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### AGE AND CHRONOTYPE ASSOCIATED WITH SLEEP TIMING CHANGES DURING COVID-19-RELATED LOCKDOWNS IN THE US

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**Introduction:** Global lockdowns implemented to reduce spread of the Coronavirus Disease 2019 (COVID-19) have offered unique insight into how sleep patterns change when typical social obligations are significantly reduced. Here, we aimed to replicate findings of sleep timing delays and reduced social jetlag during lockdown using a large, regionally-diverse sample of participants from the United States (US). Further, we conducted exploratory analyses to determine if observed sleep changes were associated with age and self-reported chronotype.

**Methods:** A sample of 691 US adults (age 18-89) completed the Ultrashort Munich Chronotype Questionnaire twice during the same assessment: once querying retrospective memory for sleep patterns in the 6-weeks prior to February 1, 2020 (Pre-Lockdown) and a second time for sleep patterns in the 6-weeks prior to ~May 20th (Peak-Lockdown in the US). Participants also completed the abbreviated Morningness-Eveningness Questionnaire to assess chronotype. We compared sleep duration (SDur), sleep onset time (SO), sleep end time (SEnd), social jetlag (SJL; difference between work-day and free-day sleep midpoint) and social sleep restriction (SSR; difference between work-day and free-day sleep duration) Pre- to Peak-Lockdown. We conducted exploratory analyses to determine whether Pre- to Peak-Lockdown changes in these sleep metrics were associated with age or chronotype. Main analyses were preregistered with Open Science Framework (<https://osf.io/4a3fx>).

**Results:** During the Peak-Lockdown period, participants, on average, reported significantly later SO and SEnd times and significantly reduced SJL and SSR compared with the Pre-Lockdown period. Change in SJL and SSR Pre- to Peak-Lockdown was significantly positively associated with age and chronotype such that SJL and SSR decreased more during lockdown in younger participants and those with an evening chronotype.

**Conclusion:** Our results support lockdown-associated sleep timing delays and reduced SJL and SSR. Younger age and evening chronotype were associated with greater reductions in SJL and SSR during lockdown. These findings suggest that individuals, particularly young individuals and those with an evening chronotype, experience greatest desynchrony between intrinsic and social sleep timing when conforming to typical pre-pandemic social schedules.

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### THE ASSOCIATION BETWEEN RECENT CANNABIS USE AND NIGHTLY SLEEP DURATION IN ADULTS IN THE USA FROM 2005-2018

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**Introduction:** Shifts in medicolegal attitudes towards cannabis, coupled with widespread legalization, have led to North America having the highest prevalence of cannabis use worldwide. Amongst other known physiologic effects, regular cannabis use can cause changes to sleep duration and quality. The purpose of this study was to

examine the relationship between recent cannabis use and sleep duration using a nationally representative data set.

**Methods:** A cross-sectional analysis of adults was undertaken using the National Health and Nutrition Examination Survey (NHANES) data from 2005–2018. Respondents were dichotomized by whether or not they had used cannabis in the past 30 days. The primary outcome was inadequate nightly sleep duration, defined as self-reported sleep duration less than 6 hours per night. Secondary outcomes were related to self-reported issues with sleep. Multiple logistic regression was used to adjust for potential confounders and survey sample weights were considered in the model.

**Results:** Compared to those with no recent cannabis use (n=18,631), recent users (n=3,135) were more likely to report less than 6 hours of sleep per night (aOR 1.33 95% 1.13–1.57, p<0.001). Recent users were also more likely to report difficulty falling asleep, staying asleep, or sleeping too much in the past two weeks (aOR 1.21, 95% CI: 1.09–1.35, p<0.001), and having ever mentioned these issues to a physician (aOR 1.21, 95% CI: 1.07–1.37, p=0.003). Respondents using cannabis at least 20 of the past 30 days were characterized as heavy users, and were even more likely than moderate users to report insufficient sleep. These results did not significantly differ between years of survey administration.

**Conclusion:** Recent cannabis use was associated with inadequate nightly sleep duration in adults and demonstrates a dose-dependent relationship. Although this relationship is complex and our findings cannot suggest directionality, they highlight the need to further characterize the sleep health of regular cannabis users in the general population. This is especially prudent as cannabinoids are becoming widely accepted for recreational use and increasingly prescribed as medical therapy.

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### SLEEP DISTURBANCES, ONLINE INSTRUCTION, AND LEARNING DURING COVID-19: EVIDENCE FROM 4148 ADOLESCENTS IN THE NESTED STUDY

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**Introduction:** COVID-19 fundamentally altered education in the United States. A variety of in-person, hybrid, and online instruction formats took hold in Fall 2020 as schools reopened. The Nationwide Education and School in TEens During COVID (NESTED) study assessed how these changes impacted sleep. Here we examined how instruction format was associated with sleep disruption and learning outcomes.

**Methods:** Data from 4148 grade 6-12 students were included in the current analyses (61% non-male; 34% non-white; 13% middle-school). Each student's instructional format was categorized as: (i) in-person; (ii) hybrid [ $\geq 1$  day/week in-person]; (iii) online/synchronous (scheduled classes); (iv) online/asynchronous (unscheduled classes); (v) online-mixed; or (vi) no-school. Sleep disturbances (i.e., difficulty falling/staying asleep) were measured with validated PROMIS t-scores. A bootstrapped structural equation model examined how instructional format and sleep disturbances predict school/learning success (SLS), a latent variable loading onto 3 outcomes: (i) school

engagement (ii) likert-rated school stress; and (iii) cognitive function (PROMIS t-scores). The model covaried for gender, race-ethnicity, and school-level

**Results:** Our model fit well (RMSEA=.041). Examining total effects (direct + indirect), online and hybrid instruction were associated with lower SLS ( $b$ 's: -.06 to -.26;  $p$ 's<.01). The three online groups had the strongest effects (synchronous:  $b$  = -.15; 95%CI: [-.20, -.11]; asynchronous:  $b$  = -.17; [-.23, -.11]; mixed:  $b$  = -.14; [-.19, -.098];  $p$ 's<.001). Sleep disturbance was also negatively associated with SLS ( $b$  = -.02; [-.02, -.02],  $p$ <.001). Monte-carlo simulations confirmed sleep disturbance mediated online instruction's influence on SLS. The strongest effect was found for asynchronous instruction, with sleep disturbance mediating 24% of its effect ( $b$  = -.042; [-0.065, -.019];  $p$ <.001). This sleep-mediated influence of asynchronous instruction propagated down to each SLS measure ( $p$ 's<.001), including a near 3-point difference on PROMIS cognitive scores ( $b$  = -2.86; [-3.73, -2.00]).

**Conclusion:** These analyses from the NESTED study indicate that sleep disruption may be one mechanism through which online instruction impacted learning during the pandemic. Sleep disturbances were unexpectedly influential for unscheduled instruction (i.e., asynchronous). Future analyses will examine specific sleep parameters (e.g., timing) and whether sleep's influence differs in teens who self-report learning/behavior problems (e.g., ADHD). These nationwide data further underscore the importance of considering sleep as educators and policy makers determine school schedules.

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### ADOLESCENT SLEEP VARIABILITY, SOCIAL JETLAG, AND MENTAL HEALTH DURING COVID-19: FINDINGS FROM A LARGE NATIONWIDE STUDY

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**Introduction:** Adolescents are vulnerable to short, insufficient sleep stemming from a combined preference for late bedtimes and early school start times, and also circadian disruptions from frequent shifts in sleep schedules (i.e., social jetlag). These sleep disruptions are associated with poor mental health. The COVID-19 pandemic has impacted education nationwide, including changes in instructional formats and school schedules. With data from the Nationwide Education and Sleep in TEens During COVID (NESTED) study, we examined whether sleep variability and social jetlag (SJL) during the pandemic associate with mental health.

**Methods:** Analyses included online survey data from 4767 students (grades 6-12, 46% female, 36% non-White, 87% high school). For each weekday, participants identified if they attended school in person (IP), online-scheduled synchronous classes (O/S), online-no scheduled classes (asynchronous, O/A), or no school. Students reported bedtimes (BT) and wake times (WT) for each instructional format and for week-ends/no school days. Sleep opportunity (SlpOpp) was calculated from BT and WT. Weekday night-to-night SlpOpp variability was calculated with mean square successive differences. SJL was calculated as the difference between the average sleep midpoint on free days (O/A, no school, weekends) versus scheduled days (IP, O/S). Participants also completed the PROMIS Pediatric Anxiety and Depressive Symptoms

Short Form. Data were analyzed with hierarchical linear regressions controlling for average SlpOpp, gender, and school-level (middle vs high school).

**Results:** Mean reported symptoms of anxiety ( $60.0 \pm 9.1$ ;  $14\% \geq 70$ ) and depression ( $63.4 \pm 10.2$ ;  $22\% \geq 70$ ) fell in the at-risk range. Shorter average SlpOpp (mean= $8.3 \pm 1.2$ hrs) was correlated with higher anxiety ( $r = -.10$ ) and depression ( $r = -.11$ ;  $p$ 's<.001) T-scores. Greater SlpOpp variability was associated with higher anxiety ( $B = .71$  [95%CI=.41-1.01,  $p$ <.001) and depression ( $B = .67$  [.33-1.00],  $p$ <.001) T-scores. Greater SJL (mean= $1.8 \pm 1.2$ hrs; 94% showed a delay in midpoint) was associated with higher anxiety ( $B = .36$  [.12-.60],  $p$ <.001) and depression ( $B = .77$  [.50-1.03],  $p$ <.001) T-scores.

**Conclusion:** In the context of system-wide education changes during COVID-19, students on average reported at-risk levels of anxiety and depression symptoms which were associated with greater variability in sleep opportunity across school days and greater social jetlag. Our findings suggest educators and policymakers should consider these sleep-mental health associations when developing instructional formats and school schedules during and post-pandemic.

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### CHANGES IN CHILDREN'S SCHOOLYEAR AND SUMMER SLEEP DURING THE COVID-19 PANDEMIC

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**Introduction:** In spring 2020, elementary schools closed to minimize the spread of COVID-19. Questionnaire data suggest children's sleep was impacted during the pandemic, yet device-based data (i.e. accelerometry) on this topic is lacking. The purpose of this study was to examine children's sleep during the COVID-19 pandemic (i.e. spring and summer 2020) compared to previous data collected from the same children during each of the two previous years (spring and summer 2018 and 2019).

**Methods:** 68 children (age =  $9.9 \pm 1.2$  years, 56% Black, 53% male) previously recruited for an observational cohort study wore a Fitbit Charge 2 on their wrist during the spring and summer from 2018-2020 (i.e. six 30-day measurement periods). We used multilevel mixed models to examine how children's sleep patterns changed during the pandemic accounting for previous trajectory (i.e. 2018 to 2019). Models included age, sex, and race as covariates.

**Results:** Children had an average of 84 nights of sleep data across all six 30-day measurement periods. In the spring of the pandemic, children slept 24.6 minutes more (95%CI = 11.6, 37.5) compared to previous springs. During the pandemic summer, they slept 40.0 minutes more (95%CI = 24.6, 58.5) compared to previous summers. Sleep midpoint was 117.1 minutes later (95%CI = 103.6, 130.6) in the spring during the pandemic and 46.0 minutes later (95% CI = 26.9, 65.2) in the summer during the pandemic compared to previous years. Sleep efficiency improved slightly by 1.3% (95% CI = 0.7, 1.9) and 3.6% (95% CI = 2.7, 4.5) in spring and summer, respectively, during the pandemic compared to previous years.

**Conclusion:** During the COVID-19 pandemic, children slept longer after accounting for previous developmental trends. Notably, the shift in sleep timing during the pandemic was nearly two hours later in the spring compared to previous years, potentially due to the lack of structure usually provided by school. Later sleep timing is independently associated with poor health behaviors (e.g., nutrition, physical activity, screen time). Future studies should examine if these changes in sleep