HPA axis activity, which is often adaptive in the moment as the individual adjusts to the demands of the specific stressor. However, over time, this prolonged activation may result in eventual HPA axis dysregulation, wherein individuals' response to stress drops below what would normally be expected. In their seminal meta-analysis of chronic stress and the HPA axis, Miller and colleagues (2007) found that time was negatively associated with HPA axis activity (i.e., the longer it had been since the stressor emerged, the lower an individuals' morning and daily cortisol volume), whereas *current* experiences of stress were associated with greater morning and daily cortisol output. In the context of college life, it may be expected that recent, developmentally-salient stressors (e.g., academic, financial stress) would be positively linked with HPA axis activity, whereas stressors that are often present in ethnic/racial minority youths' lives prior to college (e.g., discrimination) may be negatively associated with diurnal cortisol. Thus, future research is needed that examines multiple forms of stress that differ in both type (e.g., nature, controllability) and timing (e.g., past year versus past semester).

A Multi-Risk Model Approach

There is prior evidence in adolescent and young adult populations supporting that general life stress (Miller et al., 2017; Morin-Major et al., 2016), academic-related stress

(Bai et al., 2017; McGregor et al., 2016), and minority-specific stressors (Skinner et al., 2011; Zeiders et al., 2014) are each implicated in physiological stress activity. However, less is known about the additive influence of these stressors; that is, the unique impact of specific forms of stress when accounting for other forms. Previous work provides support for the unique effects of minority- and college-related stressors on Latino students' health. Specifically, studies have found that minority-specific stressors (e.g., college climate, discrimination, intra-ethnic pressures) and general college stress are uniquely associated with depressive symptoms in minority (Wei et al., 2010) and predominantly Latino college students (Arbona & Jiménez, 2014; Arbona et al., 2018). Yet, no known study has examined the unique effects of minority-specific stressors alongside other forms of life stress (e.g., general, academic, social) on HPA axis functioning in particular. This is a critical gap in the literature, as these findings may serve to identify specific forms of stress that are particularly influential on Latino college students' physiological functioning, which may, in turn, help to clarify observed ethnic/racial differences in diurnal cortisol (e.g., DeSantis et al., 2007).

Beyond the effects of individual stressors are the common (i.e., shared) effects of multiple forms of stress. To date, no known studies have modeled different types of stress as an unobserved latent variable predicting physiological functioning. However, a recent study compared alternative methods to assess cumulative risk, among them being latent factor analysis, and found important similarities and differences in predicting outcomes (Ettekal et al., 2019), highlighting the importance of testing competing models.

Characterizing stress as a latent variable provides the utility of examining what is in common among discrete forms of stress, while also potentially providing an indirect measure of the individuals' *perceptions* of stress. For example, it is possible that what is shared among these stressor-specific constructs are influenced, to a degree, by individual differences in stress perceptions. Thus, comparing results of the common (i.e., latent) model to those of the additive effects may provide meaningful information regarding whether HPA axis functioning is a result of something potentially "trait-like" (i.e., how a person perceives stress in general), rather than stressor-specific effects.

Latino college students may also endure the *cumulative* impact of multiple sources of stress. Consistent with allostatic load (McEwen, 1998), the accumulation of multiple stressors may be particularly deleterious for HPA axis functioning due to the "wear and tear" that results from chronic activation of biological systems. Although no studies have examined cumulative stress among Latino college students in particular, there is prior research to suggest that cumulative stress negatively impacts HPA axis functioning among minority groups (Kwak et al., 2017; Suglia et al., 2010). For example, Suglia and colleagues (2010) found that cumulative stress (e.g., discrimination, negative life events, community violence) was associated with lower morning cortisol and a flatter DCS among Black, but not Hispanic, pregnant women. In addition, a recent study found that Latino adolescents who reported greater cumulative family stress (e.g., financial, career, relationships, prejudice) had a lower CAR than those who endorsed low amounts of stress (Kwak et al., 2017). Further, a longitudinal analysis of predominantly African

Americans found that perceptions of discrimination that were high and stable across adolescence (e.g., ages 16 to 18) predicted higher levels of allostatic load (e.g., cortisol, blood pressure, BMI) in young adulthood (Brody et al., 2014). Although these studies do not generalize to the demographics of the current study, they provide general evidence for the link between cumulative stress and HPA axis functioning.

The Present Study

The primary objective of the present study was to advance the understanding of physiological stress processes among Latino college students by examining associations between multiple characterizations of stress and diurnal cortisol. Specifically, in an effort to untangle the complex associations between stress and HPA axis functioning, I tested three models: (1) the additive effects of stress on diurnal cortisol, (2) the common effects of stress on diurnal cortisol, and (3) the cumulative risk of stress on diurnal cortisol (Figure 1). Given that ethnic/racial minorities are known to experience multiple sources of stress during college (e.g., Wei et al., 2010; Wei et al., 2011), this multi-risk model approach sought to identify whether the common and/or cumulative effects of multiple forms of stress provide important information about physiological stress processes, separate from what can be observed by the additive effects of stress. I hypothesized that each form of stress would predict a flatter DCS (*Hypothesis 1a*). Further, based on previous findings (Bai et al., 2017; Miller et al., 2017; Skinner et al, 2011; Zeiders et al., 2014), I predicted that general, social, academic, financial, and bicultural stress would be associated with an increased CAR, while discrimination would be linked with a reduced

CAR (*Hypothesis 1b*). Due to a lack of previous research examining stress as a latent variable, my hypotheses regarding the common effects of stress on diurnal cortisol were exploratory (i.e., non-directional). Lastly, in line with prior findings (Kwak et al., 2017; Suglia et al., 2010), I hypothesized that cumulative stress would be associated with a flatter DCS (*Hypothesis 2a*) and a reduced CAR (*Hypothesis 2b*). Exploratory analyses included testing for potential non-linear associations between cumulative stress and diurnal cortisol, to elucidate whether there was a specific inflection point at which the cumulative correlates of stress became particularly deleterious.

CHAPTER 2

METHOD

Participants

209 Hispanic/Latino college students (M_{age} = 18.10, *SD* = 0.41; 64.4% female) were recruited during the spring or summer of their senior year in high school prior to enrolling at a large university in the southwestern United States (T1; Spring 2017). This study utilized data from participants' second semester of college (T3; Spring 2018; *N* = 196; M_{age} = 18.95, *SD* = .40). Participants were recruited through university orientation sessions, as well as via e-mail, text messaging, and phone conversations in English or Spanish. Inclusion criteria required that participants: (1) had gained acceptance to the focal university and had paid an initial deposit or selected to defer payment, (2) were current seniors in high school, (3) identified as Hispanic/Latino, and (4) lived within 60 miles of the university when they were recruited. All participants identified broadly as Hispanic or Latino, with the majority of participants specifically identifying as being of Mexican descent (84.4%), followed by South or Central American (8.9%) and Cuban (6.1%) descent. Eleven percent (11.1%) of participants were first-generation immigrants (born outside the U.S.), 63.3% were second generation (born in U.S. with at least one parent born outside the U.S.), and 25.6% were third generation or greater (both parents born in the U.S.). Thirty-three percent (33.3%) of the sample reported that their parents had attained less than a high school degree, 21.7% of parents earned a high school degree

or GED, 25.0% of parents completed some college, 16.2% of parents had obtained a Bachelor's degree, and 3.9% reported that their parents had a graduate education.

Procedure

The university's Institutional Review Board approved all procedures before data collection began. Informed consent and assent (i.e., for participants under the age of 18) were obtained from all participants prior to beginning study procedures. Study personnel travelled to participants' homes or hosted participants in a campus lab to deliver study materials, collect survey responses, and provide instructions for saliva sampling and daily diary procedures. Participants also completed an online battery of survey measures at a time of their convenience during the semester, which included measures of demographic information, cultural values, emotional health, and stress experiences.

During the week following the home and/or lab visit, participants wore wrist-based accelerometers (e.g., actigraphy watch) to assess objective sleep throughout the week (M_{nights} = 6.49, *SD* = .91) and completed 4-5 diary entries per day, across 7 days (*M* = 26.20, *SD* = 3.98). Participants also provided saliva samples via passive drool 5 times a day for 3 weekdays: immediately upon waking, 30 minutes after waking, twice during the day (approx. 2 hr and 8 hr from initial waking sample, to avoid mealtimes), and at bedtime. Participants were asked not to eat, drink, or brush their teeth an hour prior to saliva sampling. Participants recorded the date and time of each sample, but also used a track cap compliance device (MEMS 6$^{\text{TM}}$ (Aardex)) to objectively record the sample time upon track cap opening. Participants were instructed to press a button on the actigraphy watches each time they had completed a saliva sample or a daily diary entry (i.e., as secondary indicators). After providing each saliva sample, participants completed brief diary entries using web-based smartphones that assessed questions about stressors experienced in the last hour or across the day (e.g., bicultural stress). Further, participants reported whether they had recently eaten, exercised, used caffeine, nicotine, medication, slept, or experienced pain (i.e., as potential covariates in cortisol analysis).

Compliance with saliva sampling procedures for the waking and post-30 minute waking sample was determined via participants recordings of time on vials, track cap device times, actigraphy-recorded times, and daily diary times. Because noncompliance with saliva sampling procedures can bias cortisol estimates (Stalder et al., 2016; Kudielka et al., 2003), each indicator of time was carefully inspected to determine "compliant" versus "noncompliant" saliva samples (Doane & Zeiders, 2014). Criteria for compliance are as follows: For the waking sample: track-cap detected times were within 15 minutes of participants' actigraphy-recorded times (87.9% of samples with complete compliance data; 75% of all waking samples); for the second (post 30-minute waking) sample: track-cap detected times were within 25 to 45 minutes after track-cap detected times of waking sample times (85.7% of samples with valid track-cap data; 82.9% of valid samples of all second samples). Additionally, these rates required that actigraphy or track cap data were available for samples to be considered compliant, resulting in noncompliance if this data were missing. Lastly, to avoid biased estimates of DCS and CAR (see Stalder et al., 2016), cortisol values from noncompliant samples were treated as missing data in final analyses (4.9% of all samples).

Measures

Salivary cortisol. Salivary cortisol was assessed at T3. Participants were instructed to store their completed saliva samples in the refrigerator until study personnel retrieved the samples to return them to the lab (typically 4 days later). Samples were stored at -80 degrees Celsius, per existing recommendations (Nicolson, 2008). Once the study was completed and all saliva samples had been retrieved, they were placed on dry ice and transported via courier across three days to the Biochemisches Labor at the University of Trier in Germany for assay. This is the preferred method for handling and transporting salivary biomarkers (Granger et al., 2012). Samples were assayed in duplicate for salivary cortisol (Dressendörfer et al., 1992). Average concentration from both assays (excluding the samples for which only one assay was possible) was used to assess cortisol in nanomoles per liter.

General stress. General stress was assessed using the 4-item Perceived Stress Scale (PSS-4; Cohen et al., 1983). Participants were asked to indicate their feelings and thoughts *during the last month* using a Likert-type scale ranging from 0 (*Never*) to 4 (*Very Often*). Sample items included “How often have you felt difficulties were piling up so high that you could not overcome them?” and “How often have you felt that you were unable to control the important things in your life?” The four items were summed to create a measure of general stress (α = .66). Scores ranged from 0 to 16, with higher scores reflecting greater perceived stress.

College stress. Academic, Social, and Financial stress were each measured using the 18-item College Stress Scale (CSS; Rodriguez et al., 2000). Participants were asked to rate how stressful certain experiences were *since the beginning of the semester* using a 5-point scale that ranged from 1 (*does not apply*) to 5 (*extremely stressful*). This study examined three subscales: academic stress (7-items; e.g., "Handling your academic workload"), social stress (6-items; e.g., "Handling personal relationships"), and financial stress (5-items; e.g., "Paying for bills and living expenses"). Items within each subscale were averaged to create three college-related stress scales, with higher scores indicating greater stress in each domain. Internal consistencies were good for all three subscales: academic (α = .85), social (α = .84), and financial (α = .85).

Bicultural stress. Bicultural stress was measured using participants' nighttime daily diary reports to five items adapted from the 20-item Bicultural Stress Scale (Romero & Roberts, 2003). Questions were framed in a daily format (e.g., "Today I did not feel comfortable with people whose culture is different from mine"). Participants responded "yes" or "no" to each item; a frequency count of "yes" items were summed at each day to represent daily bicultural stress. An aggregate measure of average bicultural stress was created using the mean of participants' daily scores *across the week*. This diary-based approach has been used successfully in previous waves of this sample (e.g., during high school) as a measure of adolescents' average daily bicultural stress (see Sladek, Doane, & Park, 2020).

Discrimination stress. Perceived racial/ethnic discrimination was assessed utilizing the Adult Discrimination and Peer Discrimination Scale (Greene et al., 2006; Way, 1997). Participants were asked to rate the frequency of the occurrence of racial or ethnic-based discrimination by adults and peers at their school. Although the original scale does not include timing, the current study asked participants to think about these experiences *during their second semester* at the focal institution (e.g., Spring 2018; T3). Participants responded on a 5-point Likert scale ranging from 1 (*never*) to 5 (*all the time*). Sample items include "How often do you feel that adults treat you unfairly because of your race or ethnicity?" and "How often do you feel that other students at your school insult you because of your race or ethnicity?" The present study examined perpetrator-specific experiences of discrimination (i.e., peer-based versus adult-based), as is standard when using this measure (e.g., Greene et al., 2006) and due to recent work suggesting the need for closer attention to variation in discrimination outcomes by perpetrator (Benner et al., 2018). Peer and adult-based discrimination scores were computed by taking the average of 7 items on each scale, with higher scores indicating more experiences of peer and adult-based ethnic/racial discrimination. Internal consistencies were good for both peer ($\alpha = .93$) and adult discrimination ($\alpha = .95$).

Covariates. Several key demographic characteristics and health behaviors were examined as potential covariates, in an effort to isolate the impact of stress forms on diurnal cortisol patterns (Adam & Kumari, 2009). Momentary covariates included whether participants ate, consumed caffeine, used nicotine, experienced pain, exercised, drank alcohol, slept, or used medication within the hour prior to sampling. Day-level covariates included actigraphy-measured sleep duration. Between-person covariates included gender, immigrant generation, whether participants completed the study during the summer (1 = summer participation, 0 = school year participation), living situation (0 = lived with parents or other family, 1 = lived away from the home in university dorms, with friends, or alone), parent education, topical medication use (i.e., corticosteroids), and oral contraceptive use.

Data Analytic Plan

The final analytic sample was limited to participants who had at least one valid day of cortisol data at T3 ($N = 180$). Independent t-test and Chi-square tests were conducted to investigate whether there were differences between participants who had valid cortisol data at T3 and those who did not. Independent t-tests revealed that there were no significant group differences on any of the continuous study variables ($p > .28$). Chi-square tests indicated that participants who did not provide cortisol samples ($n = 16$) were significantly more likely to participate [in other portions of the study] during the summer than during the school year ($\chi^2 = 52.45(1)$, $p < .001$). There were no significant group differences for any other categorical variables ($p > .09$).

Three separate models were created to characterize stress: (1) additive model, (2) common model, and (3) cumulative model. Additive contributions were examined by inserting all stressors into the model simultaneously. Common effects were estimated by using multiple stressors as indicators on one or multiple latent variables. Exploratory factor analysis (EFA) were fit to determine whether the seven stress variables exhibited optimal factor structure when modeled as indicators of one or more latent factors of stress. To evaluate model fit, several fit indices were examined: chi-square test of model fit, comparative fit index (CFI), Tucker-Lewis index (TLI), and root mean square of approximation (RMSEA). Based on published criteria (Hu & Bentler, 1999), good model fit was determined if CFI and TLI values were at or above .95 and RMSEA values were less than .05; adequate model fit was determined if CFI and TLI values were between .90 and .95 and RMSEA values were between .05 and .08. Lastly, cumulative effects were measured by calculating a cumulative risk index (CRI). A count variable was created indicating how many stressors the participant experienced to a high degree. Being in the highest quartile of any one form of stress added "1" to the count. Possible scores ranged from 0 to 7.

To assess momentary (Level 1), daily (Level 2), and between-person (Level 3) variation in cortisol, three-level growth curve models were fit using Mplus 8.0 (Muthén & Muthén, 1998–2017). The diurnal cortisol pattern (e.g., DCS and CAR) was modeled at Level 1 by including growth parameters based on participants' wake time (linear), the squared function of this variable (i.e., to assess curvilinear patterns; time since waking^2), and a dummy variable corresponding to the CAR sample (1 = second sample). Momentary covariates that were significantly associated with the diurnal pattern were included at Level 1 (e.g., food, caffeine, medication use, pain). Actigraphy sleep duration was included at Level 2 as a day-level covariate. At Level 3, additive stress, common stress, and cumulative stress were included as person-specific predictors of the cortisol diurnal pattern. Between-person covariates were also included at Level 3. Each model of stress was tested separately in the analyses (presented below are equations for the additive stress model).

Level 1 (moment):

$$Cortisol_{mdi} = b_{0di} + b_{1di}(CAR_{mdi}) + b_{2di}(Time\ Since\ Waking_{mdi}) + b_{3di}(Time\ Since\ Waking^{2}_{mdi}) + b_{mdi}(Momentary\ Covariates_{mdi}) + u_{mdi}$$

Level 2 (day):

$$b_{0di} = \beta_{00i} + \beta_{01i}(Prior\ Night\ Sleep\ Duration_{0di}) + u_{0di}$$

$$b_{1di} = \beta_{10i} + \beta_{11i}(Prior\ Night\ Sleep\ Duration_{1di})$$

$$b_{2di} = \beta_{20i} + \beta_{21i}(Prior\ Night\ Sleep\ Duration_{2di})$$

$$b_{3di} = \beta_{30i} + \beta_{31i}(Prior\ Night\ Sleep\ Duration_{3di})$$

Level 3 (person):

$$\beta_{00i} = \gamma_{000} + \gamma_{001}(General\ Stress_{i}) + \gamma_{002}(Academic\ Stress_{i}) + \gamma_{003}(Social\ Stress_{i}) + \gamma_{004}(Financial\ Stress_{i}) + \gamma_{005}(Bicultural\ Stress_{i}) + \gamma_{006}(Peer\ Discrimination_{i}) + \gamma_{007}(Adult\ Discrimination_{i}) + \gamma_{00i}(Person\text{-}Level\ Covariates_{i}) + u_{00i}$$

$$\beta_{10i} = \gamma_{100} + \gamma_{101}(General\ Stress_{i}) + \gamma_{102}(Academic\ Stress_{i}) + \gamma_{103}(Social\ Stress_{i}) + \gamma_{104}(Financial\ Stress_{i}) + \gamma_{105}(Bicultural\ Stress_{i}) + \gamma_{106}(Peer\ Discrimination_{i}) + \gamma_{107}(Adult\ Discrimination_{i}) + \gamma_{10i}(Person\text{-}Level\ Covariates_{i}) + u_{10i}$$

$$\beta_{20i} = \gamma_{200} + \gamma_{201}(General\ Stress_{i}) + \gamma_{202}(Academic\ Stress_{i}) + \gamma_{203}(Social\ Stress_{i}) + \gamma_{204}(Financial\ Stress_{i}) + \gamma_{205}(Bicultural\ Stress_{i}) + \gamma_{206}(Peer\ Discrimination_{i}) + \gamma_{207}(Adult\ Discrimination_{i}) + \gamma_{20i}(Person\text{-}Level\ Covariates_{i}) + u_{20i}$$

$\beta_{30i} = \gamma_{300} + \gamma_{301}(\textit{General Stress}_i) + \gamma_{302}(\textit{Academic Stress}_i) + \gamma_{303}(\textit{Social Stress}_i) + \gamma_{304}(\textit{Financial Stress}_i) + \gamma_{305}(\textit{Bicultural Stress}_i) + \gamma_{306}(\textit{Peer Discrimination}_i) + \gamma_{307}(\textit{Adult Discrimination}_i) + \gamma_{30i}(\textit{Person-Level Covariates}_i) + u_{30i}$

Covariates that exhibited statistically significant associations with cortisol outcomes (e.g., DCS, CAR) at the bivariate level (i.e., tested in a multi-level framework) were retained in the final models. A full information maximum likelihood (FIML) method was utilized to account for missing data.

CHAPTER 3

RESULTS

Preliminary Analyses

Descriptive statistics and bivariate correlations are presented in Table 1. First, the data were examined for normality and outliers. Bicultural stress levels were significantly skewed (2.45) due to relatively low endorsement for experiences of daily bicultural stress (e.g., 47.2% reported no instance of bicultural stress); however, a majority of the sample reported experiencing at least one bicultural stressor across the week. Thus, this variable was transformed using the natural log function prior to inclusion in main analyses. Raw cortisol values were also log-transformed to account for positive skew of the cortisol distribution (skew = 2.89 before transforming, –0.39 after transforming). Plots of cortisol values are presented in Figure 2 for visualization purposes. See supplemental materials for additional plots including linear and quadratic fits to the data (Figure S1). Bivariate correlations shown in Table 1 depict the association between study variables and the average of participants' five cortisol samples across all three assessment days.

Factor Analysis of Stress

Exploratory factor analysis (EFA) was conducted to investigate the factor structure of each of the stress indicators. A scree plot, number of significant items per factor, and theoretical rationale were used to determine optimal factor structure. The scree plot identified two factors with an eigenvalue exceeding one (i.e., 2.79 and 1.42). The 2-factor solution showed significantly better statistical fit than the 1-factor solution

($\Delta\chi^2$ (6) = 158.12, $p < .001$). Thus, the 2-factor solution was retained for subsequent analyses using confirmatory factor analysis (CFA). Model fit for this two-factor CFA was good (χ^2 (13) = 15.19, $p = .30$, RMSEA = .03, CFI = .99, TLI = .99, SRMR = .04). The first factor was composed of general stress, academic stress, social stress, financial stress, and bicultural stress, and the second factor consisted of both peer and adult ethnic/racial discrimination. Factor loadings for the first latent stress factor ranged from low to high: bicultural stress ($\lambda = .42$, $SE = .07$, $p < .001$), general stress ($\lambda = .47$, $SE = .07$, $p < .001$), financial stress ($\lambda = .57$, $SE = .06$, $p < .001$), academic stress ($\lambda = .69$, $SE = .06$, $p < .001$), social stress ($\lambda = .78$, $SE = .05$, $p < .001$). Because the three highest factor loadings were subscales of the college stress scale (Rodriguez et al., 2000), this latent factor was referred to as the "college stress factor." In the second factor, peer ($\lambda = .88$, $SE = .08$, $p < .001$) and adult-based discrimination ($\lambda = .89$, $SE = .08$, $p < .001$) were both significant with high factor loadings. This factor was referred to as the "discrimination stress factor." The two latent stress factors were significantly positively correlated ($r = .36$, $p < .001$).

Cumulative Risk Index

Percentile/quartile scores were used to determine whether participants were experiencing "high" stress of any form. Scoring above the 75th percentile for any given stress form was considered high stress and given a "1" for this stressor ("0" was assigned to participants <75th percentile). The cut-off criteria values were as follows: general stress (>9.00), academic stress (>4.00), social stress (>3.67), financial stress (>3.20), bicultural stress (>0.38), peer discrimination (>2.00), adult discrimination (>2.00). These dummy variables were then summed to create an overall CRI. The distribution of this CRI (M = 1.52, SD = 1.65) was as follows: 36.7% scored “0” (i.e., experienced no stressor to a high degree), 24.4% scored “1”, 13.3% scored “2”, 10.0% scored “3”, 10.6% scored “4”, 2.8% scored “5”, 1.1% scored “6”, and 1.1% scored “7” (i.e., experienced each form of stress to a high degree).

Acknowledging the shortcomings of this traditional CRI approach (e.g., using sample-specific information to determine cut-offs), an alternative, empirically-derived CRI (alt-CRI) was calculated and included as a sensitivity test for subsequent analyses. Detailed information about the creation of the alt-CRI and corresponding descriptive statistics can be found in the supplemental materials.

Model 1: Diurnal Pattern

A linear growth model with a dummy code to represent the cortisol awakening response fit the data significantly better than an unconditional model with no predictors, $\chi^2(9) = 2{,}386.442$, $p < .001$. Adding a quadratic term fit the data significantly better than the linear model, $\chi^2(6) = 64.513$, $p < .001$. Growth modeling revealed the expected average diurnal cortisol pattern to have relatively high cortisol levels at waking (5.37 nmol/L), an approximate 84.04% increase 30 minutes after waking (cortisol awakening response)[3], and an approximate 6.8% decline in cortisol per hour estimated at waking (diurnal cortisol slope), accounting for participants’ protocol non-compliance and

---

[3] Because cortisol values were log-transformed prior to analyses, effect sizes can be interpreted after using the following formula: β% change = ([e^β] – 1).

adjusting for momentary, daily, and between-person covariates (Table 3, Model 1). Notably, 86.7% of the variance in cortisol was attributable to within-person variance (i.e., sample-to-sample, day-to-day differences; ICC = .133).

The only significant momentary (Level 1) covariate in Model 1 was eating in the past hour (γ_{400} = .057, *p* = .034); caffeine use, medication use, and experiencing pain in the past hour were not significant (*p*s > .06). Previous night sleep duration (hours; Level 2) was significantly associated with all aspects of the diurnal pattern, such that longer sleep the night before was linked with greater next-morning waking cortisol, lower CAR, steeper DCS, and a more quadratic pattern. The only covariate retained at the between-person level was topical medication use, which was significantly associated with the CAR in preliminary bivariate models (*p* = .04) but did not reach statistically significant levels in Model 1 (γ_{111} = .200, *p* = .055).

Model 2: Additive Stress

First, I examined the additive (independent) contributions of each of seven stress forms as predictors of average diurnal cortisol (e.g., CAR, DCS), including covariates (Table 2, Model 2). None of the stress forms were significantly associated with the CAR, *ps* > .06 (γ_{102}academic stress *p* = .057; γ_{107}adult discrimination *p* = .073). Further, results indicated that higher general stress was associated with an approximate 0.8% flatter per hour at waking DCS (γ_{201} = .008, *p* = .03), whereas higher bicultural stress was associated with a 6.7% steeper per hour at waking DCS, on average (γ_{205} = -.069, *p* = .047). No other stress forms were significantly associated with the DCS, *ps* > .59.

Model 3: Common Stress

Next, I entered the two-factor latent stress variable (e.g., college stress, discrimination stress) as the focal predictor of aspects of the diurnal pattern (Table 2, Model 3). This third model was composed solely of the two stress factors and previously included covariates. Results from this model indicated that greater college stress was significantly associated with an approximate 8.5% lower CAR ($\gamma_{109} = -.089$, $p = .045$), but the discrimination-specific stress factor was not significantly associated with the CAR ($\gamma_{108} = -.022$, $p = .71$). Neither latent stress factor was significantly associated with the DCS (*ps* > .82).

Model 4: Cumulative Stress

In the final model, I examined the cumulative stress risk index as a predictor of the DCS and CAR, accounting for covariates (Table 2, Model 4). Results indicated that a one unit increase on the CRI was associated with an approximate 5.4% lower CAR ($\gamma_{110} = -.055$, $p = .007$), but was not significantly related to the DCS ($\gamma_{210} = -.002$, $p = .74$). Results from sensitivity analyses testing the alternative CRI (alt-CRI) indicated that a one unit increase on the alt-CRI was associated with an approximate 6.6% lower CAR ($\gamma_{101} = -.068$, $p = .008$), but was not significantly associated with the DCS ($\gamma_{201} = .001$, $p = .874$; see Table S1, Model 5, for full statistics).

Exploratory Analyses: Quadratic Effects of Cumulative Stress

As part of exploratory analyses, I examined whether there were nonlinear effects of the CRI on diurnal cortisol by estimating a quadratic term (e.g., CRI*CRI) and entering this into the model (Table S1, Model 4a). Results indicated that the quadratic CRI term was not associated with the CAR (γ_{102} = .005, p = .62) or the DCS (γ_{202} = .004, p = .11). When investigating potential nonlinear effects of the alternative CRI on diurnal cortisol outcomes, the quadratic alt-CRI term was significantly associated with the DCS (γ_{202} = .008, p = .011), but not the CAR (γ_{102} = .009, p = .47; see Table S1, Model 5a).

CHAPTER 4

DISCUSSION

Latino adolescents transitioning to college are at an increased risk for experiences of stress, including college demands, social stressors, and ethnic/racial stigma (Huynh & Fuligni, 2012; Rodriguez et al., 2000). In an effort to disentangle the contributions of stress on Latino adolescents' physiological functioning during this transitional period, the present study utilized a "multi-risk model" approach to investigate additive, common, and cumulative effects of stress on diurnal cortisol among first-year Latino college students. Results indicated that, in the additive model, no stress forms were associated with the CAR, however, general stress was associated with a flatter DCS and bicultural stress was linked with a steeper DCS. In the common model, the latent college stress factor (e.g., social, academic, financial, general, bicultural stress) was associated with a lower CAR, but was not related to the DCS. Further, greater cumulative stress was also linked with a reduced CAR, but not the DCS. These findings provide insight into the unique links between specific stress forms and HPA axis functioning during Latino students' transition to college, accounting for other relevant stressors experienced during this time. Differences and commonalities across the three models contribute to the complex literature surrounding stress and HPA axis linkages. Importantly, findings support theoretical frameworks positing that chronic and cumulative stress exposure can lead to alterations in physiological functioning that, accumulated over time, can result in maladaptive diurnal patterns (McEwen, 1998), which may underlie existing ethnic/racial disparities in HPA axis functioning (DeSantis et al., 2007), health and disease (Meyer, 2003; Myers, 2009) and educational retention (Snyder et al., 2019). These findings may be harnessed as evidence to promote services and mechanisms that support Latino students during this transition, including resources for coping and stress management (Bottaccioli et al., 2020; Sladek et al., 2016) and increased efforts to promote diversity and inclusion across campus (Sladek et al., 2020)

Additive Model Findings

Findings indicated that general stress and bicultural stress were both significantly associated with the DCS, accounting for all other stress forms. The relation between increased general stress and a flatter DCS is not surprising, as a flatter diurnal rhythm is one of the most common indicators of altered HPA axis activity, and increased stress, in general, is related to this pattern (e.g., Miller et al., 2007). However, it was unexpected that general stress would be the *only* stress form related to a flatter rhythm. This is an interesting finding that prompts the examination of what differentiates this stressor from others. General stress was assessed using the PSS-4 (Cohen et al., 1983), a global measure of stress that assesses the degree to which individuals perceive (non-specific) events in their lives to be stressful (e.g., unpredictable, uncontrollable, overloading). Thus, it is possible that this measurement was tapping into something more unique to participants' stress perceptions (i.e., their appraisal of stress, rather than frequency/type of stress). Further, perhaps the most compelling rationale for the distinct effect of general stress is the PSS-4's assessment of stress as *uncontrollable*. In their meta-analysis, Miller et al. (2007) identified the "controllability of stress" as a major characteristic influencing how chronic stress relates to HPA axis activity, with greater uncontrollability linked with alterations in HPA axis functioning, including flatter rhythms.

The finding that increased bicultural stress was associated with a *steeper* DCS is an interesting and unexpected result of the current study. Whereas no previous research has directly examined the relation between bicultural stress and diurnal cortisol, previous research examining related cultural stressors (e.g., microaggressions, acculturative stress) led us to expect that greater bicultural stress would be linked with maladaptive patterns of HPA axis activity (Torres et al., 2018; Zeiders et al., 2018). One important consideration that may help explain this finding is the *timing* in which bicultural stress was measured. As compared to the other stress forms, which asked over the past month, semester, or year, bicultural stress was an average of the daily count of stress experiences that occurred over one week, alongside the measurement of cortisol. Thus, it is possible that average daily bicultural stress was associated with what appeared to be an "adaptive" diurnal pattern due to the body adapting to the stressor in the short-term (i.e., steeper slopes resulting from adaptive cortisol activity across days/week). Indeed, a previous study found that Latino adolescents who reported higher biculturalism exhibited greater cortisol reactivity in the face of a stressor (i.e., adaptive short-term response; Gonzales et al., 2018). Given that more bicultural youth likely encounter a greater frequency of bicultural stressors (e.g., Love & Buriel, 2007), it could be that these individuals were responding to these stressors in an adaptive manner. Future studies may choose to examine stress-HPA axis linkage over a longer period of time to better elucidate the short-term versus chronic effects of bicultural stress (i.e., whether "adaptive" diurnal patterns persist in future months/years).

Contrary to our expectations, the additive model did not yield support for the independent contributions of academic, social, financial, or discrimination stress on diurnal cortisol. These results contrast previous work linking similar stressors with HPA axis activity. For example, previous studies have linked social stress (e.g., peer problems) with a flatter DCS and greater waking cortisol (Bai et al., 2017) and academic stress (e.g., academic problems, student status) with greater morning cortisol and a flattening of the CAR (Bai et al., 2017; McGregor et al., 2016). However, it is worth noting that these studies were conducted in younger (Bai et al., 2017) and older (McGregor et al., 2016) student samples and were not framed within the undergraduate college context, as they were in the present study. Importantly, the present study estimated these stress-diurnal cortisol associations while accounting for various other forms of stress, which is not as commonly practiced in the literature and may underlie these observed differences.

The nonsignificant findings for ethnic/racial discrimination were particularly unexpected, given the accumulation of evidence linking discrimination with HPA axis functioning in adolescence and young adulthood, including a flatter DCS (Skinner et al., 2011; Zeiders et al., 2014), greater cortisol output (Huynh et al., 2016), and higher CAR (Zeiders et al., 2012). One potential explanation is that the timing of ethnic/racial discrimination was not as clearly defined as other stress forms (i.e., items were asked in the context of the current semester of college) and was more "recent" than the timing of discrimination scales that have been used in previous studies (e.g., lifetime, past-year discrimination; Huynh et al., 2016; Skinner et al., 2011; Zeiders et al., 2014). In addition, there is evidence that experiences of discrimination may *decrease* across the transition to college for Latino students (Huynh & Fuligni, 2012). Given that previous research found associations between *high and stable* trajectories of discrimination on young adult physiological functioning (Brody et al., 2014), it could be that, in our sample, recent experiences of discrimination in college were not related to cortisol the same way observed in previous studies that were longitudinal (Brody et al., 2014) or asked about discrimination across a longer time frame (Skinner et al., 2011; Zeiders et al., 2014).

Common Model Findings

The present study's examination of stress as a latent variable uncovered two distinct stress factors: (1) college stress, which consisted of social, academic, financial, general, and bicultural stress, and (2) discrimination stress, which consisted of peer and adult ethnic/racial discrimination. To the authors' knowledge, this was the first study to conduct a factor analysis using multiple stress indicators during the college years. These results highlight distinct differences between stress experiences relating to ethnic/racial discrimination, as opposed to normative college stress, general stress, and daily bicultural stress. Notably, the EFA suggested that college-specific stressors (e.g., social, academic, financial) loaded highest onto the first latent factor, demonstrating that context-specific stressors seemed to be carrying the weight of these stress perceptions. These findings support theoretical and empirical research suggesting that ethnic/racial minority students encounter minority-specific stress that is distinct from general college stress, with the latter thought of as experienced by all students (Arbona et al., 2018; Wei et al., 2010). However, in this study, bicultural stress contributed to the college stress, rather than the discrimination stress latent factor, which may point to important differences between experiences of discrimination/prejudice, as compared to other manifestations of bicultural stress (e.g., dual language demands, inter/intra-group pressures). Further, this finding may be due, in part, to bicultural stress being assessed daily, as these experiences are likely nested within college contexts (e.g., interactions with classmates). In sum, these results underscore the importance of examining interrelations between stressors, rather than assuming that all forms of stress are capturing the same underlying construct.

When examining the associations between these two latent factors and diurnal cortisol, findings revealed that greater college stress was associated with a lower CAR, but not the DCS, whereas discrimination stress was not significantly related to the CAR or DCS. Though it is surprising, from a theoretical perspective, that the discrimination factor was not associated with diurnal cortisol, these results are consistent with what was observed in the additive model, and may point to important commonalities among non-discrimination stress forms as they relate to the CAR. Although no specific hypotheses were generated for the common model, we expected that the stress forms that contributed to this latent factor (social, academic, financial, general, bicultural) would be *additively* related to a larger CAR, due to the recency and/or predictability of these stressors (Miller et al., 2007), which may elicit an "adaptive" boost of cortisol upon waking (e.g., Adam et al., 2006). In contrast, our results showed that the *common* contributions of these stressors were associated with a lower CAR, a pattern linked with fatigue and burnout (Chida & Steptoe, 2009). This finding suggests that these developmentally-salient stressors may correlate with maladaptive neuroendocrine processes (e.g., blunted CAR), even within the first year of college. However, it is important to note that none of these stressors were individually related to the CAR, suggesting that this association was driven primarily by something all five stress forms had in common (i.e., underlying unobserved latent construct), and thus moves beyond additive expectations for stress-HPA axis linkages. Given that this latent construct was comprised of college, general, *and* minority-specific stressors, it could be that these findings capture the chronic, multiple stress experiences that Latino students experience during the transition to college (Phinney & Haas, 2003; Rodriguez et al., 2000), which would be expected to result in disruptions in diurnal cortisol activity. Indeed, research has utilized unobserved latent variables as an alternate method to measuring cumulative risk (e.g., Ettekal et al., 2019), which may explain why results in the common model were similar to those of the cumulative model – a comparison that will be further discussed in later paragraphs.

Cumulative Model Findings

A primary objective of this study was to examine whether the cumulative impact of multiple stress forms was associated with diurnal cortisol in ways that were distinct from the additive or common impact of these stressors. The present study observed that cumulative stress was associated with a blunted CAR for first-year Latino students. This finding is consistent with the study hypothesis, as well as previous literature examining cumulative risk and altered HPA axis functioning (Kwak et al., 2017; Suglia et al., 2010). Specifically, the current findings closely relate to those of Kwak et al. (2017), in which higher cumulative family stress was linked with a reduced CAR among Latino adolescents. In addition, these results are consistent with allostatic load (McEwen, 1998) and minority stress models (Meyer, 2003), such that the cumulative contributions of various stressors, including general, college, and minority-specific stressors, were related to a diurnal pattern indicative of overactivation of the stress response systems (e.g., lower CAR). This finding is important as it can help inform future research on determinants of fatigue or burnout among incoming Latino college students. Specifically, it corroborates the notion that students who are "taking on too much" are not only at-risk for emotional stress (Kerr et al., 2004), but also alterations in stress responsive systems, which can serve as a mechanism for eventual disease onset (e.g., Steptoe & Serwinski, 2016).

Multi-Risk Model Approach: Differences and Takeaways

The primary goal of the multi-risk model approach was to elucidate the complex links between experiences of stress and HPA axis functioning by testing the effects of stress in three different ways (e.g., additive, common, cumulative). Though we cannot make direct comparisons across these three models, it is worthwhile to examine clear commonalities and differences observed. Perhaps the most striking difference was the aspect of diurnal cortisol that was associated with stress across the different models.

Specifically, in the additive model, general and bicultural stress were significantly associated with the DCS, whereas common and cumulative stress were not. This difference was unexpected, as previous work has consistently linked chronic stress with a flatter DCS (e.g., Miller et al., 2007), which led us to expect significant links between common and cumulative stress and DCS. However, given that time since onset of stress is associated with more altered HPA axis functioning (Miller et al., 2007), it is possible that the proximity of stress forms in the current study (e.g., daily, monthly, semesterly) may explain these null findings.

Importantly, findings from the additive model may also provide insight into nonsignificant findings across models. For example, in the common model, general and bicultural stress had the lowest factor loadings on the college stress factor (below .50), indicating that there was more variance not attributed to these stressors, which may explain why this latent factor was not associated with the DCS. Importantly, in the additive model, general stress and bicultural stress were differentially linked with the DCS (i.e., higher stress linked with flatter and steeper slopes, respectively). Thus, it is possible that the combination of these two stressors into one construct contributed to the nonsignificant DCS findings in the common and cumulative models (i.e., the opposing effects may have washed each other out). It is possible that this discrepancy across models points to a strength of the multi-risk model approach, as the removal of the additive stress model may have led to substantially different conclusions (e.g., DCS not impacted by stress, general and bicultural stress not as influential on HPA axis functioning).

In addition, there were also important similarities across models, with the most notable being that college stress and cumulative stress were both significantly associated with a lower CAR. This similarity is consistent with previous work demonstrating that both observed-score (e.g., cumulative risk index) and variable-centered (e.g., latent factor analysis) methods can be used to assess cumulative risk with multiple indicators (Ettekal et al., 2019), and that these two techniques hold unique advantages and disadvantages. For example, similar to what was observed by Ettekal et al. (2019), in the present study, effect sizes were larger in the common model as compared to the cumulative model (e.g., approximately 3.1% more of a reduction in CAR in the common model). Yet, the current study also found that the common model was less robust with regards to the statistical significance of this effect (p = .045 as compared to p = .007). The latter point highlights a potential strength of the CRI, as it allows for the inclusion of distinct risk processes (e.g., discrimination), as compared to latent factor analysis, which imposes that all stressors are interrelated. On the other hand, the common model approach provides more specificity regarding which stressors are tapping into the same underlying stress construct, which can aid in interpretation when pinpointing the combined impact of a specific set of stressors. Indeed, findings from the common model point to college-specific stress forms (e.g., social, academic, financial) as potential drivers of the link between cumulative stress and a reduced CAR, a specificity not provided by the cumulative model alone.

Taken together, findings from this multi-risk model approach provide evidence that instances of general, college-related, and cumulative stress perceptions (which may disproportionally affect ethnic/racial minority students; Phinney et al., 2003; Wei et al., 2011), were linked with alterations in HPA axis activity (which is more common among ethnic/racial minority adolescents; DeSantis et al., 2007), which has been hypothesized to underlie subsequent health and educational disparities (e.g., Meyers, 2003; Snyder et al., 2019). Future studies may seek to extend these findings by investigating HPA axis functioning as a mechanism underlying longitudinal links between stress and negative developmental outcomes, such as educational attainment and mental and physical health. Importantly, compared to the robust evidence linking the DCS with mental and physical health (see Adam et al., 2017), the literature is more mixed regarding the CAR (e.g., both heightened and blunted CAR linked with illness; Steptoe & Serwinski, 2016). Therefore, it will be important for future research to disentangle how this pattern of diurnal cortisol is longitudinally related to outcomes such as academic retention and mental and physical health.

Limitations and Future Directions

The findings of the present study should be interpreted alongside its limitations. First, participants in the present study attended a large, four-year public university in the Southwestern United States and had lived near it at the time of study recruitment. Thus, findings may not generalize well to students attending colleges that differ in geographic location, size, or who choose to attend community or two-year college contexts. Next, there were more females than males in the current study, which could have impacted study findings, as previous research has found sex differences in average levels of the CAR, as well as stress-CAR linkages (Miller et al., 2017). Further, because our sample was limited to students who provided valid cortisol data, our final sample size was 180, which could have resulted in a reduction of statistical power for models with multiple predictors (e.g., additive model). Additionally, this study was conducted within one college semester (Spring 2018); therefore, we were unable to capture the stability or enduring effects of first-year stress on subsequent HPA axis functioning across months or years later. However, the incorporation of stress forms that were specific with regards to *timing* helped clarify potential time-related effects of stress on diurnal cortisol. Similarly, this study design helped provide an important snapshot into proximal stress-HPA axis linkages within the first year of college, a time when students are at increased risk for stress experiences (Kerr et al., 2004) and potential drop-out (Hussar et al., 2020).

Conclusions & Implications

Chronic or repeated stress exposure, which may be especially common during a major sociocultural shift such as the transition to college (Kerr et al., 2004), can alter typical HPA axis functioning, which has lasting consequences on health and well-being (Adam et al., 2017). Acknowledging ethnic/racial disparities in educational attainment and diurnal patterns of cortisol for Latino individuals in the United States (DeSantis et al., 2007; Snyder et al., 2019), the present study took an intensive look into relations between stress and diurnal cortisol among first-year Latino college students by implementing a multi-risk model approach. Results of the study provide evidence for additive, common, and cumulative effects of stress on diurnal cortisol. Specifically, there were unique effects of certain stressors on students' DCS during the first semester of college, whereas common and cumulative stress were related to a blunted CAR. These findings provide preliminary evidence that college stress, which is often viewed as "normative," may have short-term negative effects on HPA axis functioning among Latino college students. Furthermore, the finding that common and cumulative stress were linked with a lower CAR, a pattern closely tied to fatigue, exhaustion, and burnout (Chida & Steptoe, 2009), suggests that Latino students may be experiencing burnout *within their first year of college*. This finding may explain increased rates of undergraduate student drop-out between the first- and second-year of college, as well as reduced rates of retention among Latino students in particular (Hussar et al., 2020; Snyder et al., 2019).

The implications of the present study findings span multiple levels of influence in youths' lives (e.g., individual, educational institution, nationwide/systemic). From an intervention standpoint, these findings point to stress-management and stress-reduction techniques as especially promising for first-year Latino college students. Indeed, the impact of daily stress perceptions on cortisol reactivity can vary as a function of students' coping strategies (Sladek et al., 2016), and evidence from randomized controlled trials indicate that stress management programs (e.g., meditation, cognitive behavioral techniques) can result in reductions in basal morning cortisol and cortisol reactivity among undergraduate students (Bottaccioli et al., 2020; Hammerfald et al., 2006; Iglesias et al., 2012), which may protect against maladaptive alterations in diurnal patterns. From a prevention standpoint, educational institutions may seek to reduce the burden of stress on ethnic/racial minority students by promoting a culture that values student diversity, as recent evidence among Latino college students suggests that an institution's commitment to diversity and inclusion can reduce physiological responses to psychosocial stress, specifically for students with greater Latino values (Sladek et al., 2020). Lastly, broader implications of these findings extend beyond educational institutions and include nationwide efforts to reduce systemic racism and inequalities in the United States by targeting mechanisms of social disadvantage (e.g., access to healthcare, educational resources, residential segregation; Caldwell et al., 2017; Hanushek & Rivkin, 2006), which may alleviate the cumulative burden of general, college, and minority-specific stressors for Latino students transitioning to college

REFERENCES

Adam, E. K. (2006). Transactions among adolescent trait and state emotion and diurnal and momentary cortisol activity in naturalistic settings. *Psychoneuroendocrinology*, *31*(5), 664-679. https://doi.org/10.1016/j.psyneuen.2006.01.010

Adam, E. K. (2012). Emotion–cortisol transactions occur over multiple time scales in development: Implications for research on emotion and the development of emotional disorders. *Monographs of the Society for Research in Child Development*, *77*(2), 17–27. https://doi.org/10.1111/j.1540-5834.2012.00657.x

Adam, E. K., Doane, L. D., Zinbarg, R. E., Mineka, S., Craske, M. G., & Griffith, J. W. (2010). Prospective prediction of major depressive disorder from cortisol awakening responses in adolescence. *Psychoneuroendocrinology, 35*(6), 921-931. https://doi.org/10.1016/j.psyneuen.2009.12.007

Adam, E. K., Hawkley, L. C., Kudielka, B. M., & Cacioppo, J. T. (2006). Day-to-day dynamics of experience–cortisol associations in a population-based sample of older adults. *Proceedings of the National Academy of Sciences, 103*(45), 17058-17063. https://doi.org/10.1073/pnas.0605053103

Adam, E. K., & Kumari, M. (2009). Assessing salivary cortisol in large- scale, epidemiological research. *Psychoneuroendocrinology, 34*(10), 1423– 1436. https://doi.org/10.1016/j.psyneuen.2009.06.011

Adam, E. K., Quinn, M. E., Tavernier, R., McQuillan, M. T., Dahlke, K. A., & Gilbert, K. E. (2017). Diurnal cortisol slopes and mental and physical health outcomes: A systematic review and meta-analysis. *Psychoneuroendocrinology, 83*, 25-41. https://doi.org/10.1016/j.psyneuen.2017.05.018

Arbona, C., Fan, W., & Olvera, N. (2018). College stress, minority status stress, depression, grades, and persistence intentions among Hispanic female students: A mediation model. *Hispanic Journal of Behavioral Sciences, 40*(4), 414-430. https://doi.org/10.1177%2F0739986318799077

Arbona, C., & Jiménez, C. (2014). Minority stress, ethnic identity, and depression among Latino/a college students. *Journal of Counseling Psychology, 61*(1), 162-168. https://doi.org/10.1037/a0034914

Bai, S., Robles, T. F., Reynolds, B. M., & Repetti, R. L. (2017). Children's diurnal cortisol responses to negative events at school and home.

Psychoneuroendocrinology, 83, 150-158. https://doi.org/10.1016/j.psyneuen.2017.05.027

Benner, A. D., Wang, Y., Shen, Y., Boyle, A. E., Polk, R., & Cheng, Y. P. (2018). Racial/ethnic discrimination and well-being during adolescence: A meta-analytic review. *American Psychologist, 73*(7), 855–883. https://doi.org/10.1037/amp0000204

Bottaccioli, A. G., Bottaccioli, F., Carosella, A., Cofini, V., Muzi, P., & Bologna, M. (2020). Psychoneuroendocrinoimmunology-based meditation (PNEIMED) training reduces salivary cortisol under basal and stressful conditions in healthy university students: Results of a randomized controlled study. *Explore, 16*(3), 189-198. https://doi.org/10.1016/j.explore.2019.10.006

Brody, G. H., Lei, M. K., Chae, D. H., Yu, T., Kogan, S. M., & Beach, S. R. (2014). Perceived discrimination among African American adolescents and allostatic load: A longitudinal analysis with buffering effects. *Child Development, 85*(3), 989-1002. https://doi.org/10.1111/cdev.12213

Caldwell, J. T., Ford, C. L., Wallace, S. P., Wang, M. C., & Takahashi, L. M. (2017). Racial and ethnic residential segregation and access to health care in rural areas. *Health & Place, 43*, 104–112. https://doi.org/10.1016/j.healthplace.2016.11.015

Chida, Y., & Steptoe, A. (2009). Cortisol awakening response and psychosocial factors: a systematic review and meta-analysis. *Biological psychology, 80*(3), 265–278. https://doi.org/10.1016/j.biopsycho.2008.10.004

Clow, A., Thorn, L., Evans, P., & Hucklebridge, F. (2004). The awakening cortisol response: methodological issues and significance. *Stress, 7*(1), 29-37. https://doi.org/10.1080/10253890410001667205

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior, 24*(4) 385-396. https://doi.org/10.2307/2136404

DeSantis, A. S., Adam, E. K., Doane, L. D., Mineka, S., Zinbarg, R. E., & Craske, M. G. (2007). Racial/ethnic differences in cortisol diurnal rhythms in a community sample of adolescents. *Journal of Adolescent Health, 41*(1), 3-13. https://doi.org/10.1016/j.jadohealth.2007.03.006

Dickerson, S. S., & Kemeny, M. E. (2004). Acute stressors and cortisol responses: a theoretical integration and synthesis of laboratory research. *Psychological bulletin*, *130*(3), 355-391. https://doi.org/10.1037/0033-2909.130.3.355

Doane, L. D., Sladek, M. R., & Adam, E. K. (2018). *An introduction to cultural neurobiology: Evidence from physiological stress systems*. In J. M. Causadias, E. H. Telzer, & N. A. Gonzales (Eds.), *The handbook of culture and biology* (p. 227–254). John Wiley & Sons, Inc.

Doane, L. D., & Zeiders, K. H. (2014). Contextual moderators of momentary cortisol and negative affect in adolescents' daily lives. *Journal of Adolescent Health*, *54*(5), 536-542. https://doi.org/10.1016/j.jadohealth.2013.10.007

Dressendörfer, R. A., Kirschbaum, C., Rohde, W., Stahl, F., & Strasburger, C. J. (1992). Synthesis of a cortisol-biotin conjugate and evaluation as a tracer in an immunoassay for salivary cortisol measurement. *The Journal of Steroid Biochemistry and Molecular Biology*, *43*(7), 683-692. https://doi.org/10.1016/0960-0760(92)90294-S

Ettekal, I., Eiden, R. D., Nickerson, A. B., & Schuetze, P. (2019). Comparing alternative methods of measuring cumulative risk based on multiple risk indicators: Are there differential effects on children's externalizing problems? *PloS one*, *14*(7), e0219134. https://doi.org/10.1371/journal.pone.0219134

Flentje, A., Heck, N. C., Brennan, J. M., & Meyer, I. H. (2019). The relationship between minority stress and biological outcomes: A systematic review. *Journal of Behavioral Medicine*. https://doi.org/10.1007/s10865-019-00120-6

Gallo, L. C., Roesch, S. C., Fortmann, A. L., Carnethon, M. R., Penedo, F. J., Perreira, K., ... & Sotres-Alvarez, D. (2014). Associations of chronic stress burden, perceived stress, and traumatic stress with cardiovascular disease prevalence and risk factors in the HCHS/SOL Sociocultural Ancillary Study. *Psychosomatic medicine*, *76*(6), 468-475. https://doi.org/10.1097/psy.0000000000000069

Garcia, A. F., Wilborn, K., & Mangold, D. L. (2017). The cortisol awakening response mediates the relationship between acculturative stress and self- reported health in Mexican Americans. *Annals of Behavioral Medicine, 51*(6), 787–798. https://doi.org/10.1007/s12160-017-9901-5

García Coll, C. G., Crnic, K., Lamberty, G., Wasik, B. H., Jenkins, R., Garcia, H. V., & McAdoo, H. P.(1996). An integrative model for the study of developmental competencies in minority children. *Child Development, 67*(5), 1891-1914. http://dx.doi.org/10.1111/j.1467-8624.1996.tb01834.

Gonzales, N. A., Johnson, M., Shirtcliff, E. A., Tein, J. Y., Eskenazi, B., & Deardorff, J. (2018). The role of bicultural adaptation, familism, and family conflict in Mexican American adolescents' cortisol reactivity. *Development and Psychopathology, 30*(5), 1571-1587. https://doi.org/10.1017/S0954579418001116

Granger, D. A., Fortunato, C. K., Beltzer, E. K., Virag, M., Bright, M. A., & Out, D. (2012). Focus on methodology: salivary bioscience and research on adolescence: an integrated perspective. *Journal of Adolescence, 35*(4), 1081-1095. https://doi.org/10.1016/j.adolescence.2012.01.005

Greene, M. L., Way, N., & Pahl, K. (2006). Trajectories of perceived adult and peer discrimination among Black, Latino, and Asian American adolescents: Patterns and psychological correlates. *Developmental Psychology, 42*(2), 218-236. http://dx.doi.org/10.1037/0012-1649.42.2.218

Hammerfald, K., Eberle, C., Grau, M., Kinsperger, A., Zimmermann, A., Ehlert, U., & Gaab, J. (2006). Persistent effects of cognitive-behavioral stress management on cortisol responses to acute stress in healthy subjects—a randomized controlled trial. *Psychoneuroendocrinology, 31*(3), 333-339 https://doi.org/10.1016/j.psyneuen.2005.08.007

Hanushek, E. A., & Rivkin, S. G. (2006). *School quality and the black-white achievement gap* (NBER Working Paper No. 12651). Cambridge, MA: National Bureau of Economic Research

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*(1), 1–55. https://doi.org/10.1080/10705519909540118

Hussar, B., Zhang, J., Hein, S., Wang, K., Roberts, A., Cui, J., Smith, M., Bullock Mann, F., Barmer, A., and Dilig, R. (2020). *The Condition of Education 2020* (NCES 2020-144). U.S. Department of Education. Washington, DC: National Center for Education Statistics. Retrieved from https://nces.ed.gov/pubs2020/2020144.pdf

Huynh, V. W., & Fuligni, A. J. (2012). Perceived ethnic stigma across the transition to college. *Journal of Youth and Adolescence, 41*(7), 817–830. https://doi.org/10.1007/s10964-011-9731-x

Huynh, V. W., Guan, S. S. A., Almeida, D. M., McCreath, H., & Fuligni, A. J. (2016). Everyday discrimination and diurnal cortisol during adolescence. *Hormones and Behavior, 80*, 76-81. https://doi.org/10.1016/j.yhbeh.2016.01.009

Iglesias, S. L., Azzara, S., Argibay, J. C., Arnaiz, M. L., de Valle Carpineta, M., Granchetti, H., & Lagomarsino, E. (2012). Psychological and physiological response of students to different types of stress management programs. *American Journal of Health Promotion, 26*(6), e149–e158. https://doi.org/10.4278/ajhp.110516-QUAL-199

Kerr, S., Johnson, V. K., Gans, S. E., & Krumrine, J. (2004). Predicting adjustment during the transition to college: Alexithymia, perceived stress, and psychological symptoms. *Journal of College Student Development*, 45(6), 593-611. https://doi.org/10.1353/csd.2004.0068

Kirschbaum, C., & Hellhammer, D. H. (2000). Salivary cortisol. In G. Fink (Ed.), Encyclopedia of stress (Vol. 3, pp. 379-384). San Diego: CA: Academic Press.

Kudielka, B. M., Broderick, J. E., & Kirschbaum, C. (2003). Compliance with saliva sampling protocols: electronic monitoring reveals invalid cortisol daytime profiles in noncompliant subjects. *Psychosomatic Medicine*, *65*(2), 313-319. https://doi.org/10.1097/01.psy.0000058374.50240.bf

Kwak, Y., Taylor, Z. E., Anaya, L. Y., Feng, Y., Evich, C. D., & Jones, B. L. (2017). Cumulative family stress and diurnal cortisol responses in Midwest Latino families. *Hispanic Journal of Behavioral Sciences, 39*(1), 82-97. https://doi.org/10.1177/0739986316684130

Love, J. A., & Buriel, R. (2007). Language brokering, autonomy, parent-child bonding, biculturalism, and depression: A study of Mexican American adolescents From immigrant families. *Hispanic Journal of Behavioral Sciences, 29*(4), 472–491. https://doi.org/10.1177/0739986307307229

Martin, C. G., Bruce, J., & Fisher, P. A. (2012). Racial and ethnic differences in diurnal cortisol rhythms in preadolescents: the role of parental psychosocial risk and monitoring. *Hormones and Behavior, 61*(5), 661-668. https://doi.org/10.1016/j.yhbeh.2012.02.025

McEwen, B. S. (1998). Stress, adaptation, and disease: Allostasis and allostatic load. *Annals of the New York Academy of Sciences, 840*, 33–44. https://doi.org/10.1111/j.1749-6632.1998.tb09546.x

McEwen, B. S., & Seeman, T. (1999). Protective and damaging effects of mediators of stress: elaborating and testing the concepts of allostasis and allostatic load. *Annals of the New York Academy of Sciences, 896*(1), 30-47. https://doi.org/10.1111/j.1749-6632.1999.tb08103.x

McFarland, J., Hussar, B., de Brey, C., Snyder, T., Wang, X., Wilkinson-Flicker, S., Gebrekristos, S., Zhang, J., Rathbun, A., Barmer, A., Bullock Mann, F., and Hinz, S. (2017). *The Condition of Education 2017* (NCES 2017- 144). U.S. Department of Education. Washington, DC: National Center for Education Statistics. Retrieved from https://nces.ed.gov/pubs2017/2017144.pdf

McGregor, B. A., Murphy, K. M., Albano, D. L., & Ceballos, R. M. (2016). Stress, cortisol, and B lymphocytes: a novel approach to understanding academic stress and immune function. *Stress, 19*(2), 185-191. https://doi.org/10.3109/10253890.2015.1127913

Meyer, I. H. (2003). Prejudice, social stress, and mental health in lesbian, gay, and bisexual populations: conceptual issues and research evidence. *Psychological Bulletin, 129*(5), 674-697. https://doi.org/10.1037/0033-2909.129.5.674

Miller, G. E., Chen, E., & Zhou, E. S. (2007). If it goes up, must it come down? Chronic stress and the hypothalamic-pituitary-adrenocortical axis in humans. *Psychological Bulletin, 133*(1), 25-45. https://doi.org/10.1037/0033-2909.133.1.25

Miller, K. F., Margolin, G., Shapiro, L. S., & Timmons, A. C. (2017). Adolescent life stress and the cortisol awakening response: the moderating roles of attachment and sex. *Journal of Research on Adolescence, 27*(1), 34-48. https://doi.org/10.1111/jora.12250

Morin-Major, J. K., Marin, M. F., Durand, N., Wan, N., Juster, R. P., & Lupien, S. J. (2016). Facebook behaviors associated with diurnal cortisol in adolescents: Is befriending stressful? *Psychoneuroendocrinology, 63*, 238-246. https://doi.org/10.1016/j.psyneuen.2015.10.005

Muthén, L. K., & Muthén, B. O. (1998–2017). *Mplus user's guide* (8th ed.). Los Angeles, CA: Muthén & Muthén.

Myers, H. F. (2009). Ethnicity-and socio-economic status-related stresses in context: an integrative review and conceptual model. *Journal of Behavioral Medicine, 32*(1), 9-19. https://doi.org/10.1007/s10865-008-9181-4

Nicolson, N. A. (2008). *Measurement of cortiso*l. In L. J. Luecken & L. C. Gallo (Eds.), *Handbook of physiological research methods in health psychology* (p. 37–74). Sage Publications, Inc. https://doi.org/10.4135/9781412976244.n3

Oakley, R. H., & Cidlowski, J. A. (2013). The biology of the glucocorticoid receptor: new signaling mechanisms in health and disease. *Journal of Allergy and Clinical Immunology, 132*(5), 1033-1044. https://doi.org/10.1016/j.jaci.2013.09.007

Phinney, J. S., & Haas, K. (2003). The process of coping among ethnic minority first-generation college freshmen: A narrative approach. *The Journal of Social Psychology, 143*(6), 707-726. https://doi.org/10.1080/00224540309600426

Pruessner, J. C., Hellhammer, D. H., & Kirschbaum, C. (1999). Burnout, perceived stress, and cortisol responses to awakening. *Psychosomatic medicine*, *61*(2), 197-204. https://doi.org/10.1097/00006842-199903000-00012

Rodriguez, N., Myers, H. F., Morris, J. K., & Cardoza, D. (2000). Latino college student adjustment: Does an increased presence offset minority-status and acculturative stresses? *Journal of Applied Social Psychology, 30*(7), 1523-1550. https://doi.org/10.1111/j.1559-1816.2000.tb02534.x

Romero, A. J., & Roberts, R. E. (2003). Stress within a bicultural context for adolescents of Mexican descent. *Cultural Diversity & Ethnic Minority Psychology, 9*(2), 171–184. https://doi.org/10.1037/1099-9809.9.2.171

Seidman, E., & French, S. E. (2004). Developmental trajectories and ecological transitions: A two-step procedure to aid in the choice of prevention and promotion interventions. *Development and Psychopathology*, *16*(4), 1141-1159. https://doi.org/10.1017/S0954579404040179

Shirtcliff, E. A., Skinner, M. L., Obasi, E. M., & Haggerty, K. P. (2017). Positive parenting predicts cortisol functioning six years later in young adults. *Developmental Science*, *20*(6), e12461. https://doi.org/10.1111/desc.12461

Skinner, M. L., Shirtcliff, E. A., Haggerty, K. P., Coe, C. L., & Catalano, R. F. (2011). Allostasis model facilitates understanding race differences in the diurnal cortisol rhythm. *Development and Psychopathology*, *23*(4), 1167-1186. https://doi.org/10.1017/S095457941100054X

Sladek, M. R., Castro, S. A., & Doane, L. D. (2021). Ethnic-Racial discrimination experiences predict Latinx adolescents' physiological stress processes across college transition. *Psychoneuroendocrinology, 128*, 105212. https://doi.org/10.1016/j.psyneuen.2021.105212

Sladek, M. R., Doane, L. D., Luecken, L. J., & Eisenberg, N. (2016). Perceived stress, coping, and cortisol reactivity in daily life: A study of adolescents during the first year of college. *Biological Psychology, 117*, 8–15. https://doi.org/10.1016/j.biopsycho.2016.02.003

Sladek, M. R., Doane, L. D., Luecken, L. J., Gonzales, N. A., & Grimm, K. J. (2020). Reducing cultural mismatch: Latino students' neuroendocrine and affective stress responses following cultural diversity and inclusion reminder. *Hormones and Behavior, 120*, 104681. https://doi.org/10.1016/j.yhbeh.2020.104681

Sladek, M. R., Doane, L. D., & Park, H. (2020). Latino adolescents' daily bicultural stress and sleep: Gender and school context moderation. *Health Psychology, 39*(3), 179–189. https://doi.org/10.1037/hea0000824

Snyder, T. D., de Brey, C., & Dillow, S. A. (2019). Digest of Education Statistics 2017, NCES 2018-070. *National Center for Education Statistics.* Retrieved from https://nces.ed.gov/pubs2018/2018070.pdf

Stalder, T., Kirschbaum, C., Kudielka, B. M., Adam, E. K., Pruessner, J. C., Wüst, S., . . . Clow, A. (2016). Assessment of the cortisol awakening response: Expert consensus guidelines. *Psychoneuroendocrinology, 63*, 414–432. https://doi.org/10.1016/j.psyneuen.2015.10.010

Steptoe, A., & Serwinski, B. (2016). Chapter 34 - Cortisol Awakening Response. In G. Fink (Ed.), *Stress: Concepts, Cognition, Emotion, and Behavior* (Handbook of Stress, Vol. 1, pp. 277–283). San Diego: Academic Press. https://doi.org/10.1016/B978-0-12-800951-2.00034-0

Suglia, S. F., Staudenmayer, J., Cohen, S., Enlow, M. B., Rich-Edwards, J. W., & Wright, R. J. (2010). Cumulative stress and cortisol disruption among Black and Hispanic pregnant women in an urban cohort. *Psychological Trauma: Theory, Research, Practice, and Policy, 2*(4), 326-334. https://doi.org/10.1037/a0018953

Torres, L., Mata-Greve, F., & Harkins, A. (2018). A preliminary investigation of acculturative stress and diurnal cortisol among Latina women. *Journal of Latina/o Psychology, 6*(2), 149–158. https://doi.org/10.1037/lat0000088

U.S. Census Bureau. (2017). *2017 National Population Projections*. Washington, DC: U.S. Census Bureau. Retrieved from https://www.census.gov/data/tables/2017/demo/popproj/2017-summary-tables.html

Way, N. (1997). Adult and peer discrimination measure. *Unpublished manuscript*.

Wei, M., Ku, T. Y., & Liao, K. Y. H. (2011). Minority stress and college persistence attitudes among African American, Asian American, and Latino students: Perception of university environment as a mediator. *Cultural Diversity and Ethnic Minority Psychology, 17*(2), 195-203. https://doi.org/10.1177%2F0739986318799077

Wei, M., Liao, K. Y. H., Chao, R. C. L., Mallinckrodt, B., Tsai, P. C., & Botello-Zamarron, R. (2010). Minority stress, perceived bicultural competence, and depressive symptoms among ethnic minority college students. *Journal of Counseling Psychology, 57*(4), 411-422. https://doi.org/10.1037/a0020790

Zeiders, K. H., Doane, L. D., & Roosa, M. W. (2012). Perceived discrimination and diurnal cortisol: Examining relations among Mexican American adolescents. *Hormones and Behavior, 61*(4), 541-548. https://doi.org/10.1016/j.yhbeh.2012.01.018

Zeiders, K. H., Hoyt, L. T., & Adam, E. K. (2014). Associations between self-reported discrimination and diurnal cortisol rhythms among young adults: The moderating role of racial–ethnic minority status. *Psychoneuroendocrinology, 50*, 280-288. https://doi.org/10.1016/j.psyneuen.2014.08.023

Zeiders, K. H., Landor, A. M., Flores, M., & Brown, A. (2018). Microaggressions and diurnal cortisol: Examining within-person associations among African-American and Latino young adults. *Journal of Adolescent Health, 63*(4), 482-488. https://doi.org/10.1016/j.jadohealth.2018.04.018

APPENDIX A

TABLES

Table 1. *Bivariate Correlations and Descriptive Statistics.*

	1	2	3	4	5	6	7	8	9	10
1. Waking cortisol	--									
2. 30 min postwaking cortisol	.62***	--								
3. 3 hours postwaking cortisol	.25**	.43***	--							
4. 8 hours postwaking cortisol	.32***	.45***	.53***	--						
5. Bedtime cortisol	.19*	.30***	.45***	.55***	--					
6. General stress	-.08	-.18*	.05	.02	.05	--				
7. Academic stress	-.02	-.14†	.04	.06	.11	.30***	--			
8. Social stress	.01	-.09	.01	.01	.02	.38***	.54***	--		
9. Financial stress	-.05	-.12	-.17*	.03	.03	.23**	.43***	.43***	--	
10. Bicultural stress	.06	-.03	-.06	-.09	-.01	.14†	.31**	.33***	.21**	--
11. Peer discrimination	.05	-.03	.03	.05	-.002	.24**	.12	.25**	.19*	.23**
12. Adult discrimination	.004	-.14†	-.03	.03	-.005	.28***	.11	.25**	.22**	.19*
13. Cumulative risk index	.01	-.15*	.04	.01	.05	.49***	.54***	.64***	.52***	.53***
14. Average sleep duration	.18*	-.05	.16*	-.10	-.08	-.07	-.05	.001	-.05	-.001
15. Gender (1 = male)	-.07	-.09	.03	-.08	-.13†	-.18*	-.05	-.13†	-.17*	-.11
16. Immigrant generation	.02	.002	.01	-.06	.06	-.13†	-.07	-.06	-.01	-.14†
17. Summer participation	-.07	-.11	-.14†	-.10	-.02	.00	.04	-.05	.04	.00
18. Living situation	.002	.05	.04	-.02	-.03	-.13†	-.05	-.12	.04	.04
19. Parent education	.02	.08	-.06	.03	.08	-.21**	-.26***	-.14†	-.18*	-.13†
20. Topical medication use	.02	.17*	.15*	.25**	.15*	.09	.11	.13†	.04	.02
21. Oral contraceptive use	-.06	-.04	.17*	.11	.10	.15*	-.09	.10	-.02	-.10
M	6.71	7.26	6.32	5.89	5.03	7.44	3.46	3.13	2.69	0.20
SD	0.67	0.59	0.51	0.56	0.73	2.73	0.73	0.86	0.93	0.27
Minimum	4.04	4.23	4.30	4.51	2.81	0.00	1.57	1.33	1.00	0.00
Maximum	8.23	8.37	8.42	8.91	7.30	13.00	5.00	5.00	5.00	1.30

Note. $N = 180$. Averages of raw cortisol values (nmol/L) presented for descriptive purposes. Bicultural stress levels natural log transformed for analyses due to positive skew, but descriptive statistics presented represent original scores. Average sleep duration = average total sleep time across days that cortisol samples were provided. Gender: 1 = male, 0 = female; Immigrant generation: 0 = participant, parents, and both sets of grandparents born outside U.S., 7 = all were born in U.S.; Parent education: 1 = completed less than high school, 10 = graduate degree; Living situation: 1 = living away from home in university dorms or apartment, 0 = living at home with parents or other relatives; Focal institution: 1 = attending larger focal institution, 0 = attending another college institution. Topical medication use: 0 = no, 1 = yes; Oral contraceptive use: 0 = no, 1 = yes.

$^{\dagger}p < .10$. $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

Table 1 (cont.)

	11	12	13	14	15	16	17	18	19	20	21
1. Waking cortisol											
2. 30 min postwaking cortisol											
3. 3 hours postwaking cortisol											
4. 8 hours postwaking cortisol											
5. Bedtime cortisol											
6. General stress											
7. Academic stress											
8. Social stress											
9. Financial stress											
10. Bicultural stress											
11. Peer discrimination	--										
12. Adult discrimination	.79***	--									
13. Cumulative risk index	.61***	.61***	--								
14. Average sleep duration	-.05	-.04	-.03	--							
15. Gender (1 = male)	-.12	-.12	-.12	-.15*	--						
16. Immigrant generation	-.15*	-.15*	-.15†	.08	.03	--					
17. Summer participation	-.02	-.02	-.02	.14†	-.01	.14†	--				
18. Living situation	-.002	-.04	-.02	.01	.03	.03	-.15*	--			
19. Parent education	-.11	-.15†	-.25**	-.05	.09	.45***	.05	.03	--		
20. Topical medication use	-.10	-.09	.003	-.14†	.00	.03	-.01	-.02	.12	--	
21. Oral contraceptive use	-.07	-.01	-.02	.02	-.29***	.05	-.02	-.10	.01	.14†	--
M	1.52	1.54	1.52	6.52	0.33	2.56	0.09	0.61	3.75	0.07	0.14
SD	0.69	0.74	1.65	1.19	--	2.32	--	--	2.38	--	--
Minimum	1.00	1.00	0.00	4.11	--	0.00	--	--	1.00	--	--
Maximum	3.57	4.00	7.00	10.88	--		--	--	10.00	--	--

Note. $N = 180$. Averages of raw cortisol values (nmol/L) presented for descriptive purposes. Bicultural stress levels natural log transformed for analyses due to positive skew, but descriptive statistics presented represent original scores. Average sleep duration = average total sleep time across days that cortisol samples were provided. Gender: 1 = male, 0 = female; Immigrant generation: 0 = participant, parents, and both sets of grandparents born outside U.S., 7 = all were born in U.S.; Parent education: 1 = completed less than high school, 10 = graduate degree; Living situation: 1 = living away from home in university dorms or apartment, 0 = living at home with parents or other relatives; Focal institution: 1 = attending larger focal institution, 0 = attending another college institution. Topical medication use: 0 = no, 1 = yes; Oral contraceptive use: 0 = no, 1 = yes.
$^{\dagger}p < .10$. $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

Table 2. *Fixed Effects Estimates from Three-Level Growth Models of Diurnal Cortisol*

	Model 1		Model 2		Model 3		Model 4	
	Est.	*SE*	Est.	*SE*	Est.	*SE*	Est.	*SE*
Waking cortisol level, b_0								
Average waking cortisol level, β_{00}								
Intercept (waking cortisol level), γ_{000}	6.68**	0.04	6.68**	0.04	6.68**	0.04	6.68**	0.04
Night-before sleep duration, β_{010}	0.10**	0.03	0.10**	0.03	0.10**	0.03	0.10**	0.03
General stress, γ_{001}	--	--	-0.03	0.02	--	--	--	--
Academic stress, γ_{002}	--	--	0.01	0.08	--	--	--	--
Social stress, γ_{003}	--	--	0.05	0.06	--	--	--	--
Financial stress, γ_{004}	--	--	-0.07	0.06	--	--	--	--
Bicultural stress, γ_{005}	--	--	0.12	0.16	--	--	--	--
Peer discrimination, γ_{006}	--	--	0.13	0.13	--	--	--	--
Adult discrimination, γ_{007}	--	--	-0.10	0.15	--	--	--	--
Discrimination stress factor, γ_{008}	--	--	--	--	0.004	0.08	--	--
College stress factor, γ_{009}	--	--	--	--	-0.02	0.06	--	--
Cumulative risk index, γ_{010}	--	--	--	--	--	--	0.01	0.04
Cortisol awakening response (1 = second sample), b_1								
Average size of cortisol awakening response (CAR), β_{10}								
Intercept (CAR), γ_{100}	0.61**	0.03	0.60**	0.03	0.60**	0.03	0.60**	0.03
Night-before sleep duration, β_{110}	-0.07**	0.03	-0.06*	0.03	-0.07**	0.03	-0.07*	0.03
General stress, γ_{101}	--	--	-0.01	0.01	--	--	--	--
Academic stress, γ_{102}	--	--	$-0.10^{\dagger}$	0.05	--	--	--	--
Social stress, γ_{103}	--	--	-0.03	0.05	--	--	--	--
Financial stress, γ_{104}	--	--	0.04	0.04	--	--	--	--
Bicultural stress, γ_{105}	--	--	-0.09	0.12	--	--	--	--
Peer discrimination, γ_{106}	--	--	0.10	0.08	--	--	--	--
Adult discrimination, γ_{107}	--	--	$-0.13^{\dagger}$	0.07	--	--	--	--
Discrimination stress factor, γ_{108}	--	--	--	--	-0.02	0.06	--	--
College stress factor, γ_{109}	--	--	--	--	**-0.09***	**0.04**	--	--
Cumulative risk index, γ_{110}	--	--	--	--	--	--	**-0.06****	**0.02**
Topical medication use, γ_{111}	$0.20^{\dagger}$	0.10	0.23*	0.10	0.23*	0.11	$0.20^{\dagger}$	0.10
Diurnal cortisol slope (time since waking), b_2								
Average diurnal cortisol slope (DCS), β_{20}								
Intercept (DCS), γ_{200}	-0.07**	0.01	-0.07**	0.01	-0.07**	0.01	-0.07**	0.01
Night-before sleep duration, β_{210}	-0.03**	0.01	-0.03**	0.01	-0.03**	0.01	-0.03**	0.01

Table 2 (cont.)

	Model 1		Model 2		Model 3		Model 4	
	Est.	*SE*	Est.	*SE*	Est.	*SE*	Est.	*SE*
General stress, γ_{201}	--	--	**0.01***	**0.004**	--	--	--	--
Academic stress, γ_{202}	--	--	0.001	0.02	--	--	--	--
Social stress, γ_{203}	--	--	0.001	0.01	--	--	--	--
Financial stress, γ_{204}	--	--	-0.01	0.01	--	--	--	--
Bicultural stress, γ_{205}	--	--	**-0.07***	**0.04**	--	--	--	--
Peer discrimination, γ_{206}	--	--	-0.01	0.02	--	--	--	--
Adult discrimination, γ_{207}	--	--	0.01	0.02	--	--	--	--
Discrimination stress factor, γ_{208}	--	--	--	--	-0.001	0.01	--	--
College stress factor, γ_{209}	--	--	--	--	0.003	0.01	--	--
Cumulative risk index, γ_{210}	--	--	--	--	--	--	-0.002	0.01
Quadratic function (time since waking^2), b_3								
Average quadratic function, β_{30}								
Level 1 intercept (quadratic function), γ_{300}	-0.17**	0.02	-0.17**	0.02	-0.17**	0.02	-0.17**	0.02
Night-before sleep duration, β_{310}	0.14**	0.04	0.14**	0.04	0.14**	0.04	0.14**	0.04
General stress, γ_{301}	--	--	-0.03	0.02	--	--	--	--
Academic stress, γ_{302}	--	--	0.06	0.09	--	--	--	--
Social stress, γ_{303}	--	--	-0.06	0.08	--	--	--	--
Financial stress, γ_{304}	--	--	0.06	0.06	--	--	--	--
Bicultural stress, γ_{305}	--	--	0.32†	0.19	--	--	--	--
Peer discrimination, γ_{306}	--	--	-0.002	0.11	--	--	--	--
Adult discrimination, γ_{307}	--	--	-0.02	0.12	--	--	--	--
Discrimination stress factor, γ_{308}	--	--	--	--	-0.02	0.07	--	--
College stress factor, γ_{309}	--	--	--	--	0.02	0.06	--	--
Cumulative risk index, γ_{310}	--	--	--	--	--	--	0.02	0.03
Eating in last hour, γ_{400}	0.06*	0.03	0.07*	0.03	0.06*	0.03	0.06*	0.03
Caffeine in last hour, γ_{500}	-0.14†	0.08	-0.14†	0.08	-0.13†	0.08	-0.13†	0.08
Pain in last hour, γ_{600}	0.07	0.06	0.07	0.06	0.07	0.06	0.08	0.06
Medication in last hour, γ_{700}	-0.16†	0.08	-0.15†	0.08	-0.14†	0.08	-0.15†	0.08

Note. N = 2667 samples nested within 180 individuals. Cortisol values (nmol/L) transformed using the natural log function. Besides growth parameters, continuous level 1 and level 2 predictors were centered within-person; continuous level 3 predictors were grand-mean centered. $^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$.

APPENDIX B

FIGURES

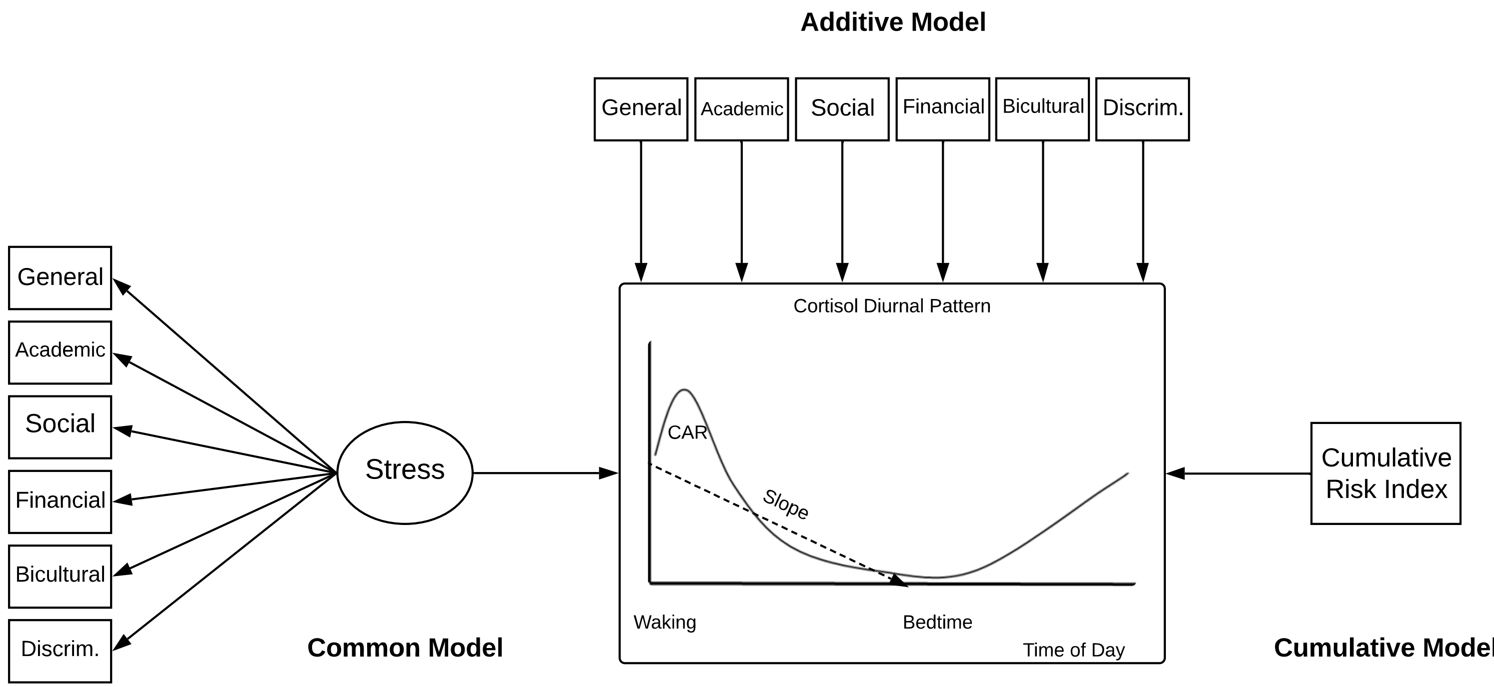

Figure 1. Theoretical representation of study research aims.

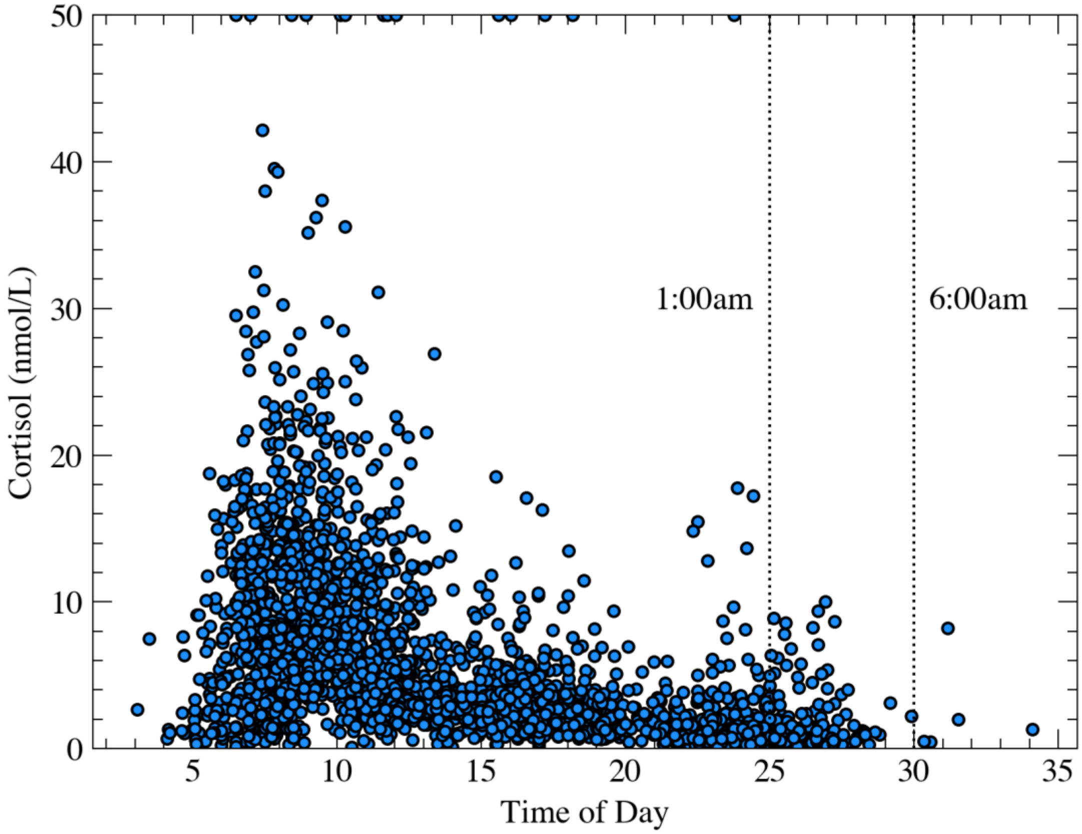

Figure 2. Cortisol values (nmol/L) across the waking day.
Note. Time of day is presented on a 24-hr scale (e.g., 5 = 5AM; 24 = 12AM). Values above 24 correspond to the next waking day (25 = 1AM, 30 = 6AM). Extreme values winsorized to = 50.

APPENDIX C

SUPPLEMENTAL MATERIALS

Sensitivity Analyses

Alternative Cumulative Risk Index. Given the added complexity of stress experiences and diurnal cortisol patterns, the present study used empirically derived cut-off CRI values, rather than sample-specific information, to create an alternative CRI (alt-CRI). Criteria for receiving a "1" (high stress label) for each stress form was as follows: general stress values above 10 (modifying previously established cut-off criteria for PSS-14, with 11+ representing "high levels" of stress; 10.6% of sample), academic, social, and financial stress scores above 4 (e.g., average response of "very stressful" across all items; 26.3%, 17.9%, and 11.7% of sample, respectively), daily bicultural stress scores above .75 (e.g., at least one bicultural stressor per day for at least three-fourths of study week, or alternatively, reporting multiple stressors on one day across the week; 12.8% of sample), and peer/adult discrimination values above 3 (e.g., average response of "sometimes" for ethnic/racial discrimination; 6.8% of sample for peer, 7.9% for adult). The distribution of the alt-CRI (M = .93, SD = 1.31) was as follows: 52.8% scored "0" (i.e., experienced no stressor to a high degree), 22.2% scored "1", 13.3% scored "2", 6.1% scored "3", 2.8% scored "4", 2.2% scored "5", and 0.6% scored "7" (i.e., experienced high degree of each stressor).

Table S1. *Fixed Effects Estimates from Three-Level Growth Models of Diurnal Cortisol – Sensitivity and Exploratory Analyses.*

	Model 4a (CRI^2)		Model 5 (alt-CRI)		Model 5a (alt-CRI^2)	
	Est.	*SE*	Est.	*SE*	Est.	*SE*
Waking cortisol level, b_0						
Average waking cortisol level, β_{00}						
Intercept (waking cortisol level), γ_{000}	6.74**	0.06	6.68**	0.04	6.76**	0.05
Night-before sleep duration, β_{010}	0.10**	0.03	0.10**	0.03	0.10**	0.03
Cumulative risk index, γ_{001}	0.04	0.04	0.003	0.05	0.10*	0.04
Cumulative risk index^2, γ_{002}	-0.02	0.02	--	--	**-0.05***	**0.02**
Cortisol awakening response (1 = second sample), b_1						
Average size of cortisol awakening response (CAR), β_{10}						
Cortisol awakening response (1 = second sample), γ_{100}	0.59**	0.04	0.60**	0.03	0.59**	0.04
Night-before sleep duration, β_{110}	-0.07*	0.03	-0.07**	0.03	-0.07**	0.03
Cumulative risk index, γ_{101}	-0.06*	0.03	**-0.07****	**0.03**	-0.09*	0.04
Cumulative risk index^2, γ_{102}	0.01	0.01	--	--	0.01	0.01
Topical medication use, γ_{103}	0.19†	0.11	0.24*	0.11	0.23*	0.11
Diurnal cortisol slope (time since waking), b_2						
Average diurnal cortisol slope (DCS), β_{20}						
Diurnal cortisol slope (time since waking), γ_{200}	-0.09**	0.01	-0.07**	0.01	-0.09**	0.01
Night-before sleep duration, β_{210}	-0.03**	0.01	-0.03**	0.01	-0.03**	0.01
Cumulative risk index, γ_{201}	-0.01*	0.01	0.001	0.01	-0.02	0.01
Cumulative risk index^2, γ_{202}	0.004	0.00	--	--	**0.01***	**0.00**
Quadratic function (time since waking^2), b_3						
Average quadratic function, β_{30}						
Quadratic function (time since waking^2), γ_{300}	-0.12**	0.04	-0.17**	0.02	-0.11*	0.04
Night-before sleep duration, β_{310}	0.14**	0.04	0.14**	0.04	0.14**	0.04
Cumulative risk index, γ_{301}	0.04	0.05	0.01	0.04	0.09	0.06
Cumulative risk index^2, γ_{302}	-0.01	0.01	--	--	-0.03†	0.02
Eating in last hour, γ_{400}	0.06*	0.03	0.06*	0.03	0.06*	0.03
Caffeine in last hour, γ_{500}	-0.13†	0.08	-0.13†	0.08	-0.13†	0.08
Pain in last hour, γ_{600}	0.08	0.06	0.08	0.06	0.08	0.06
Medication in last hour, γ_{700}	-0.15†	0.08	-0.14†	0.08	-0.14†	0.08

Note. N = 2667 samples nested within 180 individuals. Cortisol values (nmol/L) transformed using the natural log function. Besides growth parameters, continuous level 1 and level 2 predictors were centered within-person; continuous level 3 predictors were grand-mean centered. CRI^2 = exploratory model examining potential nonlinear effects for the traditional CRI used in primary analyses. Alt-CRI = alternative CRI calculated using empirically-derived criteria and tested as sensitivity analyses. Alt-CRI^2 = exploratory model examining potential nonlinear effects for the alternative CRI.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$.

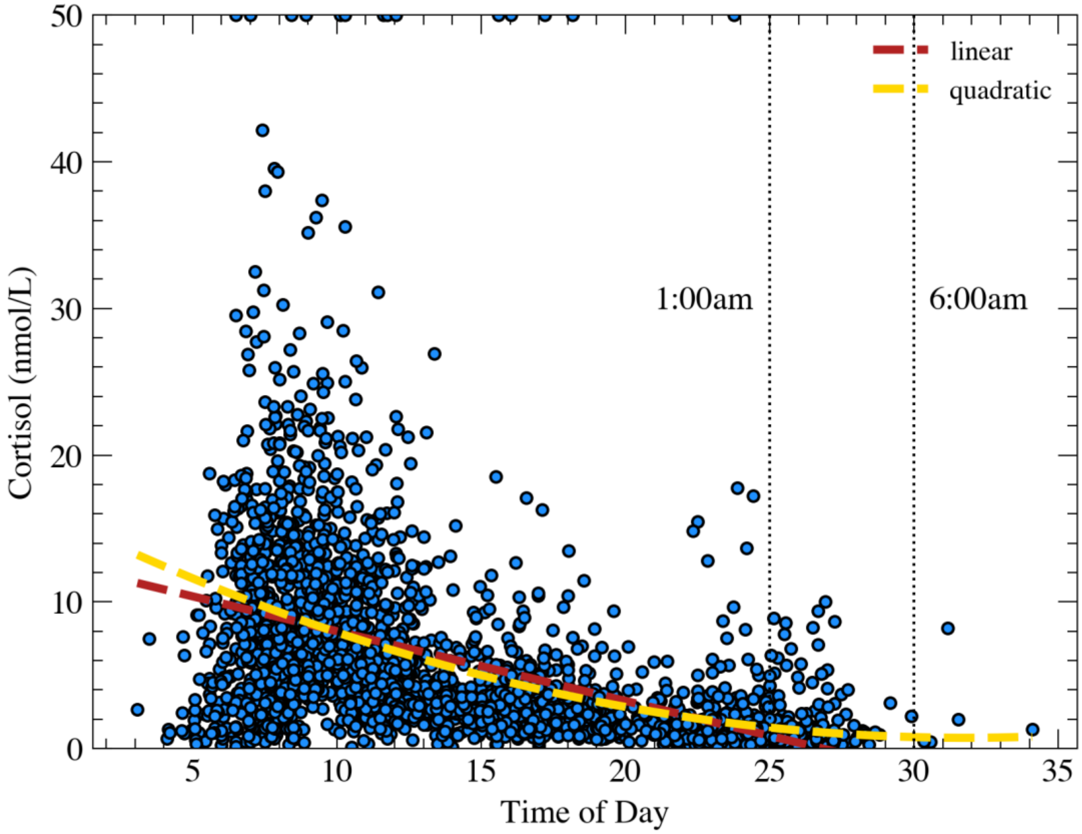

Figure S1. Cortisol values (nmol/L) across the waking day with linear and quadratic fit. *Note:* Time of day is presented on a 24-hr scale (e.g., 5 = 5AM; 24 = 12AM). Values above 24 correspond to the next waking day (25 = 1AM, 30 = 6AM). Extreme values winsorized to = 50. Linear R^2 = .21 Quadratic R^2 = .22.

APPENDIX D

IRB PROTOCOL APPROVAL

APPROVAL:CONTINUATION

Leah Doane
CLAS-NS: Psychology
480/965-5289
Leah.Doane@asu.edu

Dear Leah Doane:

On 2/16/2021 the ASU IRB reviewed the following protocol:

Type of Review:	Modification and Continuing Review
Title:	Transiciones: Supporting Latinos during the Transition to College
Investigator:	Leah Doane
IRB ID:	STUDY00002676
Category of review:	
Funding:	Name: William T. Grant Foundation, Grant Office ID: Not yet assigned, Funding Source ID: Grant# 188935; Name: William T. Grant Foundation, Grant Office ID: MGS0430, Funding Source ID: Grant #184370
Grant Title:	None
Grant ID:	None
Documents Reviewed:	None

The IRB approved the protocol from 2/16/2021 to 2/15/2024 inclusive. Three weeks before 2/15/2024 you are to submit a completed Continuing Review application and required attachments to request continuing approval or closure.

If continuing review approval is not granted before the expiration date of 2/15/2024 approval of this protocol expires on that date. When consent is appropriate, you must use final, watermarked versions available under the “Documents” tab in ERA-IRB.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,