For all humans, sleep is a biological imperative. Despite its biological bases, however, sleep and sleep behavior are influenced by sociocultural contexts (El-Sheikh, 2011). Sleep is important for development, functioning, and health at all points along the developmental lifespan. Yet, sleep is especially elusive for adolescents. Some research cites the importance of biological changes during this period (Adam et al., 2015; Carskadon et al., 1998), while other research points to socially constructed forces (Carskadon, 1999; Dunster et al., 2018; El-Sheikh, 2011; El-Sheikh et al., 2010), and yet other research points to a mismatch of biological and societal influences (Doane et al., 2019; El-Sheikh & Buckhalt, 2005; Friedman, 2011; Singh & Kenney, 2013). Taken together, the research is clear that sleep is a complex biobehavioral function that is subject not only to biological influences, but also social ones.

A growing body of research finds that adolescent sleep is sensitive to daily social experiences, with stress having a particularly important influence (Campbell et al., 2020; Mellman et al., 2018; Rubens et al., 2018; Yap et al., 2020). For youth of color, discrimination is a form of stress linked to sleep, especially sleep disturbances (Goosby et al., 2017; Hoggard & Hill, 2016; Huynh & Gillen-O’Neel, 2013; Slopen et al., 2016; Zeiders, 2017). Furthermore, sleep is associated with poor outcomes, daytime functioning, and overall adjustment (El-Sheikh et al., 2013; Short et al., 2020; Wolfsön & Carskadon, 2003). Similarly, discrimination stress is also linked to a host of shorter- and longer-term compromises in mental health.
health among adolescents (Benner et al., 2018; Pascoe & Smart Richman, 2009; Priest & Williams, 2018). This study focused on negative mood, anxious mood, positive mood, rumination, and somatic symptoms because meta-analytic approaches find robust associations between these indicators and ethnic/racial discrimination (Benner et al., 2018) and sleep (Short et al., 2020).

Theoretical bases

The race-based disparities in stress and sleep in context (RDSSC; Levy et al., 2016) model provides a comprehensive and holistic framework for how ethnic/racial discrimination stress and sleep are implicated in health disparities. The RDSSC model proposes that sleep disturbances serve as an intermediary, biological pathway through which ethnic/racial discrimination stress ultimately leads to cascading effects on developmental outcomes. Applied to the current study, sleep disturbance was investigated as an explanatory mechanism linking ethnic/racial discrimination stress to compromised psychological outcomes among youth of color. While there is fragmented evidence for parts of the model, empirical support for the RDSSC model as a whole is somewhat nascent (e.g., Goosby et al., 2018; Huyhn et al., 2016; Zeiders, 2017). Investigating the mediating role of sleep disturbances linking ethnic/racial discrimination stress to mental health among ethno-racially diverse adolescents is well supported by the RDSSC model. Moreover, the current study expanded the RDSSC model by investigating whether proposed pathways were evident at both the daily level and across individuals (i.e., person-level) over time.

Building off the conceptual foundations of the RDSSC model, the current study analyzed data from a sizable sample of ethno-racially diverse adolescents using an intensive longitudinal design. The current study uniquely contributes to theoretical and empirical knowledge. Theoretically, the study investigated the short- and longer-term developmental pathways through which ethnic/racial discrimination is implicated in mental health through a biobehavioral mechanism such as sleep. Contributing empirical knowledge, the study employed multilevel data to investigate associations between ethnic/racial discrimination and mental health, considering both within-person and between-person effects (Curran & Bauer, 2011). Repeated measures of daily sleep/wake problems in multilevel mediation models (Preacher et al., 2010) disentangled whether, and to what degree, daily sleep/wake problems mediate the associations between ethnic/racial discrimination and health outcomes both at the daily level (i.e., how does ethnic/racial discrimination today impact anxiety today?) and individual level (i.e., how does ethnic/racial discrimination today predict and levels of anxiety in the longer term?). Investigating proximal, daily-level (i.e., Level-1) processes compared to longer-term individual-level (i.e., Level-2) outcomes, this study examined whether sleep operated as a daily-level mediator for daily-level and/or person-level mental health outcomes. Specifically, the study considered four multilevel mediation models with different combinations of daily- (i.e., Level-1) or person- (i.e., Level-2) level predictors and outcomes with daily (i.e., Level-1) sleep/wake problems as the mediator: (1) daily sleep/wake problems mediate daily-level ethnic/racial discrimination and daily mental health outcomes (i.e., do last night's sleep/wake problems explain associations between yesterday's ethnic/racial discrimination and today's mental health?, 1-1-1 model; Figure 1); (2) daily sleep/wake problems mediate person-level ethnic/racial discrimination and daily mental health outcomes (i.e., do last night's sleep/wake problems explain associations between ethnic/racial discrimination in the past 6 months and today's mental health?, 2-1-1 model; Figure 2); (3) daily sleep/wake problems mediate daily ethnic/racial discrimination and person-level mental health outcomes (i.e., do last night's sleep/wake problems explain associations between ethnic/racial discrimination and today's mental health?, 1-1-2 model; Figure 2).

![Figure 1](image-url) **Figure 1** Daily-level sleep mediates daily-level discrimination and daily-level mental health outcomes (the 1-1-1 model). Note: In this model, daily-level (level-1) variables include daily ethnic/racial discrimination (the predictor), daily sleep/wake problems (the mediator), daily mental health outcomes (the outcomes), and weekday/weekend for daily sleep/wake problems and mental health; person-level (level-2) variables include demographic covariates measured at T1 before daily diary assessment.
explain associations between yesterday's ethnic/racial discrimination and mental health over the past 2 weeks?, 1-1-2 model; Figure 3), and daily sleep/wake problems mediate person-level ethnic/racial discrimination and person-level mental health outcomes (i.e., do last night's sleep-wake problems explain associations between ethnic/racial discrimination in the past 6 months and mental health over the past 2 weeks?, 2-1-2 model; Figure 4). Investigating this combination of possibilities elucidated the more immediate and cumulative impact of sleep disturbance and how daily sleep/wake problems provide an explanatory pathway to daily and/or longer-term mental health over time.

**Linking ethnic/racial discrimination stress to mental health**

Ethnic/racial discrimination is considered to be unequal treatment due to membership in an ethnic/racial group (Williams et al., 2003). Ethnic/racial discrimination stress can stem from institutional and societal sources; however, the current study focused specifically on interpersonal experiences. Discrimination based on ethnicity/race is a normative, chronic, and harmful experience for youth of color (Benner et al., 2018; Branscombe et al., 1999; Fisher et al., 2000). Although interpersonal discrimination stress has been conceptualized as everyday
events experienced as daily hassles or microaggressions (Sue, 2010), most of the existing research has measured discrimination stress as a retrospective recollection of past events, subject to reporting biases. Recently, researchers have begun to conceptualize and measure discrimination stress as a daily phenomenon (Goosby et al., 2018; Seaton & Douglass, 2014; Torres & Ong, 2010; Yip, 2015; Zeiders, 2017). Capturing daily experiences of ethnic/racial discrimination stress provides unique insight into the proximal links between ethnic/racial discrimination stress, sleep, and psychological adjustment. Indeed, proximal reports of ethnic/racial discrimination may be better able to capture the impact of ethnic/racial discrimination (Benner et al., 2018). Repeated reports also begin to elucidate the temporal mechanisms responsible for the eventual development of observed health disparities, a phenomenon of interest in the current study.

Recent daily diary studies observed considerable variability in discrimination stress experiences from one day to the next. For example, a study of Black adolescents found that while daily discrimination stress is not particularly frequent, there was considerable variability in daily discrimination stress with some adolescents reporting higher frequency than others (Seaton & Douglass, 2014). However, research including Black, Asian, and Latinx adolescents is clear that ethnic/racial discrimination stress is a chronic stressor for people of color (Conrad et al., 2000), and there is increasing evidence that discrimination is associated with poor sleep quality and shorter sleep duration (Cheon et al., 2019; Goosby et al., 2018; Grandner et al., 2012; Hoggard & Hill, 2016; Lewis et al., 2013). Moreover, discrimination stress has been explored as an explanatory mechanism for long-standing ethnic/racial differences in sleep (Fuller-Rowell et al., 2017; Tomfohr et al., 2012). Black adults spent more time in light sleep and less time in deep sleep compared to their White counterparts; however, using hospital laboratory polysomnography, researchers found that ethnic/racial differences in sleep quality and feelings of fatigue were completely or partially mediated by ethnic/racial discrimination (Fuller-Rowell et al., 2017; Steffen & Bowden, 2006; Thomas et al., 2006). Ethnic/racial differences in sleep were no longer significant once researchers took into account the effects of ethnic/racial discrimination stress. Regardless of ethnicity, both Black and White respondents who reported more ethnic/racial discrimination stress were more likely to experience poor sleep quality and higher levels of fatigue.

**Linking ethnic/racial discrimination stress to sleep disturbances and sleep/wake concerns**

Ethnic/racial discrimination stress is a chronic stressor for people of color (Conrad et al., 2000), and there is increasing evidence that discrimination is associated with poor sleep quality and shorter sleep duration (Cheon et al., 2019; Goosby et al., 2018; Grandner et al., 2012; Hoggard & Hill, 2016; Lewis et al., 2013). Moreover, discrimination stress has been explored as an explanatory mechanism for long-standing ethnic/racial differences in sleep (Fuller-Rowell et al., 2017; Tomfohr et al., 2012). Black adults spent more time in light sleep and less time in deep sleep compared to their White counterparts; however, using hospital laboratory polysomnography, researchers found that ethnic/racial differences in sleep quality and feelings of fatigue were completely or partially mediated by ethnic/racial discrimination (Fuller-Rowell et al., 2017; Steffen & Bowden, 2006; Thomas et al., 2006). Ethnic/racial differences in sleep were no longer significant once researchers took into account the effects of ethnic/racial discrimination stress. Regardless of ethnicity, both Black and White respondents who reported more ethnic/racial discrimination stress were more likely to experience poor sleep quality and higher levels of fatigue.
racial discrimination stress also reported less deep sleep and more fatigue (Tomfohr et al., 2012).

Sleep disturbance is a multi-dimensional construct (Chen et al., 2015; Irwin et al., 2016); and for the purposes of the current study, sleep disturbance is operationalized as sleep/wake problems, including self-reported difficulty staying asleep, daytime dysfunction (e.g., difficulty staying awake during the day), and daytime sleepiness. Taken together, the research suggests that ethnic/racial differences in sleep are at least partially explained by experiences with ethnic/racial discrimination stress, underscoring the importance of examining sleep as a key physiological pathway for the effects of ethnic/racial discrimination stress.

### Linking sleep disturbances to mental health

Like ethnic/racial discrimination stress, sleep has profound implications for mental health. The importance of sleep quality and quantity for health outcomes has been widely cited. Data collected from self-report measures, as well as sophisticated, hospital laboratory polysomnographs finds consistent links between poor sleep and compromised psychological health outcomes (Ford & Kamerow, 1989; Hamilton et al., 2007; Meerlo et al., 2008; Moore et al., 2002). Sleep disturbance has been linked to key somatic and mental health indicators such as mood, fatigue, muscle pain, backache, and dizziness (Kouroš & El-Sheikh, 2015; Shaver & Paulsen, 1993; Wolfson & Carskadon, 1998); as well as depressive symptoms, anxiety, and psychological distress (Beatty et al., 2011; Haack & Muhling, 2005; Hamilton et al., 2007).

Sleep difficulties exert effects on emotional processes and adjustment through decoupling of cortical and limbic regions of the brain reducing control over negative emotions (Baum et al., 2014; Telzer et al., 2013; Yoo et al., 2007). The current study focused specifically on sleep/wake concerns, a marker of sleep quality that has associations with adolescent mental health independent of sleep duration (Dewald et al., 2010; Shimizu et al., 2020). For example, excessive daytime sleepiness compromises alertness and neurobehavioral functioning (Dewald et al., 2010; Gregory & Sadeh, 2011; Millman et al., 2005), thereby increasing risk for emotional, behavioral, and cognitive problems (Fallone et al., 2002).

### The current study

With a large and ethno-racially diverse sample of adolescents, the current study investigated theoretical and empirical support for whether sleep disturbances provided an explanatory link between ethnic/racial discrimination stress and mental health outcomes. In particular, the study focused on negative mood, anxious mood, positive mood, rumination, and somatic symptoms since these have been shown in meta-analytic approaches to have robust associations with ethnic/racial discrimination (Benner et al., 2018) and sleep (Short et al., 2020). In addition, sleep disturbance was assessed with a multi-dimensional assessment of sleep/wake problems including disturbances during nighttime sleep, daytime dysfunction (e.g., inability to focus during the day), and daytime sleepiness. With daily assessments of each construct over 14 days (i.e., daily assessments), and with person-level measures assessed before and after the 14 days (person-level assessments), the current study investigated hypothesized associations informed by the RDSSC model (Levy et al., 2016) across multiple levels. Based on clear theoretical foundations and prior research, analyses of daily sleep/wake problem as a mediator of the impact of ethnic/racial discrimination on outcomes were confirmatory in nature. Focusing first on daily sleep/wake problems predicting daily health outcomes (Figures 1 and 2), it was hypothesized that daily ethnic/racial discrimination stress would be associated with lower levels of mental health and that this association would at least partially mediated by sleep disturbances. In particular, informed by meta-analysis results in which the strongest effects between ethnic/racial discrimination and mental health were observed for depression and internalizing symptoms, with smaller, significant effects, for general well-being and self-esteem (Benner et al., 2018), it was also hypothesized that there would be larger effects of ethnic/racial discrimination on negative mental health indicators (i.e., negative mood, anxious mood, rumination, and somatic symptoms), compared to the positive one (i.e., positive mood). Moreover, it was hypothesized that daytime dysfunction and daytime sleepiness would be more likely to mediate the effects of ethnic/racial discrimination on mental health compared to sleep disturbance. Over time, these daily-level associations were predicted to affect longer-term mental health and predict individual-level outcomes (Figures 3 and 4) with similar predictions as the daily-level associations. However, since there is no prior research investigating differences between daily- and person-level associations, these four different multi-level mediation models remain exploratory. Informed by research that finds more proximal measures of ethnic/racial discrimination have stronger effects (Benner et al., 2018), it was hypothesized that full mediation would be more likely for daily-level associations (Figures 1 and 2) and partial mediation would be more likely for predicting longer-term outcomes (Figures 3 and 4).

### METHOD

#### Participants

This study analyzed data from the first wave of a 4-year longitudinal study examining stress, sleep, and daily activities. Participants included 350 ethno-racially diverse
ninth-grade adolescents (69% females) whose ages ranged from 13 to 17 years old ($M = 14.27$ years, $SD = 0.61$). The sample consisted of 76 Black, 145 Asian (74% Chinese, 8% Korean, 4% Indian, 1% Filipinx, 1% Vietnamese, and 12% other), and 129 Latinx (25% Dominican, 24% South American, 22% Mexican, 15% Puerto Rican, 5% Central American, and 9% other) youth. These groups were purposefully sampled to represent the three largest racial/ethnic minority groups in the United States. The majority (76%) of the sample identified as monoethnic/racial; with the remainder identifying with more than one ethnic/racial group (i.e., multiethnic/racial). Most of the adolescents (77%) were born in the United States. A considerable proportion of participants reported their parents completed high school or above (mothers = 59%, fathers = 48%). Prior studies drawing on the same data set found no significant differences in age, gender, nativity, or parental educational level across Black, Asian, and Latinx groups (Yip, Cham, et al., 2020; Yip, Cheon, et al., 2020).

**Procedures**

Adolescents were recruited from five public high schools selected for their ethnic/racial diversity based on Department of Education statistics. These schools are in a diverse, urban metropolis in the United States and had an average 0.47 diversity index (ranging from 0.29 to 0.62, with higher scores reflecting greater ethnic/racial diversity; Simpson Diversity Index, 1949). Other school and regional statistics on graduation rates and attendance suggest that these schools are largely representative of the larger metropolitan area public high schools. All Black, Asian, and Latinx ninth-grade adolescents in the five participating schools were invited to participate in this study. The response rates ranged from 6% to 31% across schools. These were challenged schools where 72% of students (ranging from 52% to 86%) were socioeconomically disadvantaged and four schools employed metal detectors at the entrance. Adolescents with parental consent met in small groups (1 to 10 students) after school dismissal and completed an online pretest survey (i.e., T1) about demographics and their experiences on a day; nighttime disturbance, daytime dysfunction, problems: nighttime disturbance, daytime dysfunction, and sleep, and psychological adjustment in the past 6 months. Next, they completed daily diary reports every night before bed for 14 consecutive days (i.e., daily-level data) using a data-enabled electronic tablet provided by the research team. Participants completed a mean of 10.60 reports of daily diaries ($SD = 3.44$; more than 82% of adolescents completed at least half of the 14-day diary assessment). After the 14 days, adolescents completed an online posttest survey (i.e., T2) and were compensated $20. Due to the limited availability of research materials, data presented in this study were collected in four cohorts ($n = 85, 90, 89$, and 86 for Cohorts 1 to 4, respectively). Data were collected from January 2015 to May 2018, specifically data collection dates by cohort are as follows: Cohort 1 (January 2015 to May 2015), Cohort 2 (October 2015 to March 2016), Cohort 3 (November 2016 to May 2017), and Cohort 4 (November 2017 to May 2018). There were no differences in reports of T1 ethnic/racial discrimination ($F(3, 333) = 0.54, p > .05$) or daily ethnic-racial discrimination ($F(3, 325) = 0.07$ to 2.02, $ps > .05$) across cohorts. There were no demographic differences in age, gender, ethnicity/race, parental education level, or reports of discrimination by cohort.

**Measures**

**Ethnic/racial discrimination—Predictor**

Adolescents’ daily ethnic/racial discrimination was measured using the six-item Racial/Ethnic Discrimination Index (“Today, I was treated unfairly because of my ethnicity/race,” “I felt stress because of my ethnicity/race,” “Others treated me poorly because of my ethnicity/race,” “I was teased because of my ethnicity/race,” “I felt uncomfortable because of my ethnicity/race,” and “I felt unsafe because of my ethnicity/race.”) published elsewhere (Feng et al., 2021). The scale was rated on a 3-point Likert scale ranging from 0 (did not happen/ was not a problem today) to 2 (very much a problem) with higher scores reflecting more ethnic/race-based discrimination. Prior empirical studies using the same scale reported good internal consistency at daily level ($\alpha = .90$) and supported its criterion-related validity (Feng et al., 2021). Consistent with previous studies observing that daily discrimination is a low-frequency experience (Torres & Ong, 2010), we dichotomized daily ethnic/racial discrimination ($0 = no discrimination on a day, 1 = at least one discrimination on a day; M = 0.08, SD = 0.28$). The intraclass correlation coefficient (ICC) for daily ethnic/racial discrimination was .50, reflecting considerable variation across days across participants.

Adolescents’ person-level ethnic/racial discrimination at T1 was measured using the same 6 scale items. Participants rated their ethnic/racial discrimination experiences on a 7-point Likert scale (ranging from 0 = not at all to 6 = extremely) with higher scores reflecting more ethnic/racial discrimination in the past 6 months. This scale had good internal consistency at the person level ($\alpha = .92$). This indicator was also treated as a binary variable ($0 = no discrimination in the past 6 months, 1 = at least one discrimination in the past 6 months; M = 0.45, SD = 0.50$).

**Daily sleep/wake problems—Mediator**

This study included three indicators of daily sleep/wake problems: nighttime disturbance, daytime dysfunction,
Mental health outcomes

Five indicators of adolescent mental health, both daily- and person-level, were included in the study: negative mood, anxious mood, positive mood, rumination, and somatic symptoms. An adapted version of the Profile of Mood States (McNair et al., 1971) assessed daily negative mood (4 items, i.e., sad, hopeless, discouraged, and blue), anxious mood (4 items, i.e., anxious, nervous, unable to concentrate, on edge/uneasy), and positive mood (4 items, i.e., happy, calm, joyful, and excited). Participants rated their daily mood on a 5-point Likert scale (0 = not at all, 4 = extremely) with higher scores reflecting higher levels of a particular mood state. Adolescents’ somatic symptoms were measured using the Index of Somatic Symptoms (Walker et al., 2001), a daily scale adapted from the Children’s Somatization Inventory (Garber et al., 1991). Adolescents rated six types of symptoms (i.e., headache, nausea, tiredness, sore muscles, stomachache, and feeling weak) on a 4-point scale ranging from 0 (not at all) to 3 (a whole lot). Rumination (i.e., a passive coping with repeated thinking about the negative situations) was measured using an adapted version of the subscale of the Children’s Response Styles Questionnaire (Abela et al., 2004), a 4-item daily measure (e.g., Why can’t I handle things better?) that was rated on a 3-point scale (0 = no, I did not do this today, 2 = a lot of the time).

Mean scores of each daily-level measure were included in analysis, with higher scores reflecting more rumination responses. The ICCs for negative mood (ICC = .64), anxious mood (ICC = .64), positive mood (ICC = .62), somatic symptoms (ICC = .63), and rumination (ICC = .61) observed considerable variation in these constructs across days across participants.

Person-level health was measured at T2 after the end of the 14-day diary surveys. Adolescents reported their person-level negative mood, anxious mood, positive mood, and somatic symptoms in the past 2 weeks using the same scales for daily measures of mood states (“Rate the extent to which these words describe your feelings during the past 2 weeks.”) and somatic symptoms (“How often did you experience the following symptoms in the past 2 weeks?”), as listed above. Adolescents’ person-level rumination was measured by a 13-item subscale of the Children’s Response Styles Questionnaire (Abela et al., 2004): “The following statements are ways people can describe themselves. Choose a response that indicates how you generally feel.” Items (e.g., “When I was sad, I thought about how alone I felt”) were rated on a 4-point scale (0 = almost never, 3 = almost always). Mean scores for each person-level measure were included in analysis with higher scores indicating more ruminative responses in the past 2 weeks. Cronbach’s alphas suggested good internal consistency: negative mood (α = .90), anxious mood (α = .85), positive mood (α = .81), somatic symptoms (α = .82), and rumination (α = .96).

Of note, reports of mental health that are collected at the daily level are conceptually different from retrospective reports of mental health; daily reports assess dynamic, day-to-day fluctuations of adolescents’ mental health, whereas retrospective reports (whether assessed at a single time, or repeated over time) capture a broader assessment of adolescents’ experiences over the past 2 weeks. A novel contribution of the current study is the combination of the two assessment approaches to provide a unique snapshot into how daily-level processes are implicated in adolescents’ longer-term experiences, which over time, provides the foundation for long-term mental health outcomes.

Covariates

Models involving daily-level mental health outcomes controlled for previous-day health and the effects of weekend/weekday (0 = weekend, 1 = weekday). Models involving person-level mental health at T2 controlled for the same variable at T1. Given the impact of the day of the week on sleep (Roepke & Duffy, 2010; Vitale et al., 2015), current analyses also include weekend/weekday.
as a covariate for daily sleep/wake problems. Six demographic covariates were included in all analyses: (1) age, (2) gender (0 = male, 1 = female), (3) ethnicity/race (African, Asian, and Latinx; Asian was the largest group and served as the reference), (4) multiethnic/racial status (0 = monoethnic/racial, 1 = multiethnic/racial), (5) mother education level (0 = less than high school or unknown, 1 = high school or above), and (6) father education level (0 = less than high school or unknown, 1 = high school or above).

Data analytic strategy

Adolescents were asked to evaluate today's ethnic/racial discrimination, last night's sleep/wake problems, and today's mental health in diary reports. For analytical purposes, the time-lagged measures were shifted such that daily ethnic/racial discrimination (predictor) predicted same-night sleep/wake problems (mediator) which predicted next-day health outcomes (outcome, Figure 1). A multilevel structural equation modeling (MSEM) framework was used to examine indirect effects of daily sleep/wake problems, given that this approach outperforms multilevel modeling by reducing bias of the indirect effects via separating between- and within-level components of indirect effects (Preacher et al., 2010). Four sets of MSEMs were conducted to examine each hypothesis: (1) the 1-1-1 model (Figure 1), that is, daily ethnic/racial discrimination predicts same-day sleep/wake problems (path a) and next-day mental health (path c'), and daily sleep/wake problems predict next-day mental health (path b); (2) the 2-1-1 model (Figure 2), that is, person-level ethnic/racial discrimination at T1 predicts daily sleep/wake problems (path a) and next-day mental health (path c'), and daily sleep/wake problems predict next-day mental health (path b); (3) the 1-1-2 model (Figure 3), that is, daily ethnic/racial discrimination predicts same-day sleep/wake problems (path a) and person-level mental health at T2 (path c'), and daily sleep/wake problems predict mental health at T2 (path b); and (4) the 2-1-2 model (Figure 4), that is, person-level ethnic/racial discrimination at T1 predicts daily sleep/wake problems (path a) and person-level health at T2 (path c'), and daily sleep/wake problems predict health at T2 (path b). To avoid unnecessary complications and enhance model convergence, the MSEM models included random intercepts (i.e., the between-person variance in the outcome(s) separate from the within-person variance, which is measured by the residual variance; random intercepts are only present in equations involving daily-level (level-1) variables, that is, sleep mediators in all models and mental health outcomes in 1-1-1 and 2-1-1) and fixed slopes (i.e., within-person direct effects are assumed to be fixed and not varying between participants; Preacher et al., 2010).

Investigating multiple multilevel mediation models allowed for the examination of both within-person and between-person effects. Between-person effects can be understood as “trait” effects (e.g., how likely a person perceives ethnic/racial discrimination in general) or contextual effects if the between-person effects are different from the within-person effects. Within-person effects refer to intra-individual differences (i.e., “state” experiences, e.g., variation in daily experiences of ethnic-racial discrimination). For same-level (e.g., 1-1) and cross-level (e.g., 2-1 and 1-2) pathways, between-person effects indicate the associations explained by variances at the between-person level (by extracting the variances of the level-2 variable). For the present study, only the mediation model involving all daily-level variables (i.e., 1-1-1) provides both within-person and between-person mediation effects. In contrast, models including a person-level variable (i.e., 2-1-1, 1-1-2, and 2-1-2) examine mediation effects at the between-person level (Preacher et al., 2010). Since the primary research question is whether daily sleep/wake problems mediate the impact of ethnic/racial discrimination on mental health across multiple levels, this study focuses on the interpretation of between-person mediation across the four models.

Finally, each sleep/wake problem indicator (i.e., nighttime disturbance, daytime dysfunction, and daytime sleepiness) was tested in separate models with the inclusion of all mental health indicators. All MSEMs were fit in Mplus 8.4 (Muthén & Muthén, 1998–2019), using maximum likelihood estimation with robust standard errors. Selection bias due to missing data ($M = 20.68\%, SD = 9.50\%$, ranges $= 0\%$ to $36\%$) was minimized by including demographics (e.g., ethnicity/race) significantly associated with missingness of study variables as covariates in all models. We used the default setting in Mplus where observations with missing values on the predictor or any covariates omitted from analyses, that is, list-wise deletion. Following Preacher et al. (2010) and Preacher and Selig (2012), we used the Monte Carlo method to construct the 95% CI, where the exclusion of zero indicates a significant mediation effect. The mediation effect sizes were calculated using standardized path coefficients $\beta$ and the effect size $v$ (Lachowicz et al., 2018), which is interpreted as the proportion of variance in the outcome explained by the mediator and the predictor that “corrects for spurious correlation induced by the ordering of variables (e.g., the causal ordering of predictor, mediator, and outcome variables)” (p. 249), with a range from 0 (no explained variance) to 1 (perfect explained variance). For the standardized path coefficients $\beta$, we used the daily-level $SD$s when the effect was at the daily level and the person-level $SD$s when the effect was at the person level.
RESULTS

Preliminary analyses

The means, standard deviations, ranges, and correlations among the primary study variables are presented in Table 1. Results of daily-level correlations (below-diagonal, Table 1) are interpreted as associations across days (i.e., ignoring individual differences across adolescents). These daily-level correlations indicated that daily ethnic/racial discrimination was associated with greater same-day sleep/wake problems (i.e., nighttime disturbance, daytime dysfunction, and daytime sleepiness) and more negative mental health outcomes (i.e., higher levels of negative mood, anxious mood, rumination, and somatic symptoms as well as lower levels of positive mood). Additionally, daily sleep/wake problems were associated with worse next-day mental health outcomes across days, except for a nonsignificant association between daily nighttime disturbance and next-day positive mood. Across days, daily positive mood was negatively associated with all negative mental health outcomes; daily unfavorable mental health variables were positively correlated with each other. Results of person-level indicators (above-diagonal, Table 1) indicated similar patterns to the daily-level results. In addition, person-level nighttime disturbance (the average 14 days of nighttime disturbance) was associated with lower levels of positive mood at T2. Cross-level correlations (i.e., between daily-level and person-level variables) observed significant associations among all primary study variables (ps < .05; Table S1).

MSEM results: The 1-1-1 and 2-1-1 models

The 1-1-1 model (Figure 1) examined whether the daily associations between ethnic/racial discrimination and daily mental health were mediated by daily sleep/wake problems. The 2-1-1 model (Figure 2) investigated if the impact of 6-month ethnic/racial discrimination (T1) on daily mental health outcomes was mediated by daily sleep/wake problems. In common, these two models share a focus on daily-level mediators and daily-level outcomes, and vary with respect to whether they include a daily- or person-level predictor. Results are reported in Table 2 (between-person effects) and Table S2 (within-person effects). This study primarily focused on the interpretation of between-person effects, that is, mediation across days across adolescents (explained by between-person variances).

Nighttime disturbance (row A): The 1-1-1 and 2-1-1 models

On days in which adolescents experienced ethnic/racial discrimination, they reported greater same-day nighttime disturbance (path a). On days in which adolescents had greater daily nighttime disturbance, they also reported more negative mood, anxious mood, rumination, and somatic symptoms the next day (path b). Mediation effects were significant and supported partial mediation, since the direct effects of daily ethnic/racial discrimination to the four negative health outcomes were significant. The mediation effect size $v$ showed that 4.6%, 4.4%, 1.2%, and 17.9% of the variance in next-day negative mood, anxious mood, rumination, and somatic symptoms was explained by same-day nighttime disturbance and ethnic/racial discrimination. The effect size for rumination was the smallest among these four outcomes because the path from nighttime disturbance to rumination was the smallest. Daily nighttime disturbance was not associated with next-day positive mood, and the mediation effect to positive mood was not significant (mediation effect size $v = 0.0\%$).

Adolescents who reported more ethnic/racial discrimination in the past 6 months also reported greater daily nighttime disturbance (path a). On days in which adolescents had greater nighttime disturbance, they experienced more next-day negative mood, anxious mood, rumination, and somatic symptoms (path b). Mediation effects for the models predicting negative mood, anxious mood, rumination, and somatic symptoms were significant and full mediation was supported. The mediation effect size $v$ showed that 0.8%, 0.8%, 0.3%, and 2.6% of the variance in next-day negative mood, anxious mood, rumination, and somatic symptoms was explained by same-day nighttime disturbance and ethnic/racial discrimination. The mediation effect for the model predicting positive mood was not significant (mediation effect size $v = 0.0\%$).

Taken together, daily nighttime disturbance partially or fully mediated the impact of daily ethnic/racial discrimination and ethnic/racial discrimination at T1 (i.e., discrimination in the preceding 6 months) on daily mental health outcomes, including negative mood, anxious mood, rumination, and somatic symptoms (1-1-1 and 2-1-1 models). The mediation effect sizes of these outcomes in the 2-1-1 models were smaller than the corresponding effect sizes in the 1-1-1 models because path a was smaller in the 2-1-1 models. There were no mediating effects for daily level or ethnic/racial discrimination at T1 (i.e., discrimination in the preceding 6 months) and daily positive mood (1-1-1 and 2-1-1 models).

Daytime dysfunction (row B): The 1-1-1 and 2-1-1 models

On days in which adolescents experienced ethnic/racial discrimination, they reported greater same-day daytime dysfunction (path a). On days in which adolescents had greater daytime dysfunction, they also reported more negative mental health outcomes (i.e., negative mood,
## TABLE 1  Sample descriptives among primary study variables

| Variable                                | Valid N (cases) | M (person) | SD (person) | Minimum (person) | Maximum (person) |
|-----------------------------------------|-----------------|------------|-------------|------------------|------------------|
| 1. Ethnic/racial discrimination         | 345             | 0.08       | 0.28        | 0                | 1                |
| 2. Nighttime disturbance                | 345             | 0.56       | 0.59        | 0                | 3                |
| 3. Daytime dysfunction                  | 345             | 0.59       | 0.74        | 0                | 3                |
| 4. Daytime sleepiness                   | 345             | 0.88       | 0.88        | 0                | 3                |
| 5. Negative mood                        | 345             | 0.71       | 0.88        | 0                | 3                |
| 6. Anxious mood                         | 345             | 0.53       | 0.59        | 0                | 3                |
| 7. Positive mood                        | 345             | 0.70       | 0.88        | 0                | 3                |
| 8. Rumination                           | 345             | 0.53       | 0.59        | 0                | 3                |
| 9. Somatic symptoms                     | 345             | 0.71       | 0.88        | 0                | 3                |

*Note: Correlations presented below diagonal are among daily-level (level-1) variables (i.e., same-day ethnic/racial discrimination and sleep/wake problems and next-day mental health outcomes). Correlations presented above diagonal are among person-level (level-2) variables (i.e., T1 ethnic/racial discrimination, 14-day average of sleep/wake problems, and T2 mental health outcomes).*

*p < .05; **p < .01.
## Table 2
Multilevel structural equation modeling estimates for daily-level mental health outcomes (the 1-1-1 and 2-1-1 models, between-person effects)

| Model         | Outcome           | n    | Path a Estimate | SE  | β    | Path b Estimate | SE  | β    | Path c Estimate | SE  | β    | Mediation Effect | Estimate | SE  | Partial (%) |
|---------------|-------------------|------|-----------------|-----|------|-----------------|-----|------|-----------------|-----|------|------------------|----------|-----|--------------|
| (A) Nighttime disturbance |                 |      | Path a | Path b | Path c |                   |     |     |                  |     |     |                  |          |     |              |
| 1-1-1         | Negative mood     | 3722 | 0.83  | 0.17  | 0.43  | 0.77             | 0.13| 0.52 | 0.94             | 0.27| 0.33 | 0.64             | 0.17     |     | 4.6%         |
|               | Anxious mood      | 3722 | 0.83  | 0.17  | 0.43  | 0.77             | 0.13| 0.51 | 0.74             | 0.26| 0.25 | 0.64             | 0.16     |     | 4.4%         |
|               | Positive mood     | 3722 | 0.83  | 0.17  | 0.43  | −0.16            | 0.17| −0.07| −0.17            | 0.29| −0.04| −0.13            | 0.14     |     | 0.0%         |
|               | Rumination        | 3722 | 0.83  | 0.17  | 0.43  | 0.25             | 0.07| 0.27 | 0.69             | 0.19| 0.39 | 0.21             | 0.07     |     | 1.2%         |
|               | Somatic symptoms  | 3722 | 0.83  | 0.17  | 0.43  | 0.75             | 0.07| 1.01 | 0.27             | 0.12| 0.18 | 0.63             | 0.13     |     | 17.9%        |
| 2-1-1         | Negative mood     | 4093 | 0.13  | 0.05  | 0.16  | 0.93             | 0.11| 0.64 | 0.02             | 0.08| 0.02 | 0.12             | 0.05     |     | 0.8%         |
|               | Anxious mood      | 4093 | 0.13  | 0.05  | 0.16  | 0.89             | 0.11| 0.61 | 0.03             | 0.08| 0.02 | 0.12             | 0.05     |     | 0.8%         |
|               | Positive mood     | 4093 | 0.13  | 0.05  | 0.16  | −0.14            | 0.15| −0.07| −0.28            | 0.10| −0.16| −0.02            | 0.02     |     | 0.0%         |
|               | Rumination        | 4093 | 0.13  | 0.05  | 0.16  | 0.36             | 0.06| 0.39 | 0.09             | 0.05| 0.12 | 0.05             | 0.02     |     | 0.3%         |
|               | Somatic symptoms  | 4093 | 0.13  | 0.05  | 0.16  | 0.79             | 0.06| 1.12 | 0.04             | 0.04| 0.06 | 0.10             | 0.04     |     | 2.6%         |
| (B) Daytime dysfunction |                 |      | Path a | Path b | Path c |                   |     |     |                  |     |     |                  |          |     |              |
| 1-1-1         | Negative mood     | 3724 | 0.41  | 0.16  | 0.20  | 0.57             | 0.11| 0.39 | 1.35             | 0.30| 0.45 | 0.23             | 0.10     |     | 0.5%         |
|               | Anxious mood      | 3724 | 0.41  | 0.16  | 0.20  | 0.68             | 0.11| 0.48 | 1.11             | 0.26| 0.37 | 0.28             | 0.12     |     | 0.8%         |
|               | Positive mood     | 3724 | 0.41  | 0.16  | 0.20  | −0.60            | 0.13| −0.30| −0.06            | 0.28| −0.01| −0.25            | 0.11     |     | 0.3%         |
|               | Rumination        | 3724 | 0.41  | 0.16  | 0.20  | 0.33             | 0.07| 0.40 | 0.77             | 0.18| 0.45 | 0.13             | 0.06     |     | 0.5%         |
|               | Somatic symptoms  | 3724 | 0.41  | 0.16  | 0.20  | 0.48             | 0.07| 0.56 | 0.69             | 0.19| 0.39 | 0.20             | 0.08     |     | 1.0%         |
| 2-1-1         | Negative mood     | 4096 | 0.13  | 0.06  | 0.15  | 0.67             | 0.12| 0.43 | 0.05             | 0.08| 0.04 | 0.09             | 0.04     |     | 0.3%         |
|               | Anxious mood      | 4096 | 0.13  | 0.06  | 0.15  | 0.77             | 0.12| 0.51 | 0.04             | 0.08| 0.03 | 0.10             | 0.04     |     | 0.5%         |
|               | Positive mood     | 4096 | 0.13  | 0.06  | 0.15  | −0.57            | 0.13| −0.29| −0.23            | 0.10| −0.14| −0.07            | 0.04     |     | 0.2%         |
|               | Rumination        | 4096 | 0.13  | 0.06  | 0.15  | 0.37             | 0.07| 0.42 | 0.09             | 0.05| 0.11 | 0.05             | 0.02     |     | 0.3%         |
|               | Somatic symptoms  | 4096 | 0.13  | 0.06  | 0.15  | 0.52             | 0.07| 0.58 | 0.07             | 0.05| 0.09 | 0.07             | 0.03     |     | 0.6%         |
| (C) Daytime sleepiness |                |      | Path a | Path b | Path c |                   |     |     |                  |     |     |                  |          |     |              |
| 1-1-1         | Negative mood     | 3727 | 0.80  | 0.28  | 0.20  | 0.27             | 0.06| 0.36 | 1.37             | 0.27| 0.45 | 0.21             | 0.10     |     | 0.4%         |
|               | Anxious mood      | 3727 | 0.80  | 0.28  | 0.20  | 0.28             | 0.06| 0.37 | 1.16             | 0.25| 0.38 | 0.22             | 0.10     |     | 0.4%         |
|               | Positive mood     | 3727 | 0.80  | 0.28  | 0.20  | −0.47            | 0.08| −0.49| 0.06             | 0.29| 0.02 | −0.38            | 0.14     |     | 0.8%         |
|               | Rumination        | 3727 | 0.80  | 0.28  | 0.20  | 0.08             | 0.03| 0.17 | 0.84             | 0.17| 0.46 | 0.06             | 0.03     |     | 0.1%         |
|               | Somatic symptoms  | 3727 | 0.80  | 0.28  | 0.20  | 0.25             | 0.05| 0.59 | 0.69             | 0.18| 0.40 | 0.20             | 0.08     |     | 1.1%         |

(Continues)
anxious mood, rumination, and somatic symptoms) and less positive mood the next day (path b). Mediation effects were significant, supporting partial mediation for the four negative health outcomes; however, the effect to positive mood was fully mediated. The mediation effect size $\nu$ showed that $0.5\%$, $0.8\%$, $0.5\%$, $1.0\%$, and $0.3\%$ of the variance in next-day negative mood, anxious mood, rumination, somatic symptoms, and positive mood was explained by same-day daytime dysfunction and ethnic/racial discrimination.

Adolescents who reported ethnic/racial discrimination in the past 6 months experienced greater daily daytime dysfunction (path a). On days in which adolescents had greater daytime dysfunction, they also reported more negative mental health outcomes (i.e., negative mood, anxious mood, rumination, and somatic symptoms) and less positive mood the next day (path b). Mediation effects were significant: (1) the effects to negative mood, anxious mood, rumination, and somatic symptoms were fully mediated, and (2) the effect to positive mood was partially mediated. The mediation effect size $\nu$ showed that $0.3\%$, $0.5\%$, $0.3\%$, $0.6\%$, and $0.2\%$ of the variance in next-day negative mood, anxious mood, rumination, somatic symptoms, and positive mood explained by same-day daytime dysfunction and ethnic/racial discrimination.

Taken together, daily daytime dysfunction partially or fully mediated the impact of daily level and prior 6-month ethnic/racial discrimination on daily mental health outcomes, including negative mood, anxious mood, positive mood, rumination, and somatic symptoms (1-1-1 and 2-1-1 models). The mediation effects via daytime dysfunction for both the 1-1-1 and 2-1-1 models explained $\leq 1.0\%$ of the variance in the outcomes.

Daytime sleepiness (row C): The 1-1-1 and 2-1-1 models

On days in which adolescents experienced ethnic/racial discrimination, they reported greater same-day daytime sleepiness (path a). On days in which adolescents had greater daytime sleepiness, they also reported more negative mental health outcomes (i.e., negative mood, anxious mood, rumination, and somatic symptoms) and less positive mood the next day (path b). The mediation effects were significant: (1) the effects to negative mood, anxious mood, rumination, and somatic symptoms were partially mediated, and (2) the effect to positive mood was fully mediated. The mediation effect size $\nu$ showed that $0.4\%$, $0.4\%$, $0.1\%$, $1.1\%$, and $0.8\%$ of the variance in next-day negative mood, anxious mood, rumination, somatic symptoms, and positive mood was explained by same-day daytime sleepiness and ethnic/racial discrimination.

Adolescents who reported ethnic/racial discrimination in the past 6 months experienced greater daytime sleepiness (path a). On days in which adolescents had
greater daytime sleepiness, they also reported more negative mental health outcomes (i.e., negative mood, anxious mood, rumination, and somatic symptoms) and less positive mood the next day. Mediating effects were significant: (1) the effects to negative mood, anxious mood, and somatic symptoms were fully mediated, and (2) the effects to positive mood and rumination were partially mediated. The mediation effect size $\nu$ showed that 0.2%, 0.3%, 0.6%, 0.4%, and 0.1% of the variance in next-day negative mood, anxious mood, somatic symptoms, positive mood, and rumination was explained via same-day daytime sleepiness and ethnic/racial discrimination.

Taken together, daily daytime sleepiness partially or fully mediated the impact of daily level and prior 6-month ethnic/racial discrimination on daily negative mood, anxious mood, positive mood, rumination, and somatic symptoms (1-1-1 and 2-1-1 models). The mediation effects via daytime sleepiness in both the 1-1-1 and 2-1-1 models explained ≤1.0% of the variance in the outcomes.

**MSEM results: The 1-1-2 and 2-1-2 models**

The 1-1-2 model (Figure 3) examined whether the impact of daily ethnic/racial discrimination on overall experiences of mental health outcomes in 2 weeks was mediated by daily sleep/wake problems, and the 2-1-2 model (Figure 4) investigated if the impact of ethnic/racial discrimination in the past 6 months (T1) on overall experiences of mental health outcomes in 2 weeks was mediated by daily sleep/wake problems. In common, these two models share a focus on having a daily-level mediator with person-level outcomes, and vary with respect to whether they include a daily- or person-level predictor. Results are reported in Table 3 (between-person effects) and Table S3 (within-person effects).

**Nighttime disturbance (row A): The 1-1-1 and 2-1-1 models**

On days in which adolescents experienced ethnic/racial discrimination, they reported greater same-day nighttime disturbance (path $a$). Adolescents who reported greater daily nighttime disturbance experienced higher overall levels of negative mental health outcomes (i.e., negative mood, anxious mood, rumination, and somatic symptoms) in the past 2 weeks (path $b$). Mediating effects were significant: (1) the effects to person-level negative mood and rumination at T2 (i.e., negative mood and rumination in the past 2 weeks) were partially mediated, and (2) the effects to person-level anxious mood and somatic symptoms at T2 (i.e., anxious mood and somatic symptoms in the past 2 weeks) were fully mediated. The mediation effect size $\nu$ showed that 2.4%, 0.7%, 1.9%, and 4.2% of the variance of negative mood, rumination, anxious mood, and somatic symptoms was explained by same-day nighttime disturbance and ethnic/racial discrimination. Daily nighttime disturbance was not associated with person-level positive mood at T2, and the mediating effect to positive mood was not significant (mediation effect size $\upsilon = 0.1\%$).

Adolescents who reported ethnic/racial discrimination in the past 6 months experienced greater daily nighttime disturbance (path $a$). Adolescents who reported greater daily nighttime disturbance experienced higher levels of negative mental health outcomes (i.e., negative mood, anxious mood, rumination, and somatic symptoms) and less positive mood in the past 2 weeks (path $b$). Mediating effects were significant: (1) the effects to person-level negative mood and somatic symptoms at T2 (i.e., negative mood and somatic symptoms in the past 2 weeks) were fully mediated, and (2) the effects to person-level anxious mood, positive mood, and rumination at T2 (i.e., anxious mood, positive mood, and rumination in the past 2 weeks) were fully mediated. The mediation effect size $\upsilon$ showed that 0.5%, 0.5%, 0.4%, 0.0%, and 0.2% of the variance in negative mood, somatic symptoms, anxious mood, positive mood, and rumination was explained by same-day nighttime disturbance and ethnic/racial discrimination.

Taken together, daily nighttime disturbance partially or fully mediated the impact of daily level discrimination and prior 6-month ethnic/racial discrimination on overall experiences of negative mental health outcomes in the past 2 weeks, including negative mood, anxious mood, rumination, and somatic symptoms (1-1-2 and 2-1-2 models). The mediating effect was observed for ethnic/racial discrimination in the past 6 months (but not daily ethnic/racial discrimination) and positive mood in the past 2 weeks (2-1-2 model). Most mediation effects via nighttime disturbance in both the 1-1-1 and 2-1-1 models explained ≤1.0% of the variances in the outcomes.

**Daytime dysfunction (row B): The 1-1-1 and 2-1-1 models**

On days in which adolescents experienced ethnic/racial discrimination, they reported greater same-day daytime dysfunction (path $a$). Adolescents who reported greater daily daytime dysfunction experienced higher levels of negative mental health outcomes (i.e., negative mood, anxious mood, rumination, and somatic symptoms) and lower levels of positive mood in the past 2 weeks (path $b$). Mediating effects were significant: (1) the effects to person-level negative mood, anxious mood, positive mood, and rumination at T2 (i.e., negative, anxious, and positive mood and rumination in the past 2 weeks) were partially mediated, and (2) the effect to person-level somatic symptoms at T2 (i.e., somatic symptoms in the past 2 weeks) was fully mediated. The mediation effect
| Model | Outcome | \( n \) | \( Path \ a \) | \( Path \ b \) | \( Path \ c \) | Mediation effect |
|-------|---------|---------|---------|---------|---------|----------------|
| | | Estimate | \( SE \) | \( \beta \) | Estimate | \( SE \) | \( \beta \) | Estimate | \( SE \) | \( \beta \) | Estimate | \( SE \) | \( \beta \) |
| (A) Nighttime disturbance | | | | | | | | | | | | |
| 1-1-2 | Negative mood | 4684 | 0.87 | 0.18 | 0.44 | 0.79 | 0.16 | 0.37 | 0.82 | 0.34 | 0.19 | 0.69 | 0.19 | Partial 2.4% |
| | Anxious mood | 4684 | 0.87 | 0.18 | 0.44 | 0.73 | 0.15 | 0.33 | 0.69 | 0.35 | 0.16 | 0.63 | 0.17 | Full 1.9% |
| | Positive mood | 4684 | 0.87 | 0.18 | 0.44 | −0.24 | 0.16 | −0.10 | −0.53 | 0.27 | −0.11 | −0.21 | 0.15 | — |
| | Rumination | 4684 | 0.87 | 0.18 | 0.44 | 0.40 | 0.14 | 0.21 | 0.61 | 0.30 | 0.16 | 0.35 | 0.13 | Partial 0.7% |
| | Somatic symptoms | 4684 | 0.87 | 0.18 | 0.44 | 0.68 | 0.10 | 0.48 | −0.38 | 0.22 | −0.14 | 0.59 | 0.14 | Full 4.2% |
| 2-1-2 | Negative mood | 4772 | 0.15 | 0.05 | 0.17 | 0.94 | 0.13 | 0.46 | 0.15 | 0.10 | 0.09 | 0.14 | 0.05 | Full 0.5% |
| | Anxious mood | 4772 | 0.15 | 0.05 | 0.17 | 0.84 | 0.12 | 0.40 | 0.21 | 0.10 | 0.12 | 0.12 | 0.05 | Partial 0.4% |
| | Positive mood | 4772 | 0.15 | 0.05 | 0.17 | −0.30 | 0.14 | −0.13 | −0.30 | 0.11 | −0.16 | −0.04 | 0.03 | Partial 0.0% |
| | Rumination | 4772 | 0.15 | 0.05 | 0.17 | 0.47 | 0.13 | 0.26 | 0.30 | 0.09 | 0.20 | 0.07 | 0.03 | Partial 0.2% |
| | Somatic symptoms | 4772 | 0.15 | 0.05 | 0.17 | 0.60 | 0.09 | 0.45 | 0.12 | 0.07 | 0.11 | 0.09 | 0.03 | Full 0.5% |
| (B) Daytime dysfunction | | | | | | | | | | | | |
| 1-1-2 | Negative mood | 4684 | 0.40 | 0.15 | 0.19 | 0.93 | 0.15 | 0.48 | 1.11 | 0.31 | 0.27 | 0.37 | 0.14 | Partial 0.7% |
| | Anxious mood | 4684 | 0.40 | 0.15 | 0.19 | 1.06 | 0.15 | 0.56 | 0.87 | 0.32 | 0.22 | 0.42 | 0.17 | Partial 1.0% |
| | Positive mood | 4684 | 0.40 | 0.15 | 0.19 | −0.62 | 0.14 | −0.29 | −0.47 | 0.22 | −0.10 | −0.25 | 0.10 | Partial 0.2% |
| | Rumination | 4684 | 0.40 | 0.15 | 0.19 | 0.58 | 0.12 | 0.34 | 0.70 | 0.31 | 0.19 | 0.23 | 0.10 | Partial 0.3% |
| | Somatic symptoms | 4684 | 0.40 | 0.15 | 0.19 | 0.59 | 0.10 | 0.44 | −0.05 | 0.18 | −0.02 | 0.23 | 0.10 | Full 0.6% |
| 2-1-2 | Negative mood | 4773 | 0.14 | 0.05 | 0.16 | 1.01 | 0.14 | 0.51 | 0.11 | 0.10 | 0.07 | 0.14 | 0.06 | Full 0.6% |
| | Anxious mood | 4773 | 0.14 | 0.05 | 0.16 | 1.11 | 0.14 | 0.58 | 0.14 | 0.10 | 0.08 | 0.16 | 0.06 | Full 0.7% |
| | Positive mood | 4773 | 0.14 | 0.05 | 0.16 | −0.61 | 0.14 | −0.29 | −0.24 | 0.11 | −0.13 | −0.09 | 0.04 | Partial 0.2% |
| | Rumination | 4773 | 0.14 | 0.05 | 0.16 | 0.59 | 0.11 | 0.34 | 0.27 | 0.09 | 0.18 | 0.08 | 0.03 | Partial 0.2% |
| | Somatic symptoms | 4773 | 0.14 | 0.05 | 0.16 | 0.56 | 0.10 | 0.42 | 0.11 | 0.07 | 0.10 | 0.08 | 0.03 | Full 0.4% |
| (C) Daytime sleepiness | | | | | | | | | | | | |
| 1-1-2 | Negative mood | 4688 | 0.70 | 0.27 | 0.17 | 0.39 | 0.07 | 0.37 | 1.29 | 0.27 | 0.31 | 0.27 | 0.11 | Partial 0.3% |
| | Anxious mood | 4688 | 0.70 | 0.27 | 0.17 | 0.45 | 0.07 | 0.43 | 1.07 | 0.29 | 0.25 | 0.31 | 0.13 | Partial 0.5% |
| | Positive mood | 4688 | 0.70 | 0.27 | 0.17 | −0.49 | 0.08 | −0.46 | −0.46 | 0.20 | −0.11 | −0.34 | 0.14 | Partial 0.5% |
| | Rumination | 4688 | 0.70 | 0.27 | 0.17 | 0.15 | 0.06 | 0.16 | 0.87 | 0.29 | 0.23 | 0.11 | 0.06 | Partial 0.1% |
| | Somatic symptoms | 4688 | 0.70 | 0.27 | 0.17 | 0.34 | 0.05 | 0.51 | 0.01 | 0.17 | 0.00 | 0.24 | 0.10 | Full 0.6% |
Adolescents who reported ethnic/racial discrimination in the past 6 months experienced greater daily daytime dysfunction (*path a*). Adolescents who reported greater daily nighttime disturbance experienced higher levels of negative mental health outcomes (i.e., negative mood, anxious mood, rumination, and somatic symptoms) and lower levels of positive mood in the past 2 weeks (*path b*). Mediation effects were significant: (1) the models predicting person-level negative mood, anxious mood, and somatic symptoms at T2 (i.e., negative and anxious mood and somatic symptoms in the past 2 weeks) were fully mediated; and (2) the models predicting person-level positive mood and rumination at T2 (i.e., positive mood and rumination in the past 2 weeks) were partially mediated. The mediation effect size showed that 0.7%, 1.0%, 0.2%, 0.3%, and 0.6% of the variance in negative mood, anxious mood, positive mood, rumination, and somatic symptoms was explained by same-day daytime dysfunction and ethnic/racial discrimination.

Taken together, daily daytime dysfunction partially or fully mediated the impact of daily level discrimination and prior 6-month ethnic/racial discrimination on mental health in the past 2 weeks, including negative mood, anxious mood, positive mood, rumination, and somatic symptoms (1-1-2 and 2-1-2 models). Mediation effects via daytime dysfunction in both the 1-1-2 and 2-1-2 models explained ≤1.0% of the variance in the outcomes.

Daytime sleepiness (row C): The 1-1-1 and 2-1-1 models

On days in which adolescents experienced ethnic/racial discrimination, they reported greater same-day daytime sleepiness (*path a*). Adolescents who reported greater daily daytime sleepiness experienced higher levels of negative mental health outcomes (i.e., negative mood, anxious mood, rumination, and somatic symptoms) and lower levels of positive mood in the past 2 weeks (*path b*). Mediation effects were significant: (1) the models predicting person-level negative mood, anxious mood, positive mood, rumination, and somatic symptoms at T2 (i.e., mental health in the past 2 weeks) were partially mediated; and (2) the model predicting person-level somatic symptoms at T2 (i.e., somatic symptoms in the past 2 weeks) was fully mediated. The mediation effect size showed that 0.3%, 0.5%, 0.5%, 0.1%, and 0.6% of the variance in negative mood, anxious mood, positive mood, rumination, and somatic symptoms was explained by same-day daytime sleepiness and ethnic/racial discrimination.

Adolescents who reported ethnic/racial discrimination in the past 6 months experienced greater daily daytime...
sleepiness (*path a*). Adolescents who reported greater daily daytime sleepiness experienced higher levels of negative mental health (i.e., negative mood, anxious mood, rumination, and somatic symptoms) and lower levels of positive mood in the past 2 weeks (*path b*). Mediation effects were significant: (1) the model predicting person-level negative mood and somatic symptoms at T2 was fully mediated, and (2) the models predicting person-level anxious mood, positive mood, and rumination at T2 were partially mediated. The mediation effect size *v* showed that 0.3%, 0.5%, 0.4%, 0.4%, and 0.0% of the variance in negative mood, somatic symptoms, anxious mood, positive mood, and rumination was explained by same-day daytime sleepiness and ethnic/racial discrimination.

Taken together, daily daytime sleepiness partially or fully mediated the impact of daily level and prior 6-month ethnic/racial discrimination on mental health outcomes in the past 2 weeks, including negative mood, anxious mood, positive mood, rumination, and somatic symptoms (1-1-2 and 2-1-2 models). Mediation effects via daytime sleepiness in both the 1-1-2 and 2-1-2 models explained ≤1.0% of the variance in the outcomes.

**Supplemental analyses**

**Ethnic/racial differences**

Given ethnic/racial disparities in sleep (Huynh & Gillen-O’Neel, 2013; Slopen & Williams, 2014; Yip et al., 2020), it is possible that the mediating effects of sleep/wake problems differ by ethnic/racial groups. Supplemental MSEMs were conducted separately for Asian and Latinx adolescents; models were not identified for Black youth due to the small sample size (*n* = 76). Results for the Asian subgroup across the four MSEMs observed full mediation effects that were not found in the full sample: Daily daytime sleepiness fully mediated the impact of daily level and prior 6-month ethnic/racial discrimination on positive mood (1-1-1 model: *b* = −.47, *SE* = .20, *p* = .02; 2-1-1 model: *b* = −.18, *SE* = .07, *p* = .02; 1-1-2 model: *b* = −.41, *SE* = .19, *p* = .03; 2-1-2 model: *b* = −.19, *SE* = .09, *p* = .03).

For Latinx adolescents, daily nighttime disturbance partially or fully mediated the effects of daily level and prior 6-month ethnic/racial discrimination on somatic symptoms (1-1-1 model: *b* = .60, *SE* = .23, *p* = .01; 2-1-1 model: *b* = .15, *SE* = .07, *p* = .03; 1-1-2 model: *b* = .60, *SE* = .25, *p* = .02; 2-1-2 model: *b* = .13, *SE* = .05, *p* = .01). These findings suggest that Asian youth might be more sensitive to the effects of daytime sleepiness, whereas Latinx adolescents might be more likely to be impacted by nighttime disturbance.

**Health outcomes as mediators**

Alternative MSEMs were conducted to examine possible mediating effects of daily-level mental health outcomes (i.e., daily negative mood, positive mood, and rumination for the 1-1-1 and 2-1-2 models) on the associations between ethnic/racial discrimination and sleep/wake problems. Results observed: (1) daily negative mood fully mediated the effects of same-day ethnic/racial discrimination on next-day sleep/wake problems (i.e., 1-1-1 model; nighttime disturbance: *b* = .45, *SE* = .11, *p* = .00; daytime dysfunction: *b* = .41, *SE* = .11, *p* = .00; daytime sleepiness: *b* = .67, *SE* = .20, *p* = .00), and partial or full mediation effects were observed for the 2-1-2 model (daytime dysfunction: *b* = .07, *SE* = .04, *p* = .04; daytime sleepiness: *b* = .09, *SE* = .04, *p* = .04); (2) daily positive mood did not mediate the effects of same-day ethnic/racial discrimination on next-day sleep/wake problems (i.e., 1-1-1 model), but partial or full mediation effects were found for the 2-1-2 model (daytime dysfunction: *b* = .06, *SE* = .03, *p* = .03; daytime sleepiness: *b* = .17, *SE* = .06, *p* = .00); and (3) daily rumination partially or fully mediated the effects of ethnic/racial discrimination on sleep/wake problems for the 1-1-1 model (nighttime disturbance: *b* = .26, *SE* = .08, *p* = .00; daytime dysfunction: *b* = .37, *SE* = .10, *p* = .00; daytime sleepiness: *b* = .30, *SE* = .13, *p* = .02) and the 2-1-2 model (nighttime disturbance: *b* = .08, *SE* = .03, *p* = .01; daytime dysfunction: *b* = .13, *SE* = .05, *p* = .01; daytime sleepiness: *b* = .13, *SE* = .05, *p* = .01). As such, these findings support bidirectional associations between daily negative mood and rumination and daily sleep/wake problems.

**Possible method artifacts**

As a test of sensitivity, day of study (i.e., 1–14) was included in all daily-level models, and results are no different from those reported here.

**DISCUSSION**

Although there is strong theoretical support for considering sleep, and sleep/wake problems as biopsychosocial pathways through which exposure to ethnic/racial discrimination and unfair treatment exacts a toll on health (Levy et al., 2016), there has been less empirical support, especially in ethno-racially diverse adolescent samples. The analyses presented here were not preregistered, however, they are considered confirmatory in nature due to existing empirical and theoretical support for the investigated associations. Investigating ethnic/racial discrimination and mental health outcomes at the daily- and person- (i.e., the past 2 weeks) levels, this study investigated the extent to which daily sleep/wake concerns held explanatory power. Adding novelty to the study of adolescent sleep, this investigation considers multiple dimensions of sleep/wake concerns, including disturbances during nighttime sleep, daytime dysfunction, and daytime sleepiness. To our
knowledge, this is the first study to observe that daily indices of sleep/wake problems serve as mediating links between the social stress of ethnic/racial discrimination and mental health. Accordingly, focusing on ways to disrupt this pathway may provide a developmental framework for mitigating the health consequences of ethnic/racial discrimination. Specifically, this study observes that daily sleep experiences can be linked to both daily and longer-term mental health for ethnically diverse adolescents.

The current study was designed so that multiple multilevel models were tested in tandem to provide a more coherent theoretical and empirical story. In common, all four models included sleep/wake problems as a daily-level mediator. From there, these four models were further divided such that two models considered a daily-level mediator and outcome (i.e., 1-1-1, 2-1-1) examining how daily sleep/wake problems are implicated in next-day mental health outcomes. The remaining two models considered a daily-level mediator with a person-level outcome (i.e., 1-1-2, 2-1-2) examining how daily sleep/wake problems are implicated in longer-term, individual differences in mental health outcomes. Taken together, across the three sleep/wake indices (i.e., nighttime disturbance, daytime dysfunction, daytime sleepiness) and the five mental health outcomes (i.e., negative mood, anxious mood, rumination, somatic symptoms, positive mood), there was evidence that sleep-related concerns serve as an explanatory pathway through which ethnic/racial discrimination is implicated in mental health problems.

**Linking ethnic/racial discrimination stress to sleep/wake disturbances**

As hypothesized and as supported by prior research (Cheon et al., 2019; Goosby et al., 2018; Grandner et al., 2012; Hoggard & Hill, 2016; Lewis et al., 2013; Xie et al., 2021), ethnic/racial discrimination was associated with sleep/wake concerns. What this study contributes is a focus on temporal associations such that daily ethnic/racial discrimination was associated with same-day sleep/wake problems. On days in which adolescents experienced ethnic/racial discrimination, they also reported elevated levels of nighttime disturbance, daytime dysfunction, and daytime sleepiness (1-1-1 and 1-1-2 models). Investigating ethnic/racial discrimination in the past 6 months, the data also evidenced associations with the same daily sleep/wake concerns (2-1-1 and 2-1-2 models). Taken together, these analyses suggest that both concurrent and recent past experiences of ethnic/racial discrimination have implications for daily sleep/wake experiences. Although Table S1 reports a significant correlation between daily and past 6-month ethnic/racial discrimination, suggesting an association between concurrent and past discrimination experiences, the timeframes under investigation were not overlapping. This observation raises suggestions for future directions to consider investigating contributions of stability and change in discrimination experiences over time.

**Linking sleep disturbances to mental health**

Also as hypothesized and as supported by prior research (Beatty et al., 2011; Hamilton et al., 2007; Kouros & El-Sheikh, 2015; Shaver & Paulsen, 1993; Wolfson & Carskadon, 1998), the three sleep/wake indicators under investigation were also associated with mental health outcomes of negative mood, anxious mood, rumination, somatic symptoms, and positive mood. Importantly, the multilevel structure of the data allowed for investigation of same- (i.e., 1-1-1 and 2-1-1) and cross-level (i.e., 1-1-2 and 2-1-2) associations. These analyses suggest that prior night’s sleep had significant implications for next-day mental health indices (Kouros & El-Sheikh, 2015). At the same time, the analyses also suggest that sleep/wake issues were associated with how adolescents reported feeling in terms of their overall functioning in the past 2 weeks. This study contributes to research that investigates how sleep is implicated in adolescent mental health, with a specific focus on sleep quality rather than sleep duration (Dewald et al., 2010; Shimizu et al., 2020). Applied to interventions and programming, these data suggest that focusing on sleep quality may be just as important as focusing on sleep duration as a lever for improving adolescent mental health (Davenport et al., 2020).

**Mediated pathways through sleep/wake problems**

Apart from contributing temporal and multilevel research to ethnic/racial discrimination, sleep, and mental health, perhaps the most notable contribution of this study is the investigation of mediated pathways between discrimination and mental health as explained by sleep/wake concerns. Informed by the theoretical formulation outlined by the RDSSC model (Levy et al., 2016), the current study supports conceptualizations of sleep disturbances as intermediary, biological pathways through which ethnic/racial discrimination stress ultimately leads to cascading effects on developmental outcomes. This observation complements existing research focusing on discrimination, sleep, and developmental outcomes (e.g., Goosby et al., 2018; Huynh et al., 2016; Zeiders, 2017). Moreover, the current study contributes a multilevel consideration to the RDSSC model by investigating pathways at both the daily level and across individuals (i.e., person-level) over time.

Results for the person-level outcomes (i.e., 1-1-2 and 2-1-2) as mediated through daily sleep/wake concerns were
largely similar to those for the daily-level outcomes (i.e., 1-1-1 and 2-1-1), underscoring that sleep/wake concerns that bleed into daytime activities have a particularly detrimental impact on mental health. In addition, these results underscore how daily experiences can impact outcomes over time. As supported by the RDSSC model (Levy et al., 2016), these results elaborate a pathway through which daily experiences of discrimination contribute to health disparities over time (Priest & Williams, 2018; Williams & Mohammed, 2009). Contributing to developmental science, this pathway elucidates how repeated experiences of ethnic/racial discrimination can culminate into measurable disparities in mental health over time. The current study included a 2-week snapshot of adolescent lives, and it is important for future research to consider how prolonged and repeated patterns contribute to development, and disparities over time.

Moreover, evidence for full (and partial) mediated effects holds promise for how developmental scientists might develop programs and policies for interrupting the pathways between discrimination and mental health. Meta-analytic contributions make clear the linkages between discrimination and compromised health (Benner et al., 2018; Pascoe & Smart Richman, 2009; Priest & Williams, 2018); what has been less clear is how to mitigate these associations. The current study suggests that focusing on how well adolescents are sleeping, may be a promising avenue for disrupting the harmful mental health effects of discrimination experiences.

In addition to noting significant associations, it is also important to consider which associations were not statistically significant. For example, there was not a significant association between ethnic/racial discrimination and positive mood, which is consistent with meta-analyses finding that this effect is generally weaker than associations with negative mood (Benner et al., 2018; Schmitt et al., 2014). These data suggest that while ethnic/racial discrimination was associated with adolescents feeling worse, it was not associated with them feeling less positive.

In addition to using inferential statistics to investigate mediation effects, we also presented the effect size $\nu$ (Lachowicz et al., 2018). Most partial or full mediation effects had effect sizes that explained ≤1.0% of the variance in the outcomes. Currently, there are no guidelines about acceptable magnitudes of $\nu$. Of note, some full mediation effects had smaller $\nu$ values than the partial mediation effects. This is a cutting-edge topic, that requires additional scholarship to more comprehensively understand the properties of $\nu$.

Supplemental analyses

Group-specific analyses were conducted for the Asian and Latinx subgroups to further interrogate the full sample results. These analyses suggest that there may be the reason to expect differences by ethnicity/race; for example, mediating effects were observed in the Asian subsample but were not observed in the full sample. In the Latinx subsample, a different set of full mediation effects were observed that were not found in the full sample. Specifically, these models suggest that discrimination may be more likely to impact daytime sleepiness for Asian youth whereas discrimination may be more likely to impact nighttime disturbances for Latinx youth. Taken together, these additional analyses suggest that there is reason to further explore group-specific analyses in future research.

Finally, alternative models where mental health was considered as the mediating pathway leading to sleep/wake concerns were also estimated. Together, these analyses suggest that negative mood and rumination were supported as mediating links between ethnic/racial discrimination and some sleep/wake concerns, although not as consistently as models in which sleep/wake concerns served as the mediator. As such, the data provide preliminary evidence for possible bidirectional associations between sleep and negative adjustment indices that should be the focus of future investigation.

CONCLUSIONS AND LIMITATIONS

Although the current study contributes to the developmental science on ethnic/racial discrimination stress, sleep, and adolescent outcomes, it is not without limitations. First, the study relies on adolescent self-reported sleep instead of passive data collected by wrist actigraphy or polysomnography, leaving open the possibility of reporting biases. The research on how self-reported sleep is associated with actigraphy and polysomnography is an active area of research (Lee et al., 2019; Meltzer et al., 2016; Zinkhan et al., 2014). However, all indicators of sleep/wake disturbances come from popular and well-validated measures. Relatedly, the current study only focused on three of many possible sleep indicators (e.g., sleep onset latency, sleep duration, sleep efficiency, sleep regularity) and future studies should consider a broader scope of sleep processes to gather a fuller picture of all the ways in which sleep may be impacted by discrimination. Third, while the current study included proximal, daily reports of mental health, it also incorporated retrospective reports of the recent past (i.e., past 2 weeks), and is therefore subject to possible reporting biases. Also, adolescents in this sample resided in a large, urban and diverse area and their experiences may not generalize to adolescents in other areas since experiences of discrimination and sleep have been found to be associated with contextual variables and neighborhood characteristics (Huynh & Gillen-O’Neel, 2013; Levy et al., 2016). Next, although data collection spanned a 2-week period and included
retrospective reports up to the past 6 months, this topic would benefit from research including a longer period of development. Third, we dichotomized ethnic/racial discrimination (Torres & Ong, 2010), which can result in loss of information, variance, and statistical power (MacCallum et al., 2002). Although there was support for full mediation in several models tested in this paper, the current study does not suggest that sleep/wake problems are the only possible mediating pathway between discrimination and mental health. In fact, there are likely several other processes such as social cognitive processes, social support, executive functioning, and presence of same-race peers that intervene between discrimination and outcomes that are fruitful areas for future research. Lastly, although multiple multilevel mediation models allow for the examination of both within-person and between-person mediation effects of daily sleep, only between-person effects were interpreted in the current study, given that within-person mediation effects were not statistically significant. Future work examining mediation effects at the within-person level would be informative to demonstrate more stringent associations (Curran & Bauer, 2011) among daily ethnic/racial discrimination, sleep/wake problems, and mental health outcomes.

Despite these limitations, the current study makes important contributions to the developmental science of how social experiences of exclusionary and discriminatory behaviors are related to sleep/wake concerns, which in turn, predict compromised mental health among ethno-racially diverse adolescents. These data make clear that discrimination is a public health concern. More importantly, these data also point to the potential to interrupt the impact of ethnic/racial discrimination by focusing on levers of change related to sleep for adolescents. In addition, the study adds to the growing literature about how focusing on sleep health may improve consequent health and development among marginalized youth.

**ORCID**

Tiffany Yip 🐦 https://orcid.org/0000-0001-7488-533X
Mingjun Xie 🐦 https://orcid.org/0000-0003-2032-0389

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