## Title

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## Authors

Yang, Chun-Chi
Hinshaw, Stephen P

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*Article*

# Associations Between Dimensional Persistence of ADHD and Adult Sleep Quality in a Prospective Study of Girls

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**Chun-Chi Yang[1] and Stephen P. Hinshaw[1,2]**

## Abstract

**Objectives:** We investigated the prospective association between (a) ADHD symptom dimensions, including their persistence and (b) adult sleep quality in a female sample, covarying adult depressive symptoms.

**Methods:** Participants comprised four persistence groups (persisters, partials, desisters, and comparison) based on overall ADHD diagnosis and separate dimensions of inattention and hyperactivity/impulsivity (HI) in childhood, late adolescence, and early adulthood, featuring girls with ($n = 140$) and without ($n = 88$) carefully diagnosed ADHD.

**Results:** Only persistence of inattention predicted lower adult sleep quality when covarying young-adult depression, which was also a significant predictor. When additionally covarying stimulant medication use in adulthood, inattention persistence lost significance, although depression maintained significance, with medication use predicting worse sleep quality.

**Conclusions:** Persistence of inattentive (but not HI) symptoms was significantly related to adult sleep quality in the context of concurrent depression. Sleep quality is an important outcome for research on and treatment for ADHD. *(J. of Att. Dis. 2023; 27(7) 777-785)*

## Keywords

ADHD persistence, inattention, HI, sleep, depression

The prevalence of ADHD, a common and highly impairing neurodevelopmental disorder, is estimated at 5% to 6% of youth under 18 worldwide (Polanczyk et al., 2014). The prevalence for adults is estimated to be about half of that figure (Faraone et al., 2015), although many adults with childhood histories of ADHD sustain lingering impairments even if symptom thresholds are no longer met (Sibley et al., 2022). ADHD is associated with a wide range of functional impairments and co-occurring disorders (Biederman et al., 2015; Caye et al., 2016; Owens et al., 2017; Hinshaw et al., 2022).

Relevant to the current investigation, up to 70% of individuals with ADHD report sleep disturbances and low sleep quality (e.g., difficulty falling asleep or maintaining sleep; see Kirov & Brand, 2014; Mulraney et al., 2016; Schredl et al., 2007; Sung et al., 2008). Sleep problems have adverse implications for attentional processes and executive functions (Turnbull et al., 2013), domains in which individuals with ADHD are already compromised (Diaz-Roman et al., 2018). Interest in sleep problems among individuals with ADHD is surging (Becker, 2020). Indeed, the relation between sleep issues and ADHD symptoms may be bidirectional and even transactional, in that sleep problems exacerbate ADHD symptom severity, which may perpetuate sleep problems (Dahl, 1996; Gregory et al., 2017; Hvolby, 2015; Voinescu et al., 2012). Diaz-Roman et al. (2018) highlighted a significant association between adult ADHD and a number of indicators of poor sleep quality (e.g., worse overall sleep, increased sleep onset latency, lower sleep efficiency). Such findings align with those from meta-analytic reviews of children and adolescents (Cortese et al., 2009).

Sleep-related issues related to ADHD span various age groups, as previous studies have revealed sleep problems in children (e.g., Lycett et al., 2014), adolescents (e.g., Becker et al., 2020; Hysing et al., 2016), and adults (e.g., Diaz-Roman et al., 2018). Most pertinent investigations have examined ADHD as a categorical construct—that is, those who meet criteria for ADHD, including the Inattentive and Combined types, versus comparison samples—rather than examining relations with the underlying symptom dimensions of inattention and hyperactivity/impulsivity (HI; Hysing et al., 2016). For example, Mayes et al. (2009) found that individuals with the combined presentation of ADHD (ADHD-C) had increased risk of sleep problems.

[1]University of California, Berkeley, USA
[2]University of California, San Francisco, USA

**Corresponding Author:**
Chun-Chi Yang, Department of Psychology, University of California, 2121 Berkeley Way, Berkeley, CA 94720, USA.
Email: youngsarah00@berkeley.edu

On the other hand, Lundervold et al. (2017) and Frick et al. (2022) showed, in children and adolescents, that sleep disturbances were concentrated in those with inattentive symptoms. Given such mixed findings, we aim to understand whether investigating these dimensions separately can provide greater insights into relevant associations over time.

There is growing evidence that individuals with ADHD are affected by sleep problems across life span (Cortese et al., 2009; Diaz-Roman et al., 2018). Importantly, Gregory et al. (2017) indicated that childhood ADHD prospectively predicted worse overall sleep quality by young adulthood. Poor sleep is particularly related to lowered executive functioning and emotional dysregulation among subsets of individuals with ADHD (Becker, 2020). However, how ADHD symptom domains are associated with subsequent sleep problems remains elusive. Herein, we focus on subjective sleep quality derived from a well-established and validated self-report measure (Pittsburgh Sleep Quality Index), during our adult follow-up of a prospectively examined sample. Although objective measures of sleep (i.e., actigraphy and polysomnography) are often considered as a gold standard, subjective reports are also crucial. Although we were not able to utilize objective sleep measures in our investigation, we used data from a well-established and validated self-report measure (Pittsburgh Sleep Quality Index; Buysse et al., 1989).

Crucially, little research has examined the *persistence* of ADHD symptoms across time in predicting adult sleep outcomes. Despite a growing body of research revealing that ADHD symptoms often persist into adulthood (Sibley et al., 2016, 2022; Simon et al., 2009), two issues are salient. First, rates of persistence versus desistance vary as a function of definitions of ADHD across development, including symptom cutoffs (Sibley et al., 2016). As indicated by Owens et al. (2017), some impairments in adulthood are quite predictable from ADHD persistence over time (e.g., self-harm, co-occurring psychopathology, occupational success) whereas others are salient even when ADHD symptoms appear to desist after childhood (e.g., academic problems, unplanned pregnancies). Unknown, however, is whether the presence of adult sleep problems is a function of ADHD symptom persistence versus desistence. Second, little work has investigated the persistence of ADHD for its separable symptom dimensions (inattention vs. HI).

Several additional factors are critical. First, the association between sex/gender and ADHD-related sleep issues is of importance. Far more longitudinal research exists on males with ADHD than females, reflecting a longstanding gender bias in the field (Hinshaw et al., 2022). A key goal, therefore, is to readdress the sex imbalance in prospective research, given that functional impairments and psychiatric comorbidities are prevalent among girls with ADHD followed into adulthood (Hinshaw et al., 2022; Owens et al., 2017). In particular, females are more likely than males to display the inattentive presentation of ADHD, and inattentive symptoms are more likely to persist over time than hyperactive-impulsive symptoms. Males with ADHD are more likely than females to present with externalizing symptoms and disruptive behaviors, especially in childhood and adolescence (Lau et al., 2021; Mowlem et al., 2019). Yet females with ADHD often present with or develop greater numbers of internalizing symptoms—which become especially salient by adolescence and adulthood (Young et al., 2020). Notably, girls with ADHD experience more sleep problems (e.g., difficulty in getting up in the morning, interrupted sleep, and high rates of daytime sleepiness) than boys with ADHD (Becker et al., 2018). Yet findings on sleep-related impairments in women with histories of childhood ADHD are sparse.

We highlight that depressive symptoms are (a) often co-occurring with ADHD in adolescence and beyond and (b) themselves strongly associated with sleep quality (Gregory et al., 2017). It is unclear whether sleep problems experienced by individuals with ADHD are linked specifically to ADHD symptoms or instead to co-occurring internalizing symptoms, particularly depression (Cortese et al., 2013; Frick et al., 2022). Therefore, we investigate the association between ADHD in childhood—and especially, symptom persistence across development—and adult sleep quality while adjusting for concurrent depression in adulthood.

In sum, per the contentions of Cortese (2015) and Gregory et al. (2017), most studies of sleep and ADHD examine children, but far less is known about sleep disturbances in adults with childhood histories of ADHD, especially girls and women. Additionally, too little is known about (a) ADHD symptom dimensions and (b) the persistence of these dimensions as related to sleep problems in young adulthood (Gregory et al., 2017). Depressive symptoms should be accounted for in relevant research, given their high levels of comorbidity with ADHD (especially in females) and their linkages with sleep-related problems.

First, we hypothesize that girls with carefully diagnosed ADHD in childhood will display greater levels of sleep-related problems than a carefully matched comparison sample, even when taking into account key childhood covariates. Second, we hypothesize that persistence of ADHD symptoms from childhood through early adulthood will be associated with decreased sleep quality in adulthood. We do not make an explicit hypothesis as to which dimension (i.e., inattention vs. HI) will have a larger effect on subsequent sleep quality, because of the lack of consistent findings in the literature reviewed above. Still, we suspect that, as with other areas of ADHD-related impairment (e.g., substance use—see Hechtman et al., 2016; Molina & Pelham, 2014; Owens et al., 2017; driving—see Merkel et al., 2016; Owens et al., 2017), the role of inattention could well be prominent. Finally, we hypothesize that such prediction from ADHD symptom dimension persistence will hold true even with statistical adjustment for key childhood covariates and adult

levels of depressive symptoms. We also examine whether reported use of stimulant treatment in adulthood will influence adult sleep.

## Method

### Participants

Data emanate from a longitudinal, four-wave study (spanning 16 years), of girls with carefully diagnosed ADHD and an race/ethnicity- and age-matched comparison group. The baseline (Wave 1) procedures involved extensive data collection from both clinical assessments and a 5-week summer program affording multi-informant evaluations of a number of core domains of impairment and strength. Participants comprised an ethnically and socioeconomically diverse sample, aged 6 to 12 years ($M_{age}$ = 9.6 years, $SD$ = 1.7), both with ($n$ = 140) and without ($n$ = 88) DSM-IV diagnosed ADHD. Of those with ADHD, 93 met criteria for the Combined type and 47 for the Inattentive type. Subsequent assessments were performed during early-mid adolescence (Wave 2; aged 11–18 years; $M_{age}$ = 14.5 years—this wave not included in the present investigation), emerging adulthood (Wave 3; aged 17–24 years; $M_{age}$ = 19.6 years), early adulthood (Wave 4; years 22–29 years; $M_{age}$ = 25.6 years). Participant retention rates ranged from 92% to 95% across waves.

This sample included 53% White, 27% African American, 11% Latina, and 9% Asian Americans, who were recruited from a large urban area. Families participating in this research project ranged, in terms of income, from receipt of public assistance to professional-level parents. For participants with and without ADHD, common comorbidities (e.g., internalizing disorders of anxiety and depression and disruptive behavior disorders) were allowed, but we excluded for both groups intellectual disabilities, pervasive developmental disorders, psychosis or overt neurological disorder, serious medical problems, and those who did not speak English at home (Hinshaw, 2002).

### Measures

*ADHD Diagnoses.* We used methodology consistent with Owens et al. (2017) to measure ADHD diagnostic status and symptom presence from childhood through adulthood, extending those methods to capture the persistence of both inattention and HI. At Wave 1, both the Swan, Nolan, and Pelham Rating Scale, 4th ed. (SNAP-IV—both parent and teacher reports) and parent report on the Diagnostic Interview Schedule for Children, 4th ed. (DISC-IV; Shaffer et al., 2000) were used to determine if participants met full criteria for ADHD and subsequent eligibility into the study, as well as the presence of symptoms of hyperactivity/impulsivity (HI), and inattention (IA). For full details, see Owens et al. (2017). We applied the same criteria at Wave 3.

At Wave 4, the SNAP-IV was the primary ADHD symptom measure. We used an "or" algorithm (symptom counted if either the parent or the participant endorsed it at a level of 2 or 3). Following the recommendations by Sibley et al. (2016), we reduced the norm-based cutoff threshold to 4 inattentive and/or hyperactive/impulsive symptoms to improve diagnostic sensitivity. Please note that for all participants at all waves, we asked them not to take stimulant medications 2 weeks prior to their lab follow-up visit.

Regarding ADHD presentation groups, for participants with ADHD at W1, DISC-IV, and SNAP-IV were administered to both parents and participants. A symptom was considered present if either the parent or the participant endorsed the symptom on the DISC-IV or if the symptom was rated as a 2 (pretty much) or 3 (very much) on the SNAP-IV by the parent or participant. A participant with at least six inattentive and six HI symptoms (with at least four in each domain on DISC-IV) were placed in the ADHD-C group. Girls with at least six inattentive symptoms (with at least four on DISC-IV) but fewer than six HI symptoms were classified into ADHD-I group. Both the DISC-IV and SNAP-IV are validated and extensively used in ADHD treatment and research (Hall et al., 2020; Wright et al., 2006; Owens et al., 2017).

*ADHD Persistence Classifications.* For the independent variable of ADHD persistence, we first used the ADHD persistence-group classification methodology from Owens et al. (2017). For participants with ADHD at Wave 1, we classified participants into three groups: Desisters, Partials, and Persisters. Participants were classified as Desisters if they endorsed threshold symptoms at Wave 1, but not at Waves 3 or 4 ($n$ = 32). Participants were classified as Partials if they endorsed symptoms at Wave 1 and Waves 3 *or* 4 ($n$ = 38). Participants were classified as Persisters if they endorsed symptoms at Waves 1, 3, *and* 4 ($n$ = 53). Comparison participants at W1 remained designated as comparisons across subsequent waves.

We then applied the Owens et al. (2017) criteria to ascertain persistence with respect to inattention versus HI separately. Regarding inattention, participants at Wave 1 with either ADHD-I or ADHD-C had high levels of inattention (with six or more inattention symptoms). At Wave 3, we applied the same threshold to determine their inattention and HI status. However, at Wave 4, as Sibley et al. (2016) recommended, we reduced the cutoff threshold to 4 for determination of persistence groups. Following Owens et al. (2017), we placed a participant into the Persister subgroup if her inattention status was positive at Wave 1, Wave 3, and Wave 4 ($n$ = 53); into the Partial subgroup if her inattention status was positive at Wave 1 and at either Wave 3 or Wave 4 ($n$ = 40); or into the Desister group if her inattention status was positive at Wave 1, but not at Wave 3 and Wave 4 ($n$ = 30). We applied the same criteria for HI persistence—but here, we could

**Table 1.** Childhood ADHD Group Versus Comparison Group on Adult Sleep Quality.

| | PSQI | | |
|---|---|---|---|
| | Model 1[a] | Model 2[b] (+W1 covariates) | Model 3[c] (+W4 BDI) |
| Comparison vs. ADHD | $F$ (1, 203) = 4.849*<br>$\eta^2$ = 0.023<br>[95% CI: 0.00, 0.078] | $F$ (1, 196) = 3.918*<br>$\eta^2$ = 0.020<br>$B$ = −1.140<br>[95% CI: −2.275, −0.004] | $F$ (1, 191) = 1.213<br>$\eta^2$ = 0.006<br>$B$ = −0.580<br>[95% CI: −1.619, .459] |

aGroup difference between childhood ADHD group and comparison group without covariates.
[b]W1 covariates added to the analysis.
[c]W4 depression level added to the analysis.
*$p < .05$.

examine only those participants in the childhood-diagnosed ADHD-C group. For them, HI persistence designations included 19 as Persisters, 25 as Partials, and 38 as Desisters. See Table 2 for summary statistics.

*Sleep Quality.* At Wave 4, participants completed the Pittsburgh Sleep Quality Index questionnaire (PSQI; Buysse et al., 1989) to assess different facets of overall sleep quality. The PSQI is an 18-item self-report measure of seven components of overall sleep quality: perceived sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medications, and daytime dysfunction. For the overall sleep quality scores, we followed scoring instructions (Buysse et al., 1989) by summing converted scores from the seven subscales. The PSQI has been extensively used, with ample validation in young adults (Grandner et al., 2006). Higher overall scores indicate poorer sleep quality.

*Covariates.* At Wave 4 participants completed the Beck Depression Inventory-II (BDI-II; Beck et al., 1996). The BDI-II is a 21-item self-report measure that has been extensively used in research and clinical practice for depression diagnosis. We analyzed the total score, except that we excluded the sleep-related item (#16) to avoid any confounding effect.

In terms of other covariates, at Wave 1 we obtained self-report measures of family yearly income and maternal education level, which we averaged as an indicator of family socioeconomic status (SES). We also covaried participant age at Wave 1. Finally, as a secondary analysis, because (in this naturalistic follow-up investigation) some participants with ADHD received stimulant medications at various phases of their lives. We examined the use of stimulant medications between Waves 3 and 4 as an additional covariate (a total of 53 of the 140 participants with childhood ADHD had received such stimulant treatment). Indeed, stimulant medication can affect sleep (Kidwell et al., 2015).

### Data Analytic Plan

All statistical analyses were performed using SPSS v.27. Before we conducted the ANOVA and ANCOVA analyses for our hypotheses, we compared group means and standard deviation for the persistence groups in sleep quality and depression severity. For our first hypothesis, we investigated the relation between childhood ADHD and adult sleep quality. Participants with childhood ADHD ($n$ = 140) were contrasted with the comparison group ($n$ = 88). We used this clinical classification as the independent variable, and the total PSQI overall sleep quality score at Wave 4 as the dependent variable, covarying participant age and family SES at Wave 1. We also covaried adult depression symptoms.

For Hypothesis 2, to examine the association between overall ADHD symptom persistence and sleep quality in adulthood, we first conducted a one-way ANOVA, with post-hoc contrasts across the four persistence classifications (Persisters, Partials, Desisters, and Comparisons). We then conducted a parallel one-way ANCOVA, covarying family SES and participant age at Wave 1. In a final ANCOVA, we additionally covaried concurrent depression—that is, depression severity at Wave 4. We then repeated these analyses for the separate persistence groups for inattention versus HI. That is, we conducted a one-way ANOVA with post-hoc contrasts across the three persistence groups and the comparison group, followed by two parallel one-way ANCOVAs, one covarying family SES and participant age at Wave 1 and the other adding depression level at Wave 4 as well. Finally, we re-conducted these analyses with the additional covariate of stimulant medication use between Waves 3 and 4.

## Results

### Hypothesis 1

First, we investigated the relation between childhood ADHD and adult sleep quality, finding significant results ($F$ = 4.849, $p$ = .029), after covarying W1 SES and age ($F$ = 3.918, $p$ = .049). That is, a diagnosis of ADHD in childhood predicted lower sleep quality. Yet ADHD became insignificant after covarying W4 depression severity ($F$ = 1.213, $p$ = .272; see Table 1), which itself had a significant effect on sleep quality.

**Table 2.** Distribution of ADHD Persistence Groups.

| | Overall ADHD groups frequency (%) | Inattention groups frequency (%) | HI groups frequency (%) |
|---|---|---|---|
| Persisters | 53 (25) | 53 (26) | 19 (11) |
| Partials | 38 (18) | 40 (19) | 25 (15) |
| Desisters | 32 (14) | 30 (15) | 38 (23) |
| Comparison | 85 (41) | 84 (41) | 84 (51) |

### *Hypothesis 2*

Next, we investigated the relation between overall ADHD persistence and adult sleep quality. In the one-way ANOVA between overall ADHD persistence groups (Table 2) and adult sleep quality, results attained significance ($F=6.380$, $p<.001$; Table 5). Post hoc comparisons revealed significant group mean differences between the comparison and persister groups ($B=-2.724$, $p<.001$) and the desister and persister groups ($B=-3.153$, $p=.003$; Table 3). In each case, the persisters reported worse sleep quality.

Next, regarding the persistence of inattention and HI (Table 2), we calculated group means and standard deviation of sleep quality in young adulthood for each group (Table 3), followed by Tukey *post hoc* comparison tests. As shown in Table 5, each ANOVA yielded statistically significant ($p<.01$) differences across the overall ADHD persistence classification ($F=6.380$, $p<.001$), the inattention classification ($F=7.226$, $p<.001$), and the HI persistence classification ($F=4.655$, $p=.004$). In parallel to the overall ADHD persistence group findings, significant differences were found between (a) persister and comparison groups and (b) persister and desister groups regarding inattention ($B=-2.784$, $p<.001$; $B=-3.510$, $p<.001$, respectively) and HI ($B=-3.660$, $p=.002$; $B=-3.259$, $p=.018$, respectively; Table 3). Again, the persisters reported worse sleep quality.

We then calculated group means and standard deviations of depression severity level in young adulthood for each persistence group and computed Tukey post hoc comparison tests (Table 4). In the overall ADHD persistence groups, mean differences were found between persister and comparison groups ($B=-9.262$, $p<.001$), between persister and desister groups ($B=-9.102$, $p<.001$), and between persister and partial groups ($B=-8.590$, $p<.001$). Similar patterns were found regarding inattention ($B=-9.457$, $p<.001$, $B=-9.349$, $p<.001$, and $B=-8.450$, $p<.001$, respectively) and HI ($B=-14.350$, $p<.001$, $B=-13.302$, $p<.001$, and $B=-8.875$, $p=.011$, respectively), persistence groups. For HI persistence groups, mean differences were found between partial and comparison groups ($B=-5.474$, $p=.050$) as well. As expected, the greater the levels of persistence, the higher the depression scores at Wave 4.

We then conducted ANCOVAs to investigate the associations between ADHD/inattention/HI persistence groups and adult sleep quality while covarying Wave 1 SES (annual household income and maternal education) and participant age, plus concurrent depression severity level at Wave 4. Group differences remained significant at the $p<.05$ level (Table 5). Yet after additionally covarying Wave 4 depression, only inattention persistence remained statistically significant at the $p<.05$ level (Table 5). That is, persistence of inattention (but not HI or overall ADHD) was significantly related to self-reported sleep problems in adulthood when adjusting for concurrent levels of depressive symptoms in adulthood.

Realizing that symptoms of anxiety and depression are highly associated, we conducted an additional analysis, finding that covarying W4 anxiety symptoms revealed significance for anxiety as well, with a same pattern as for depression (i.e., only the inattention persistence group showed lower adult sleep quality). Yet because of our hypothesis regarding depression, we consider the anxiety finding as exploratory.

Finally, we repeated the latter analyses, now adding use of stimulant medications between Waves 3 and 4 as a final covariate. In these analyses (data available upon request), the stimulant use variable had a significant effect regarding poor Wave 4 sleep quality—and its presence rendered the effect of inattention persistence to non-significance. That is, only depression severity remained as a predictor of poor sleep quality.

## Discussion

We performed a prospective longitudinal study regarding the link between (a) persistence of ADHD symptom dimensions (as well as overall ADHD diagnostic status) from childhood across the next 16 years and (b) sleep quality in young adulthood. We leveraged a diverse, well-characterized, all-female sample of girls carefully diagnosed ADHD and matched comparisons. Our key findings were as follows. First, as hypothesized, childhood ADHD status was significantly predictive of lowered sleep quality by young adulthood, with and without covariation of childhood demographic factors. Yet when contemporaneous, young-adult depressive symptoms were also covaried, prediction from childhood ADHD to young-adult sleep quality was no longer significant. Concurrent depression in young adulthood was the more powerful predictor. Second, regarding the key question of whether the persistence of ADHD symptoms over time—both overall and in terms of the two core dimensions of inattention versus HI separately—we found that persistence of overall ADHD as well as each core dimension was linked to sleep quality in adulthood. Findings withstood covariates of childhood family SES and participant age. Yet when we also covaried concurrent depressive symptoms in early adulthood in these latter analyses, we found that only persistence of inattentive symptoms across development (but not HI symptom persistence) remained significantly linked to sleep quality in adulthood.

**Table 3.** Sleep Quality Index for Each Persistence Group in Each Category.

| Sleep quality *M* (*SD*) | Overall ADHD groups | Inattention groups | HI groups |
|---|---|---|---|
| Persisters | 9.65 (3.96)[a] | 9.65 (3.96)[b] | 10.53 (3.47)[c] |
| | [CI: 8.52, 10.79] | [CI: 8.52, 10.79] | [CI: 8.75, 12.31] |
| | 46 (87%)[d] | 46 (87%)[d] | 17 (89%)[d] |
| Partials | 7.68 (3.64) | 7.88 (3.85) | 7.92 (3.28) |
| | [CI: 6.49, 8.88] | [CI: 6.64, 9.11] | [CI: 6.53, 9.30] |
| | 32 (84%)[d] | 34 (85%)[d] | 21 (84%)[d] |
| Desisters | 6.50 (3.33)[a] | 6.14 (2.77)[b] | 7.27 (3.58)[c] |
| | [CI: 5.26, 7.74] | [CI: 5.07, 7.22] | [CI: 6.08, 8.46] |
| | 23 (72%)[d] | 21 (70%)[d] | 29 (76%)[d] |
| Comparison | 6.93 (3.99)[a] | 6.87 (3.98)[b] | 6.87 (3.98)[c] |
| | [CI: 6.07, 7.79] | [CI: 6.01, 7.73] | [CI: 6.01, 7.73] |
| | 63 (75%)[d] | 62 (74%)[d] | 62 (74%)[d] |

[a]Significant group differences between the persister and desister groups ($p < .001$) and between the persister and comparison groups ($p = .003$).
[b]Significant group differences between the persister and comparison groups ($B = -2.784$; $p < .001$) and between the persister and desister groups ($B = -3.510$; $p < .001$).
[c]Significant group differences between the persister and comparison groups ($B = -3.660$; $p = .002$) and between the persister and desister groups ($B = -3.259$; $p = .018$).
[d]The number of participants (percentage of participants in that group) identified to have severe poor sleep quality (PSQI score $\geq 5$).

**Table 4.** Depression Severity for Each Persistence Group in Each Category.

| Depression *M* (*SD*) | Overall ADHD groups | Inattention groups | HI groups |
|---|---|---|---|
| Persisters | 16.27 (10.85)[a] | 16.27 (10.85)[b] | 21.17 (12.01)[c] |
| Partials | 7.83 (7.29)[a] | 7.68 (7.25)[b] | 12.29 (10.06)[c,d] |
| Desisters | 6.93 (6.80)[a] | 7.17 (6.92)[b] | 7.86 (8.32)[c] |
| Comparison | 6.82 (8.35)[a] | 7.01 (8.49)[b] | 6.82 (8.35)[c,d] |

[a]Significant group differences between the persister and comparison groups ($B = -9.262$, $p < .001$), the persister and desister groups ($B = -9.102$, $p < .001$), and between the persister and partial groups ($B = -8.590$, $p < .001$).
[b]Significant group differences between the persister and comparison groups ($B = -9.457$, $p < .001$), the persister and desister groups ($B = -9.349$, $p < .001$), and between the persister and partial groups ($B = -8.450$, $p < .001$).
[c]Significant group differences between the persister and comparison groups ($B = -14.350$, $p < .001$), the persister and desister groups ($B = -13.302$, $p < .001$), and between the persister and partial groups ($B = -8.875$, $p = .011$).
[d]Significant group differences between the partial and comparison groups ($B = -5.475$, $p = .050$).

**Table 5.** ANOVA and ANCOVA results.

| | PSQI | | |
|---|---|---|---|
| | Model 1[a] | Model 2[b](+W1 covariates and stimulant medication use) | Model 3[c] (+W4 BDI) |
| ADHD persistence groups | $F$ (3, 198) = 6.380*** | $F$ (3, 188) = 3.881** | $F$ (3, 186) = 2.169 |
| | $\eta^2 = 0.088$ | $\eta^2 = 0.058$ | $\eta^2 = 0.034$ |
| | [95% CI: 0.020, 0.159] | $R^2 = .116$ (A. $R^2 = .084$) | $p = .093$ |
| Inattention persistence groups | $F$ (3, 197) = 7.226*** | $F$ (3, 190) = 4.460*** | $F$ (3, 185) = 2.940* |
| | $\eta^2 = 0.099$ | $\eta^2 = 0.067$ | $\eta^2 = 0.046$ |
| | [95% CI: 0.026, 0.173] | $R^2 = .128$ (A. $R^2 = .095$) | $R^2 = .254$ (A. $R^2 = .225$) |
| HI persistence groups | $F$ (3, 158) = 4.655** | $F$ (3, 153) = 2.017 | $F$ (3, 150) = .632 |
| | $\eta^2 = 0.081$ | $\eta^2 = 0.039$ | $\eta^2 = 0.012$ |
| | [95% CI: 0.010, 0.158] | $p = .114$ | $p = .595$ |

[a]ANOVA model, independent variable: ADHD/inattention/HI persistence groups, dependent variable: sleep quality.
[b]ANCOVA, with SES and participants' age at Wave 1, and stimulant medication use between Wave 3 and 4 as covariates.
[c]ANCOVA, with one more covariate: depression severity level at W4.
*$p < .05$. **$p < .01$. ***$p < .001$.

In short, the persistence of inattentive symptoms, across time, predicted young-adult sleep quality, even in the presence of the more powerful predictor of young-adult depressive symptoms. These findings align with those of Lundervold et al. (2017) and Frick et al. (2022), clarifying the association between ADHD-related issues and adult sleep problems, such that inattentive but not HI symptoms may comprise the key factor—at least in an all-female sample. Although HI symptoms (and their persistence) were initially associated with later sleep quality, this association lost significance after covarying adult depressive symptoms. As females with ADHD are more likely than males to display exclusively or largely inattentive symptoms, which may grow even more salient by adolescence and adulthood (Fisher et al., 2014; Young et al., 2020), these sex-specific discoveries may help us understand more about ADHD-related impacts in females.

As might be expected developmentally, we found a higher proportion of desisters in HI persistence than in inattention persistence, aligning with previous research findings that inattention symptoms tend to persist while HI symptoms wane (Greven et al., 2011; Young et al., 2020). The finding that ADHD symptom persistence (particularly related to inattention) predicts adult sleep quality reflects earlier literature (Gregory et al., 2017; Lycett et al., 2014). We recommend that interventions for adults with ADHD focus on (a) dealing with comorbid depression (as well as anxiety) and (b) improving attentional capacities. Multimodal treatments should include transdiagnostic interventions for sleep (Harvey, 2016) to reduce such impairment.

Finally, however, when we added the variable of stimulant medication use between Waves 3 and 4—which predicted worse sleep quality at Wave 4, the persistence of inattentive symptoms lost significance (but concurrent depression remained a significant factor). These findings are ambiguous, given that our investigation comprises a naturalistic longitudinal study rather than a randomized clinical trial. First, it may well be the case that the use of stimulant medications in adulthood is a proxy for more impairing symptoms of ADHD—which may incur worse sleep quality. As well, a known side-effect of stimulants (especially if used late in the day) is impaired sleep. Again, in a study such as ours, we cannot be certain.

### *Clinical Implications and Limitations*

In this study we investigated the associations between ADHD/inattention/HI persistence and young adult sleep problems using a developmental psychopathology framework to help clarify longitudinal relations. As depression is prevalent emotional disorder among females with ADHD, especially beginning in adolescence (Gregory et al., 2017; Young et al., 2020), we recommend that depression should be routinely treated in females with ADHD.

As for limitations, although the PSQI is a well-validated subjective measure of sleep quality, the addition of objective sleep indicators is needed in subsequent research (Diaz-Roman et al., 2018). We note that self-report measures span periods of weeks, whereas objective measures typically span one or at most several nights. For future research, a combination of subjective and objective sleep quality measurements would be ideal.

Additionally, we applied SNAP-IV, not a gold-standard interview, as the single measure for ADHD diagnosis at Wave 4 in order to keep the same measure at each wave of data collection in our longitudinal project. Furthermore, we had less statistical power to test HI persistence as a predictor of adult sleep quality, given that a third of the ADHD sample was initially diagnosed with the Inattentive presentation, lacking clinically significant HI symptoms. Finally, parallel investigations in males with ADHD would be an important step.

## Conclusion

The current findings add evidence to a growing knowledge base on ADHD and sleep. Herein, we examined and confirmed that females with high levels of persistent inattention are particularly likely to display adult sleep problems, beyond levels of concurrent depressive symptoms, although such depression was the stronger predictor. Additional basic and clinical research on mechanisms related to, and interventions for, sleep problems linked with ADHD are clearly indicated.

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### ORCID iD

Chun-Chi Yang https://orcid.org/0000-0002-5399-5908

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## Author Biographies

**Chun-Chi Yang,** MA is a project coordinator and scientist-in trainig in Hinshaw Lab in the Department of Psychology at UC Berkeley.

**Stephen P. Hinshaw**, PhD is a clinical psychologist who focuses on developmental psychopathology; he is Distinguished Professor of Psychology at the University of California, Berkeley.