Ethnic-Racial discrimination experiences predict Latinx adolescents' physiological stress processes across college transition

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Summary

Consistent with conceptual frameworks of ethnic-race-based stress responses, and empirical evidence for the detrimental effects of ethnic-racial discrimination, the current study hypothesized that experiencing more frequent ethnic-racial discrimination during adolescence would predict differences in physiological responses to psychosocial stress across the college transition. U.S. Latinx adolescents (N = 84; M_{age} = 18.56; SD = 0.35; 63.1% female; 85.7% Mexican descent) completed survey measures of ethnic-racial discrimination during their final year of high school and first college semester (~5 months later), as well as a standard psychosocial stressor task during their first college semester. Repeated blood pressure and salivary cortisol measures were recorded to assess cardiovascular and neuroendocrine activity at baseline and stress reactivity and recovery. Data were analyzed using multilevel growth models. Experiencing more frequent ethnic-racial discrimination in high school, specifically from adults, predicted higher baseline physiological stress levels and lower reactivity to psychosocial stress during the first college semester, evidenced by both blood pressure and cortisol measures. Experiencing ethnic-racial discrimination from peers in high school also predicted higher baseline blood pressure in college, but not stress reactivity indices. Results were consistent when controlling for concurrent reports of ethnic-racial discrimination, gender, parents' education level, body mass index, oral contraceptive use, time between longitudinal assessments, depressive symptoms, and general perceived stress. Experiencing frequent ethnic-racial discrimination during adolescence may lead to overburdening stress response systems, indexed by lower cardiovascular and neuroendocrine stress reactivity. Multiple physiological stress systems are sensitive to the consequences of ethnic-racial discrimination among Latinx adolescents transitioning to college.

Keywords: ethnic-racial discrimination, stress reactivity, cortisol, cardiovascular, Latinx, adolescents

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1. Introduction

Experiencing unfair treatment based on one's ethnicity or race (i.e., ethnic-racial[1] discrimination; ERD) is a robust risk factor related to significant adverse health consequences (Paradies et al., 2015). ERD during adolescence may have especially detrimental and lasting effects on later health (Adam et al., 2015; Cuevas et al., 2019). In national epidemiological studies in the United States (U.S.), approximately 65% to 98% of Latinx[2] adults reported experiencing ERD in their lifetime (Arellano-Morales et al., 2015). Prevalence estimates from multiple school- and community-based studies of Latinx adolescents in the U.S. Southwest, a region with significant Latinx population growth, indicate that approximately 58% to 69% of Latinx youth aged 16-21 experience ERD, with prevalence rates significantly higher for certain groups (e.g., 86% to 94% of Latino boys aged 19-21; Zeiders et al., 2020). Given the overall prevalence and variability of ERD experiences in the lives of Latinx youth, further research is needed to better address the physiological mechanisms by which ERD negatively affects health and contributes to the persistence of ethnic-racial disparities (Neblett, 2019). Studies that have examined ERD in relation to physiological stress processes among Latinx youth are relatively scarce (Cuevas et al., 2019; Lewis et al., 2015). This underrepresentation is important to address because 1 in 4 U.S. public school students is currently Latinx, and Latinx individuals will comprise 30% of the U.S. population by 2060 (Colby and Ortman, 2014). In the current study, we extended prior research to test whether Latinx adolescents' ERD experiences reported in the final year of high school predicted cardiovascular and neuroendocrine stress responses later during their first college semester, controlling for concurrent ERD measures.

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[1] Following prior studies (Benner et al., 2018; Lewis et al., 2015), we use the term "ethnic-racial" to refer to ethnic/cultural heritage and/or membership in a socially constructed racial group in U.S. society, recognizing important conceptual distinctions between "ethnicity" and "race" and also variability in the extent to which youth make distinctions between these concepts regarding their lived experiences.

[2] We use the term "Latinx" to be inclusive of sexual orientation and gender identity/expression diversity among individuals living in the U.S. with Latin American or Spanish heritage, recognizing the diversity of ethnic-racial identification labels that Latinx individuals choose for themselves.

According to conceptual frameworks of ethnic-race-based stress, the ongoing nature of many ERD experiences can produce a chronic state of psychological stress, which in turn places burden on stress response systems involved in maintaining physiological homeostasis (Brondolo et al., 2009). Changes in cardiovascular and neuroendocrine responses have been proposed as mechanisms through which ethnic-race-based stress impacts health over time (Busse et al., 2017a; Panza et al., 2019). Both hyperresponsive and hyporesponsive physiological reactivity to laboratory-based stress tasks predict adverse health outcomes, such as cardiovascular disease risk and depression (Phillips et al., 2013). Extant studies testing ERD as a predictor of physiological stress processes have been limited by cross-sectional designs, almost exclusive focus on adult samples, consideration of a single biomarker, and limited attention to variability among ethnic-racial groups (Busse et al., 2017a; Gee et al., 2012; Lewis et al., 2015; Ong et al., 2018). The current study addressed these limitations by measuring Latinx adolescents' ERD experiences on two occasions across their transition to college as predictors of psychosocial stress reactivity of cardiovascular and neuroendocrine processes.

The autonomic nervous system (ANS) responds to stressors rapidly in the face of physical and psychosocial threats, most commonly indexed by acute increases in blood pressure at stressor onset (Goyal et al., 2008). Mounting evidence points to ERD as a contributor to ethnic-racial disparities in cardiovascular disease risk via both higher and lower stress response output (e.g., Lockwood et al., 2018). Prior studies involving experimental manipulations of ethnic-race-based stress with Latinx college students have resulted in mixed findings. For example, being exposed to a White individual with racially prejudiced attitudes increased Latinx students' blood pressure (Sawyer et al., 2012), whereas overhearing racist comments did not increase Latinx students' blood pressure (Huynh et al., 2017). General discrimination (not specific to ethnicity-race) was positively associated with resting systolic and diastolic blood pressure in a sample of African American adolescents (Goosby et al., 2015), and ERD has been positively associated with ambulatory blood pressure in studies of Latinx adults (Beatty Moody et al., 2016; McClure et al., 2010). Consistent with a lifecourse perspective on the health effects of discrimination (Gee et al., 2012), there is a need to investigate the stress-health pathways of ERD on adolescents' cardiovascular stress responses over time.

Psychological stressors that involve social evaluation and lack of control (i.e., ERD) consistently activate the hypothalamic-pituitary-adrenal (HPA) axis stress response in adolescents and adults, commonly measured with salivary cortisol (Dickerson and Kemeny, 2004). Salivary cortisol levels typically peak approximately 20-40 minutes after stressor onset (i.e., reactivity) and return to baseline up to an hour later (i.e., recovery). Studies of youth and adults have identified links between both elevated and "blunted" (i.e., lower than average) cortisol stress reactivity with indicators of poor mental and physical health (see Phillips et al., 2013, for review). Differing physiological patterns may be attributable to chronicity and type of discriminatory stress (Korous et al., 2017). For example, laboratory studies have revealed that discrete ERD experiences, such as interacting with a racially prejudiced interviewer (Townsend et al., 2014) and overhearing racist comments (Huynh et al., 2017) increased cortisol reactivity for Latinx college students. Survey measures of general discrimination (not specific to ethnicity-race) have also been positively associated with cortisol reactivity in Latinx young adults (Busse et al., 2017b). However, a less stress-responsive, relatively *lower* pattern of cortisol reactivity has emerged in relation to more frequent everyday exposure to discrimination in studies of Mexican American adolescents (Kim et al., 2018) and African American adults (e.g., Richman and Jonassaint, 2008). In order to understand mixed findings, a recent review by Busse and colleagues (2017a) identified that studies that induced relatively acute discrimination found more pronounced cortisol reactivity (e.g., Townsend et al., 2014), whereas participants who reported a more robust history of past discrimination experiences over time were more likely to demonstrate reduced responses to standardized lab stressors when compared to individuals who experienced less discrimination (e.g., Richman and Jonassaint, 2008). These relatively lower response levels may reflect a pattern of attenuation due to chronic or toxic stress (Joos et al., 2019; Susman, 2006; Trickett et al., 2010), whereby individuals who have experienced chronic stress (i.e., greater discrimination over time) adapt to prolonged activation of the HPA axis through subsequent downregulation, resulting in a period of hyposecretion and reduced cortisol reactivity to decrease potential allostatic load (Miller et al., 2007).

1.1 The Current Study – Advancing Research on Ethnic-Racial Discrimination and Physiological Stress in Developmental Context

An examination of ERD and stress processes during adolescence is critical for several reasons. First, adolescence is considered a sensitive developmental period during which ethnic-racial disparities in health take root and persist across the lifespan (Sanders-Phillips et al., 2009). By late adolescence, youth have developed cognitive awareness of unfair treatment and begin to navigate identity processes that set the foundation for subsequent anticipation and experiences of ERD (Quintana and McKown, 2008). Moreover, as adolescents transition into college they encounter a novel social context characterized by changes to familial and peer relationships that are often accompanied by elevated stress (Kerr et al., 2004). Studies of Black youth have shown that ERD in adolescence was associated with altered stress processes later in adulthood (Adam et al., 2015; Brody et al., 2014). However, ERD-related changes in stress processes have not been examined among Latinx adolescents transitioning from high school to college contexts.

A recent meta-analysis on the effects of ERD during adolescence showed that most studies (78%) used a general or overall measure of discrimination (Benner et al., 2018). Researchers have begun to emphasize the value of examining multiple sources of ERD and their differential associations with health and adjustment outcomes (Hughes et al., 2016). For example, longitudinal evidence indicates that discrimination from adults is more consequential for youth's academic outcomes, and discrimination from peers is more strongly related to aspects of well-being like depression and physical health symptoms (Del Toro and Hughes, 2019; Huynh and Fuligni, 2012). It is likely that these differential patterns reflect the importance of adults for determining students' coursework and grades, whereas peers provide social support, feedback, and identity affirmation that are important for adolescent well-being (Benner and Graham, 2013). Nonetheless, only a few college transition studies have included measurement of both ERD from peers in school and adults to unpack contextual variability in the effects of ERD on outcomes (e.g., Del Toro and Hughes, 2019; Huynh and Fuligni, 2012; Witkow et al., 2015), and none to date have examined whether distinct sources of ERD are differentially related to markers of physiological stress.

In the current study, Latinx adolescents reported on their ERD experiences from adults and peers in school prior to college, which we examined as predictors of physiological responses to psychosocial stress several months later during their first college semester. This study expands upon extant research in several novel ways to advance a developmental and contextual approach for investigating the physiological underpinnings of ethnic-race-based stress. First, few lab-based physiological stress studies have attended to the developmental period of adolescence and the transition to adulthood, which is a sensitive period during which youth of color perceive ERD experiences with increasing frequency as they grow in cognitive maturity to recognize unfair treatment and navigate shifts in social settings that heighten the frequency of encountering ERD from others (Benner, 2017; Umaña-Taylor, 2016). Second, as recent reviews of the literature have indicated (Busse et al., 2017; Korous et al., 2017; Ong et al., 2018; Panza et al., 2019), Latinx youth remain substantially underrepresented in physiological stress research relative to Black and White adults, particularly with respect to within-group study designs that allow for examination of variability within diverse groups of Latinx adolescents (exceptions included in the literature review, above). Third, following recent calls in the literature (Ong et al., 2018), our design was particularly novel because we recruited participants prior to the college transition to assess ERD with temporal precedence before a standardized lab-based stressor and with attention to developmental and contextual changes in ERD with two measurement occasions (i.e., pre-college and first college semester). Furthermore, in line with conceptual and empirical advances in ERD research from developmental and culturally informed perspectives (Benner, 2017; Benner et al., 2018), we assessed ERD from both peer and adult sources, an important innovation not yet investigated in physiological stress studies that have tended to rely on overall summary measures of ERD or general perceived discrimination without specific attention to ethnicity and race (see Ong et al., 2018, for review). Finally, in the current study we also joined recent efforts to advance the consideration of multiple physiological stress markers (i.e., blood pressure, cortisol), which we measured repeatedly during an experimental lab-based stress design and modeled using longitudinal growth trajectories to account for baseline levels and stress reactivity and recovery.

Based on ethnic-race-based models of stress (Brondolo et al., 2009) and the well-documented detrimental impact of ERD on developmental adjustment and health (Gee et al., 2012; Umaña-Taylor, 2016), we hypothesized that experiencing more frequent ERD reported in the final year of high school (compared to less frequent) would predict differences in physiological stress responses in the first college semester. Given prior mixed evidence and limited studies that have tested this question with Latinx adolescents (Busse et al., 2017a; Panza et al., 2019), we did not form *a priori* expectations for whether ERD would predict higher or lower stress reactivity patterns. Further, in line with research documenting differential associations between ERD and youth adjustment outcomes by discrimination source (Benner et al., 2018), we explored ERD from both peers in school and from adults.

2. Method

2.1 Participants

Participants were recruited from a larger longitudinal study of Latinx adolescents from over 90 different high schools who were admitted to a large university in the southwestern U.S. (see Doane et al., 2018). Sample size for the current study was determined based on prior studies (Busse et al., 2017) and review of meta-analysis on comparable stress tasks (Dickerson and Kemeny, 2004). Of 85 recruited participants for this study, one opted out of stress measures and was not included in analyses ($N = 84$; $M_{age} = 18.56$; $SD = 0.35$; 63.1% female, 36.9% male). The majority of participants (85.7%) were Mexican descent, 2nd generation regarding immigration (i.e., had at least one parent born outside the U.S.; 64.3%), and first-generation college students (i.e., neither parent completed bachelor's degree; 65.5%; see Sladek et al., 2020, for additional demographic details).

2.2 Procedure

The university Institutional Review Board approved all procedures. Participants completed online questionnaires, including demographic information and a survey measure of ethnic-racial discrimination (ERD), during senior year of high school or the following summer (T1) and first college semester (T2).

Laboratory study procedures took place during participants' first college semester (T2) in the afternoon following standard practice to account for diurnal cortisol patterning (Dickerson and Kemeny, 2004). Participants were instructed to avoid exercising, eating, or drinking besides water in the hour prior to the study. An experimenter obtained written consent and allowed participants to adjust to the room for 15 min before collecting baseline measures.

After baseline measures, participants completed a modified version of the Trier Social Stress Test (TSST; Kirschbaum et al., 1993). The TSST was selected to introduce a socially evaluative psychosocial stressor that consistently activates physiological stress processes (Goodman et al., 2017) and has external validity for the types of routine stressors college students face (Sladek et al., 2020). Based on pilot testing, modifications to the standard TSST protocol included asking participants to prepare a 5-min speech about why they are uniquely qualified for a university student award. Participants were informed they would give this speech in front of student experts who would video record their performance, and they could receive a $10 bonus if positively evaluated. After watching a brief video as part of an experimental manipulation that was not related to the aims of the current study and a 5-min preparation period, the experimenter left the room and expert judges entered (i.e., one female and one male research assistant). Judges were trained in conducting the TSST, which includes maintaining neutral facial expressions regardless of participants' performance. The team of judges in this study reflected the ethnic-racial composition of the university setting (~23% Latinx). Following the 5-min speech, participants completed a 5-min attention task on a computer to introduce a cognitive challenge to the social evaluation that was not conflated with math ability.

Blood pressure measures were recorded on three occasions: baseline, immediately post-task, and 5-min post task. Saliva samples were collected on five occasions: baseline, immediately post-task, and 15-, 30-, and 45-min post-task. This sampling timeline followed standard practice to capture physiological reactivity and recovery patterns consistent with typical cardiovascular (Figure 1a) and HPA responses (Figure 1b), respectively. In the post-task period, participants completed additional questionnaires and the experimenter measured participants' height and weight. After measures were completed, participants were thoroughly debriefed regarding the study design. Participants received $25 for completing each questionnaire at T1 and T2, and $35 (including $10 bonus) for T2 lab procedures.

2.3 Measures

2.3.1 Mean arterial blood pressure. The experimenter measured participants' arm circumference to fit the appropriate cuff size and recorded blood pressure using a Dash 3000 patient monitor (GE Healthcare). Following prior laboratory stress studies to reduce Type I error inflation for multiple significance tests (e.g., Major et al., 2012; Shalev et al., 2009; see Panza et al., 2019, for review), this study used mean arterial blood pressure (MAP) in mmHg as the focal cardiovascular outcome (MAP = 1/3(Systolic Blood Pressure) + 2/3(Diastolic Blood Pressure). Similar to other studies of Latinx youth (e.g., Huynh et al., 2017), the average of two recordings was calculated at each measurement occasion to represent baseline, post-task, and 5-min post-task blood pressure. There were no statistical outliers (+/-3 *SD*s from mean).

2.3.2 Salivary cortisol. Saliva was collected via passive drool and stored at -80C. Samples were sent by courier on dry ice over no more than 3 days to Biochemisches Labor at the University of Trier in Germany for assay. Samples were assayed for cortisol in duplicate using a competitive solid phase time-resolved fluorescence immunoassay with fluorometric endpoint detection (DELFIA; 42). The inter-assay (7.1% to 9.0%) and intra-assay (4.0% to 6.7%) coefficients of variation were acceptable. Cortisol values (nmol/L) were natural log transformed due to positive skew; no values were windsorized. Results were consistent with and without including sample outliers from one participant (>3 *SD*s from mean); thus, these data were retained in analyses.

2.3.3 Ethnic-racial discrimination (ERD). Participants' perceptions of how often they experienced ERD were assessed at T1 and T2 (Way, 1997), including how often participants were treated unfairly due to their race or ethnicity by peers in school (7 items; e.g., "How often do you feel that students at your school treat you unfairly because of your race or ethnicity?") and by adults (7 items; e.g., "How often do you feel that adults treat you with less respect because of your race or ethnicity?") using a fully-anchored response scale from 1 (*never*) to 5 (*all the time*). Prior studies of Latinx adolescents have demonstrated support for reliability and validity (e.g., Niwa et al., 2014). Following prior studies (Niwa et al., 2014), ERD from peers (T1 α = .92; T2 α = .91) and adults (T1 α = .94; T2 α = .95) were used as separate predictors.

2.3.4 Covariates. Based on prior studies (e.g., Beatty Moody et al., 2016; Foley and Kirschbaum, 2010), participant's gender (1 = male; 0 = female), body mass index (BMI), and parents' education levels were included as control variables in models for cardiovascular stress responses, and gender, time since waking (in hours), and oral contraceptive use (1 = using, *n* = 6; 0 = not using) were included as control variables in models for HPA stress responses. In addition, an experimental manipulation involving random assignment to different video viewing conditions that was not a focus of the current analyses was also included as a control variable in all models (Sladek et al., 2020). Additional covariates were considered, though they were not significantly correlated with outcomes and thus not included in final models (see Table 1), including concurrent (T2) depressive symptoms (CES-D scale; Radloff, 1977), number of days between T1 and T2, T1 general perceived stress (Perceived Stress Scale; Cohen and Williamson, 1991), and corticosteroid medication use (*n* = 10).

2.4 Analytic Strategy

Two-level longitudinal growth models were used to estimate baseline (i.e., pre-task) physiological stress levels and change trajectories (i.e., slopes) of MAP and cortisol, nested within individuals. This modeling strategy was selected to: (a) improve statistical power compared to change score analysis; (b) account for several features of stress responsivity in the same model to reduce Type I error, including mean levels, reactivity, and recovery; and (c) model average patterns (i.e., fixed effects) and individual differences in those patterns (i.e., random effects; Ram and Grimm, 2007). Following standard practice (Grimm et al., 2017; Snijders and Bosker, 2012), multilevel model building proceeded as follows: (a) visually plotting the data to determine average change patterns (Figure 1a and Figure 1b); (b) fitting unconditional random-intercept models with no predictors to partition within-person (Level 1) and between-person (Level 2) variance and examine intraclass correlations; (c) fitting random-intercept models with growth parameters (e.g., linear change over time) and conducting nested model comparisons to support adequate fit to the data; (d) testing random-slope models (i.e., between-person variance in within-person change process) using likelihood ratio chi-square difference tests; (e) introducing focal predictors (i.e., ERD) and covariates. Three MAP measurements were modeled using a linear growth model (Figure 1a). Five cortisol measurements were modeled using a bilinear spline growth model; the spline knot point was set at the modal transition between increasing and decreasing cortisol (i.e., 15-min post-task; Figure 1b; e.g., Bendezú and Wadsworth, 2017). At Level 1, reactivity was modeled with a linear growth parameter reflecting "time until post-task," and recovery was modeled with a linear growth parameter reflecting "time since post-task," in minutes centered at baseline. At Level 2, ERD (grand mean centered) was entered as a person-level predictor of baseline stress levels (i.e., intercepts) and stress response trajectories (i.e., slopes). Finally, covariates were added at Level 2. Models were fit in M*plus* version 8.4 (Muthén and Muthén, 2017) using maximum likelihood estimation with robust standard errors.

3. Results

See Table 1 for descriptive statistics and bivariate correlations. At T1, the majority of participants reported experiencing at least one form of ERD from peers at their school (63.1%) and from adults (64.3%). Regarding the most frequently endorsed ERD, participants reported that adults treated them like they are not smart (51.2%) and not as good as them (51.2%) because of their race or ethnicity. On average, ERD from peers at school significantly decreased from T1 ($M = 1.56$; $SD = 0.65$) to T2 ($M = 1.36$; $SD = 0.59$), $t(83) = 2.53$, $p = .013$. Though ERD from adults also decreased on average from T1 ($M = 1.67$; $SD = 0.76$) to T2 ($M = 1.52$; 0.76), this change was not statistically significant, $t(83) = 1.77$, $p = .081$.

3.1 Cardiovascular Stress Responses

On average, MAP significantly increased from baseline to post-task (i.e., reactivity; Table 2; Figure 1a). This linear growth model fit the data significantly better than an unconditional model that posits no changes, $\chi^2(1) = 39.218$, $p < .001$. T1 ERD from adults significantly positively predicted T2 baseline MAP and less positive (i.e., reduced) MAP reactivity to the stress task, adjusting for T2 ERD from adults, gender, BMI, parents' education, and experimental condition (Table 2). Probing simple slopes for the significant cross-level interaction (time x ERD) indicated that the estimated rate of MAP increase was less positive for participants who experienced more T1 ERD from adults (+1 *SD*), $b = 0.076$, $p = .020$, compared to participants who experienced less T1 ERD from adults (-1 *SD*), $b = 0.160$, $p < .001$ (Figure 2a). T1 ERD from peers also significantly positively predicted T2 baseline MAP, but not T2 MAP reactivity (Table 2). Results for systolic and diastolic blood pressure outcomes are available in the online supplementary materials.

3.2 HPA Axis Stress Responses

On average, cortisol significantly increased from baseline to post-task (i.e., reactivity), and significantly decreased 30 min thereafter (i.e., recovery; Table 3; Figure 1b). This bilinear spline model fit the data significantly better than an unconditional model that posits no changes, $\chi^2(2) = 101.38$, $p < .001$. There were significant between-person differences in cortisol reactivity (i.e., random slope model), $\chi^2(2) = 150.90$, $p < .001$, but not in cortisol recovery, $\chi^2(2) = 0.59$, $p = .745$; thus, analyses focused on predicting differences in cortisol at baseline and reactivity slopes. T1 ERD from adults positively predicted T2 baseline cortisol ($p = .053$) and significantly predicted less positive (i.e., reduced) cortisol reactivity to the stress task, adjusting for T2 ERD from adults, gender, time since waking, oral contraceptive use, and experimental condition (Table 3). Probing simple slopes indicated that the estimated rate of cortisol increase was less positive for participants who experienced more T1 ERD from adults (+1 *SD*), $b = 0.006$, $p = .014$, compared to participants who experienced less T1 ERD from adults (-1 *SD*), $b = 0.012$, $p < .001$ (Figure 2b). In contrast, T1 ERD from peers was not significantly associated with T2 baseline cortisol, or cortisol reactivity (Table 3).

3.3. Sensitivity Analyses

Given significant bivariate correlations between T1 ERD and T1 perceived stress and T2 depressive symptoms, as well as the variability in time between T1 and T2 assessments (Table 1), we conducted sensitivity analyses with these additional control variables included. Primary results from these alternative models remained statistically significant when adjusting for these additional covariates. Recent studies have used a novel method of calculating cortisol parameters (Miller et al., 2018). We have included alternative analyses using this method as part of the online supplementary materials.

4. Discussion

Many Latinx adolescents are routinely faced with ethnic-racial discrimination (ERD) from a variety of sources, including peers in school and adults, and the frequency with which youth experience ERD is a mounting public health concern (Neblett, 2019). Consistent with prior studies documenting the prevalence of ERD for Latinx adolescents in the U.S. Southwest (Zeiders et al., 2020), the majority of participants in this study of Latinx adolescents transitioning to college endorsed being treated unfairly based on their ethnic-racial background by their peers and adults. Conceptual frameworks regarding the consequences of ethnic-race-based stress identify changes in physiological stress processes as key biobehavioral mechanisms underlying the link between ERD and health, particularly during adolescence and young adulthood (Gee et al., 2012; Paradies et al., 2015). Prior studies of Black youth have provided evidence for this stress-health pathway, showing that repeated ERD exposure during adolescence, specifically, predicted heightened allostatic load (e.g., resting blood pressure, nighttime cortisol) indicative of cumulative health risk by age 20 (Brody et al., 2014) and overall lower diurnal cortisol levels indicative of chronic stress burden by age 32 (Adam et al., 2015). The current study took important steps by testing this theorized model in a sample of Latinx adolescents transitioning to college, including ERD measures on two occasions (pre- and post-transition) and two indices of physiological stress in response to a standard psychosocial stressor (post-transition). Results demonstrated that experiencing more frequent ERD from adults prior to college predicted lower reactivity to psychosocial stress during the first college semester (i.e., approximately 5 months later), controlling for concurrent ERD reports in college. The pattern of these results was supported by blood pressure and cortisol measures, indexing cardiovascular and neuroendocrine processes, respectively.

Experiencing more frequent ERD from adults likely serves as a source of chronic stress for Latinx adolescents, which places burden on the body's stress response systems, including cardiovascular and neuroendocrine processes (Brondolo et al., 2009). Findings from the current study were in line with recent reviews (Busse et al., 2017; Panza et al., 2019), pointing to a relatively lower or hyporesponsive stress response profile for Latinx adolescents in college who experienced more frequent ERD from adults during their time in high school. Reduced stress reactivity, contrasted with a hyperresponsive or more elevated set of responses “in the moment” as discrimination occurs, may reflect a cumulative burden on physiological systems that are tasked with maintaining homeostasis when under repeated threat (Miller et al., 2007; Pascoe and Richman, 2009; Susman, 2006). Lower reactivity to psychosocial stress has been linked with early life stress and trauma (e.g., Joos et al., 2019), and this attenuated biological profile that results from downregulation of multiple physiological stress systems can serve as a risk marker for later health problems (Chida and Steptoe, 2010; Turner et al., 2020). On the other hand, it is also possible that the reduced acute reactivity to a lab-based stressor observed in our study for youth who have experienced more frequent ERD reflects positive adaptation as physiological systems calibrate to meet social demands (Shirtcliff et al., 2014). Importantly, cardiovascular and HPA axis reactivity rates were significantly positive even for youth reporting more frequent ERD in our sample (albeit less positive than youth reporting less frequent ERD), suggesting the variation observed in our sample of Latinx adolescents falls within a generally adaptive range of stress responses to the demands of a deliberately stressful challenge task.

In prior studies of Latinx college students, discrete discriminatory experiences simulated in the lab setting have either not impacted (Huynh et al., 2017) or increased (Sawyer et al., 2012) cardiovascular reactivity to psychosocial stress. The current study, which found that individual differences in ERD predicted *lower* cardiovascular reactivity, differed from these prior studies in several ways, including our focus on assessing self-reported ERD among adolescents months before their physiological assessment in college (controlling for concurrent ERD reports). Thus, these findings help to extend understanding of *how* and potentially *for how long* discrimination can shape cardiovascular responses to stress in college. Results from the current study complement reviews of the literature showing that adults who have experienced chronic discrimination (assessed via retrospective surveys) tend to exhibit reduced reactivity over time compared to adults who have not experienced the same degree of discrimination (Brondolo et al., 2009; Panza et al., 2019; Pascoe and Richman, 2009).

Regarding neuroendocrine stress processes, results from the current study were in line with prior studies of Mexican American adolescents (Kim et al., 2018) and African American adults (Richman and Jonassaint, 2008), demonstrating that more frequent ERD predicted reduced cortisol stress reactivity several months later across the college transition. Dysregulation of the HPA axis feedback loop that aids in regulation of the body's stress response may result from exposure to chronic stress (Miller et al., 2007; Susman, 2006), such as a more prolonged history of discrimination prior to the college transition. Some prior studies of Latinx college students have found support for an opposite direction of effects, showing that discrete discriminatory experiences in the lab setting (Huynh et al., 2017) and a survey of general discrimination (Busse et al., 2017b) have been associated with higher cortisol stress responses. In a recent review, Busse and colleagues (2017a) suggested that experimentally inducing discrimination in a lab setting produces higher cortisol responses (i.e., stronger HPA axis response activated to acute socially-evaluative threat), whereas comparing individuals with and without prior experiences of discrimination reveals an association between chronic exposure to discrimination and lower cortisol responses. The current study differed from several prior studies by simultaneously modeling multiple time-sensitive aspects of the stress response profile (e.g., baseline, reactivity, recovery) using longitudinal growth modeling, compared to an overall summary index of hormonal output (see Miller et al., 2018), and by measuring ERD longitudinally on two occasions, compared to strictly concurrent measures of general discrimination (i.e., not specific to ethnicity-race). Furthermore, only one of the studies included in this recent review comprised a Latinx sample and measured discrimination specific to ethnic-racial group membership. Thus, findings from this study offer important novel evidence that experiencing ERD from adults prior to the college transition contributes to relatively lower cortisol responses to psychosocial stress up to several months later in the college setting, as compared to youth who experience less ERD from adults.

Future studies are needed to continue examining the conditions and contexts in which ERD impacts stress reactivity and health for Latinx adolescents and other youth of color. In line with previous research (e.g., Adam et al., 2015), findings from the current study point to adolescence as a critical period during which the experiences of being treated unfairly due to one's ethnic-racial background take a physiological toll later on. Furthermore, following advances in the study of ERD and its developmental impacts (e.g., Del Toro and Hughes, 2019; Niwa et al., 2014), differentiating between typical social contexts of ERD experiences in this study provided preliminary evidence that there may be more substantial physiological stress consequences for Latinx adolescents who face discrimination perpetrated by adults prior to the college transition. On average, the frequency of ERD experiences from peers decreased from high school to college in this sample, whereas ERD experiences from adults did not significantly change across this transition. More research is needed to address features of change and continuity in Latinx adolescents' lived experiences in school and neighborhood contexts in relation to physiological stress processes across developmental transitions.

The current study was not without limitations. The generalizability of the findings is unknown, pending replication. This sample comprised Latinx adolescents (mostly of Mexican descent) who enrolled in a public university in the southwestern U.S., and the sample size precluded tests of variability within the diverse Latinx population. In this study it was not possible to investigate potential stress reactivity differences by ethnic-racial group membership of the judges who evaluated participants during the stress task due to team-level diversity that mirrored the composition of the university, which is an important consideration for future ERD and stress reactivity research. The longitudinal ERD measures in this study spanned, on average, approximately 5 months across the high school to college transition period. Thus, future studies are needed to clarify how the timing and chronicity of ERD experiences play a role in physiological stress changes over shorter and longer timeframes (e.g., Adam et al., 2015). Though the study was strengthened by repeated measures of ERD across time (a rarity in physiological stress studies), conclusions regarding directionality are still limited due to lack of T1 stress reactivity measures. The current study was limited by only three blood pressure assessments (baseline, post-stressor, and 5-min post-stressor) that did not allow us to examine more detailed stress reactivity and recovery. Adding measurement timepoints may reveal additional variability in cardiovascular stress response patterns, such as more continuous measures of blood pressure (Goyal et al., 2008). Finally, future research is needed to investigate the mediational process through which ERD during adolescence may affect later health and adjustment via multiple, interconnected stress-sensitive physiological systems (e.g., immune function, allostatic load; Doane et al., 2018).

5. Conclusions

Over half of this sample of Latinx adolescents reported experiencing discrimination based on their ethnic-racial background from peers in school and from adults. Experiencing ERD prior to the college transition, particularly from adults, has implications for Latinx adolescents' physiological stress processes as they adapt to novel demands in the college context. Findings from this study demonstrated evidence for both cardiovascular and neuroendocrine stress pathways, joining recent efforts to articulate the mechanisms through which discrimination negatively affects health and well-being for members of minoritized ethnic-racial groups. These results point to the need for future research into protective factors that may mitigate this risk, such as the strengths that youth of color routinely draw on to navigate and cope with discrimination experiences (e.g., Neblett et al., 2012). For example, the impacts of ERD on physiological stress has varied by social support (Brody et al., 2014) and ethnic-racial identity (i.e., the attitudes/beliefs individuals hold about their ethnic-racial group membership; Lucas et al., 2017) in studies of African American adolescents and adults. Joining prior evidence, this study points to adolescence as an important developmental period in which to support and leverage these protective resources as part of larger efforts to reduce ethnic-racial health disparities.

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Table 1

Bivariate Correlations and Descriptive Statistics

	1	2	3	4	5	6	7	8	9	10	11	12	13	*M* (*SD*)	Range
1. Baseline mean arterial blood pressure	--													75.85 (7.61)	56.00 – 95.00
2. Baseline cortisol	.30*	--												1.28 (0.52)	0.18 – 2.58
3. T1 Ethnic-racial discrimination - Peers	.20†	.06	--											1.56 (0.65)	1.00 – 3.29
4. T2 Ethnic-racial discrimination - Peers	.05	-.03	.31*	--										1.35 (0.59)	1.00 – 3.71
5. T1 Ethnic-racial discrimination - Adults	.29*	.18†	.69*	.45*	--									1.67 (0.76)	1.00 – 4.00
6. T2 Ethnic-racial discrimination - Adults	.15	.01	.32*	.69*	.50*	--								1.52 (0.76)	1.00 – 5.00
7. Gender (1 = male)	.10	.08	-.17	-.19†	-.15	-.22*	--							0.37[a]	
8. Parent education	-.20†	.01	.004	-.10	-.11	-.15	.01	--						3.97 (2.61)	1.00 – 9.00
9. Body mass index	.34*	.04	.09	.04	.15	.08	-.16	-.09	--					27.01 (6.49)	14.49 – 47.84
10. Time since waking	.04	-.23*	-.07	.05	-.10	-.04	.03	-.21†	.12	--				7.08 (2.09)	1.70 – 13.03
11. Oral contraceptive use	-.11	-.27*	.18	-.03	.08	.10	-.21†	.05	.06	.03	--			0.07[a]	
12. Depressive symptoms	.06	.08	.16	.39*	.28*	.48*	-.20†	-.16	.05	-.11	.02	--		17.13 (8.90)	0.00 – 51.00
13. Days between T1 and T2	-.07	-.04	-.11	-.07	-.11	-.05	-.01	.02	-.04	-.03	-.02	-.03	--	167.71 (36.02)	85 – 288
14. T1 Perceived stress	-.01	.00001	.15	.18†	.29*	.35*	-.38*	-.09	.07	-.08	.19†	.46*	.04	2.90 (0.69)	1.00 – 5.00

Note. $N = 84$. T1 = high school senior year. T2 = first college semester. All measures from T2, unless otherwise indicated. Baseline = after 15 min acclimation period, prior to stress task. Mean arterial blood pressure (MAP; mmHg) = 1/3(Systolic Blood Pressure) + 2/3(Diastolic Blood Pressure). Cortisol concentration (nmol/L) natural log transformed. Parent education = average of mother's and father's: 1 = less than high school, 10 = doctorate or advanced degree. Oral contraceptive use (1 = yes, 0 = no). †$p < .10$. *$p < .05$.

[a]Proportion of sample.

Table 2

Multilevel Growth Models of Cardiovascular Stress Responses by Ethnic-Racial Discrimination

	From Adults			From Peers in School		
Fixed Effects	Est.	*SE*	*p*	Est.	*SE*	*p*
Intercept (baseline MAP), b_0	74.304*	0.971	<.001	74.383*	0.995	<.001
T1 Ethnic-racial discrimination, β_{01}	2.356*	1.058	.026	2.450*	1.129	.030
T2 Ethnic-racial discrimination, β_{02}	0.491	1.153	.671	-0.060	1.101	.957
Gender, β_{03}	3.243*	1.588	.041	3.094†	1.618	.056
Body mass index, β_{04}	0.394*	0.086	<.001	0.407*	0.087	<.001
Parent education, β_{05}	-0.383	0.307	.212	-0.457	0.297	.124
Experimental condition, β_{06}	1.318	1.315	.317	1.275	1.361	.349
Reactivity (time), b_1	0.118*	0.017	<.001	0.119*	0.017	<.001
T1 Ethnic-racial discrimination, β_{11}	-0.055*	0.028	.049	-0.044	0.037	.236
T2 Ethnic-racial discrimination, β_{12}	-0.003	0.025	.904	-0.018	0.025	.458
Random Effects	Est.	*SE*	*p*	Est.	*SE*	*p*
L1 Residual variance	17.807*	2.881	<.001	18.013*	2.942	<.001
L2 Intercept variance	27.747*	8.189	<.001	28.711*	8.424	.001
L2 Linear slope variance	0.003	0.007	.677	0.003	0.007	.649
L2 Intercept-Slope covariance	0.165	0.176	.350	0.146	0.182	.423

Note. N = 252 blood pressure assessments (each an average of two recordings) nested within 84 participants. Mean arterial blood pressure (MAP; mmHg) = 1/3(Systolic Blood Pressure) + 2/3(Diastolic Blood Pressure). Time scaled in minutes (e.g., reactivity, b_1, indicates estimated average rate of increase per minute). Gender: 1 = male, 0 = female. Parent education: average of mother and father education level. Experimental condition: see Sladek et al., 2020, for details. Est. = regression coefficient estimate (unstandardized). *SE* = robust standard error.
†$p < .10$. *$p < .05$.

Table 3

Multilevel Growth Models of Cortisol Stress Responses by Ethnic-Racial Discrimination

	From Adults			From Peers in School		
Fixed Effects	Est.	*SE*	*p*	Est.	*SE*	*p*
Intercept (baseline cortisol), b_0	1.594*	0.174	<.001	1.604*	0.173	<.001
T1 Ethnic-racial discrimination, β_{01}	0.158†	0.082	.053	0.082	0.085	.333
T2 Ethnic-racial discrimination, β_{02}	-0.035	0.078	.656	-0.032	0.077	.674
Gender, β_{03}	0.159	0.103	.125	0.150	0.102	.141
Time since waking, β_{04}	-0.049*	0.021	.021	-0.050*	0.021	.018
Oral contraceptive use, β_{05}	-0.413†	0.226	.068	-0.407†	0.229	.075
Experimental condition, β_{06}	-0.012	0.104	.911	-0.004	0.104	.973
Reactivity (time until post-task), b_1	0.009*	0.002	<.001	0.009*	0.002	<.001
T1 Ethnic-racial discrimination, β_{11}	-0.004*	0.002	.024	-0.003	0.002	.148
T2 Ethnic-racial discrimination, β_{12}	0.002	0.002	.442	0.001	0.002	.517
Recovery (time since post-task), b_2	-0.015*	0.001	<.001	-0.015*	0.001	<.001
Random Effects	Est.	*SE*	*p*	Est.	*SE*	*p*
L1 Residual variance	0.040*	0.006	<.001	0.040	0.006	<.001
L2 Intercept variance	0.207*	0.038	<.001	0.215*	0.038	<.001
L2 Linear slope variance	0.0002*	0.00003	<.001	0.0002*	0.00003	<.001
L2 Intercept-Slope covariance	-0.002*	0.001	.007	-0.002*	0.001	.004

Note. $N = 420$ saliva samples nested within 84 participants. Cortisol values (nmol/L) transformed for analyses using the natural log function. Time scaled in minutes (e.g., reactivity, b_1, indicates estimated average rate of increase per minute). Gender: 1 = male, 0 = female. Time since waking: hours between wake time and baseline measures. Oral contraceptive use: 1 = using, 0 = not using. Experimental condition: see Sladek et al., 2020, for details. Est. = regression coefficient estimate (unstandardized). E*SE* = robust standard error.
†$p < .10$. *$p < .05$.

Mean Plots of Physiological Stress Levels across Psychosocial Stress Task

Figure 1a

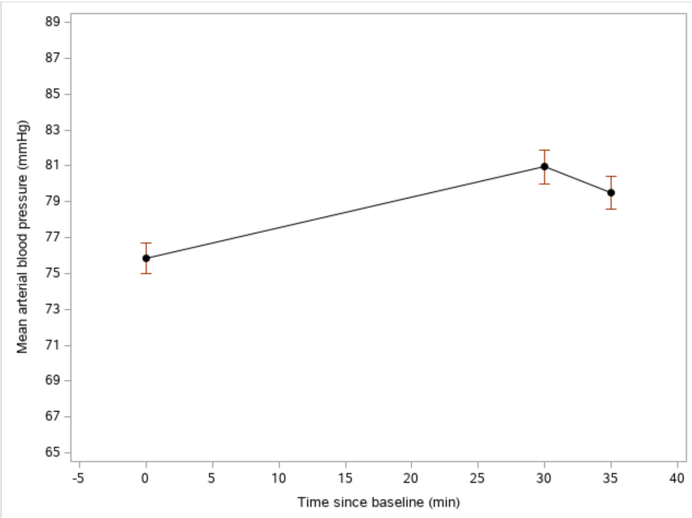
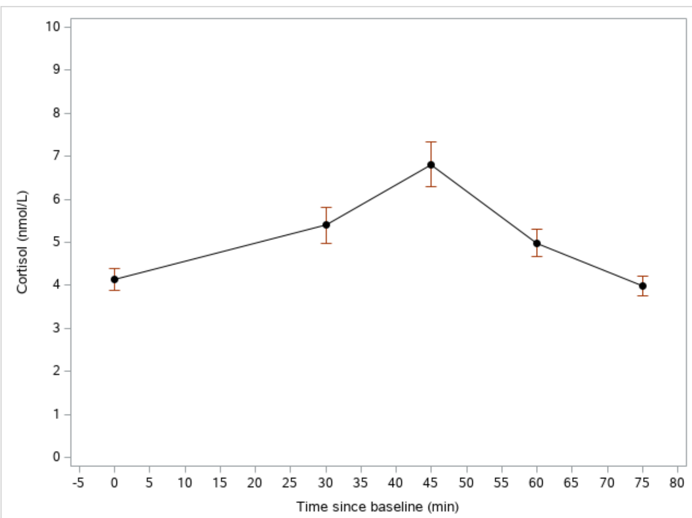


Figure 1b



Note. $N = 84$. Psychosocial stress task introduced at 10 min and completed by 30 min post baseline. Error bars reflect standard errors. Mean arterial blood pressure increased from baseline to 3rd measurement for 74.1% of participants. Cortisol increased from baseline to 3rd sample for 68.7% of participants and decreased thereafter for 95.2% of participants.

Physiological Stress Responses (T2) by Ethnic-Racial Discrimination from Adults (T1)

Figure 2a

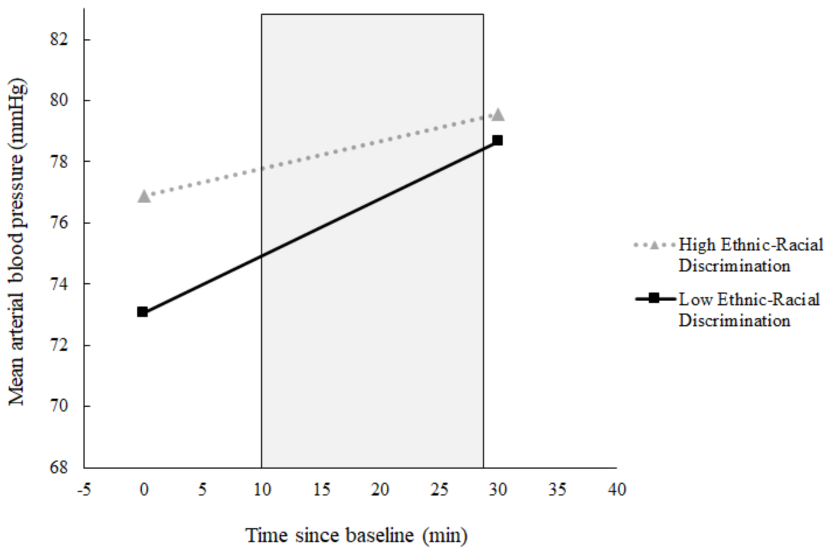
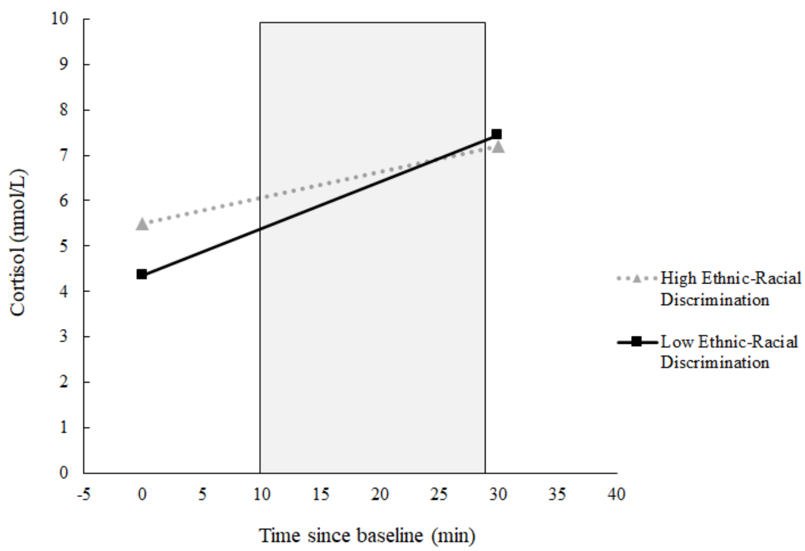


Figure 2b



Note. Shaded region indicates duration of psychosocial stress task. T2 reactivity rates (first college semester) plotted at +/-1 *SD* from sample mean of T1 ethnic-racial discrimination from adults (reported prior to college). All reactivity slopes were significant, *p*s < .05. Cortisol recovery trajectories (30 min following task) not presented here because between-person differences in rate of decrease were not statistically significant.