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# Sleep Rhythm Profiles and Attention-Deficit/Hyperactivity Disorder Among US Children: The Role of Family Resilience

**Md Roungu Ahmmad**

ahmmad@usf.edu

University of South Florida

**Md Shahinuzzaman**

University of New Mexico

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## Abstract

# Background

Age-specific sleep sufficiency and regularity are complementary dimensions of pediatric sleep health, but their composite association with attention-deficit/hyperactivity disorder (ADHD) remains unclear. We examined associations between Sleep Rhythm Profiles (SRPs) and ADHD and whether family resilience modified these associations.

# Methods

We analyzed pooled 2022–2023 National Survey of Children's Health data for children aged 6–17 years. SRPs were derived from age-specific sleep sufficiency and bedtime regularity and classified as Adequate-Regular (AR), Adequate-Irregular (AI), Insufficient-Regular (IR), or Insufficient-Irregular (II). Survey-weighted logistic regression estimated adjusted odds ratios (AORs) and 95% confidence intervals (CIs), with subgroup analyses, and sensitivity analyses were also evaluated.

# Results

The weighted population represented 31.5 million US children (mean age, 11.5 years [SD, 3.4]; 52% male), of whom 12% had ADHD. Compared with the AR profile, the II profile was associated with 49% higher adjusted odds of ADHD (AOR:1.49, 95%CI:1.20–1.85); the association was smaller for IR (AOR:1.14, 95%CI:1.01–1.30) and not evident for AI (AOR:1.11, 95%CI:0.86–1.44). Adjusted ADHD probabilities for AR versus II were 10.4% versus 14.8% among children with high family resilience and 12.0% versus 17.2% among those with lower resilience; however, formal interaction analyses showed no evidence of effect modification. Compared with no adverse sleep characteristics, one characteristic was associated with 12% higher adjusted odds of ADHD (AOR:1.12, 95%CI:1.02–1.25) and two with 53% higher odds (AOR:1.53, 95%CI:1.26–1.84). Associations were consistent across age, sex, and family-resilience strata and sensitivity analyses.

# Conclusions

The II SRP was associated with the greatest ADHD burden. SRPs may provide a multidimensional approach to characterizing sleep health in relation to ADHD.

## Introduction

In child psychiatry, ADHD is one of the most common neurodevelopmental syndromes among offspring in the United States [1, 2]. ADHD is characterized by childhood-onset attention issues, age-inappropriate excessive hyperactivity and impulsivity (American Psychiatric Association, 2013). In 2022, about 1 in 9

children, approximately 7.1 million US children aged 3 to 17 years (11.4%), had received an ADHD diagnosis [3]; around 77.9% have at least one co-occurring disorder [1], underscoring its substantial population burden. It continues into adolescence and adulthood [4] and throughout the lifespan across various areas including academic, social, and family functioning. Approximately 60% of children with ADHD have various comorbid conditions [5, 6].

One of the most significant comorbidities is sleep disturbance. It is common among children with ADHD and may include insufficient sleep, delayed sleep onset, bedtime difficulties, and disrupted sleep continuity [7, 8]. Sleep is particularly relevant to ADHD or autism spectrum disorder (ASD) because inadequate or poorly regulated sleep may affect attention, executive functioning [9–12], emotional regulation [13], and behavior, while ADHD symptoms and related treatment factors may themselves interfere with sleep, suggesting a potentially bidirectional relationship [8, 14, 15]. As such, the sleep predicament may trigger symptoms of ADHD and may worsen symptoms in children with ADHD [16]. Those offspring have sleep problems, and they have common ADHD symptoms [17]. 29.8% of the 4,013 children referred for ADHD evaluation had obstructive sleep apnea (OSA) [18]. Approximately one-third of children diagnosed with ADHD experience chronic difficulty falling asleep, known as sleep-onset insomnia [19]. These children often resist bedtime, awaken during the night, exhibit restless sleep, have difficulty waking in the morning, and obtain less overall sleep [15]. Additionally, they frequently exhibit irregular sleep-wake schedules [20] and increased nocturnal activity [8].

Most population-based studies of children's ADHD have evaluated sleep duration, sleep problems, or bedtime behaviors separately. However, sleep health is multidimensional, and adequate duration does not necessarily indicate a consistently timed sleep routine [21, 22, 22]. Sleep Rhythm profiles (SRPs) are substantial matters that describe the combination of age-specific sleep duration and a consistent bedtime for young children. Sleep sufficiency and bedtime regularity may therefore provide complementary information for neurodevelopment [22, 23], yet their combined association with ADHD remains less well characterized in nationally representative samples. Family context may also be relevant because household coping, routines, and resilience can influence children's sleep and behavioral health [24, 25]. Family resilience is a caregiver-reported household characteristic that indicates whether family members exhibit resilience when facing difficult times [25]. Family resilience has been associated with caregiver well-being among families of children with ADHD [25, 26]. However, whether it modifies the association between SRPs and ADHD is unclear, as researchers have paid little attention to this area. In addition, evaluating SRPs together with family resilience may provide a more contextualized understanding of sleep-related differences in ADHD burden.

In this study, we used pooled 2022-23 National Survey of Children’s Health (NSCH) data to examine associations between SRPs and clinician-diagnosed ADHD among US children aged 6–17 years and to assess whether these associations varied by family resilience. We also estimated adjusted probabilities of ADHD across SRPs and family-resilience groups. Secondary analyses examined the independent associations of sleep sufficiency and bedtime regularity, the cumulative burden of adverse sleep characteristics, and the consistency of SRP-ADHD associations across age and sex strata.

## Methods

# Study design and participants

We conducted a cross-sectional study using pooled 2022–2023 data from the NSCH, a nationally representative survey of noninstitutionalized children in the United States. The NSCH collects parent- or caregiver-reported information on child health, health behaviors, family characteristics, and social and neighborhood environments [27, 28]. The analysis was restricted to children aged 6–17 years because the sleep measures used to derive SRPs, including sleep duration and bedtime regularity, were available and applicable within this age range, allowing age-specific classification of sleep sufficiency as well as to focus on school-age children. The analytic sample included children with complete information on ADHD, sleep duration, bedtime regularity, family resilience, and prespecified covariates; participants with missing data for variables required in the corresponding analysis were excluded. All analyses incorporated survey weights, strata, and clustering to account for the complex survey design and generate nationally representative estimates. Details study design, and analytic framework can be found in eFigure 1.

## Outcome of interest

The primary outcome was parent- or caregiver-reported clinician-diagnosed ADHD. Respondents were asked, “Has a doctor or other health care provider ever told you that this child has Attention Deficit Disorder or Attention-Deficit/Hyperactivity Disorder, that is, ADD or ADHD?” Responses were categorized as yes or no, with ADHD analyzed as a binary outcome. Importantly, the NSCH measure reflects caregiver report of a diagnosis made by a physician or other health-care provider rather than caregiver-reported symptoms alone [27, 28]. This measure is routinely used for national surveillance and population-based epidemiological studies of diagnosed ADHD among US children; however, it does not represent an independent clinical assessment or diagnostic interview conducted as part of the NSCH.

## Age-specific sleep sufficiency and bedtime regularity

Sleep duration was assessed using the NSCH item, “During the past week, how many hours of sleep did this child get on most weeknights?” Response categories ranged from less than 6 hours to 11 or more hours per night. Consistent with age-specific sleep-duration recommendations, sleep sufficiency was classified as adequate for children aged 6–12 years reporting 9 or more hours per night and for adolescents aged 13–17 years reporting 8–10 hours per night; shorter durations were classified as insufficient [29]. Adolescents aged 13–17 years reporting 11 or more hours were not assigned to the sufficient or insufficient category and were excluded from analyses requiring this classification [12, 22, 29].

Bedtime regularity was assessed using the NSCH item, “How often does this child go to bed at about the same time on weeknights?” Response options were always, usually, sometimes, rarely, and never. Children reported as always or usually going to bed at approximately the same time were classified as having a regular bedtime, whereas those reported as sometimes, rarely, or never were classified as having an irregular bedtime. Together, these NSCH measures captured complementary dimensions of sleep health-age-specific sleep sufficiency and consistency of weeknight bedtime and were subsequently combined to derive the SRPs [23].

## Family resilience

Family resilience was assessed using the NSCH family resilience measure, which evaluates whether a child lives in a household in which family members demonstrate resilience when facing difficult times. The measure classifies families according to whether they reported demonstrating resilient behaviors all or most of the time for 0 to 1, 2 to 3, or all 4 resilience items [27]. For the primary analysis, family resilience was categorized as high resilience vs lower resilience according to the prespecified study definition [34]. Family resilience was evaluated both as an independent correlate of ADHD and as a potential modifier of the association between SRPs and ADHD.

# Covariates

Covariates were selected a priori based on their potential relationships with sleep health and ADHD. Demographic characteristics included age, sex, and race. Socioeconomic characteristics included household poverty level (≥ 400%, 200%–399%, or < 200% of the federal poverty level), parental education (college degree or higher vs less than a college degree), and family structure (2-parent household vs other family structure). Family and caregiver characteristics included maternal mental health, paternal mental health, parental coping, and emotional support. Household and neighborhood characteristics included food security, housing instability, and neighborhood support. Detailed definitions and coding of study variables are provided in eTable 1 in Supplementary Materials.

# Statistical analysis

All analyses incorporated NSCH survey weights, strata, and clustering to account for the complex sampling design and generate nationally representative estimates. Survey-weighted numbers and percentages were calculated for categorical variables, and weighted means and SDs were calculated for continuous variables. Characteristics were compared across SRPs using survey-adjusted Pearson $\chi^2$ tests with the Rao-Scott correction for categorical variables and design-based Kruskal-Wallis tests for continuous variables. Survey-weighted logistic regression was used to estimate adjusted odds ratios (ORs) and 95% CIs for the association between SRPs and ADHD. Sequential models were fitted. The crude model included joint sleep health pattern, family resilience, and their interaction. The demographic-adjusted model additionally included age, sex, and race. The fully adjusted model additionally included

household poverty level, parental education, family structure, maternal and paternal mental health, parental coping, emotional support, food security, housing instability, and neighborhood support.

Potential effect modification by family resilience was assessed by including multiplicative interaction terms between SRPs and family resilience. Fully adjusted analyses were subsequently stratified by high and lower family resilience to characterize SRPs-ADHD associations within each resilience stratum. Adjusted ADHD probabilities and absolute percentage-point (PP) differences were estimated across SRPs within each family resilience stratum. Secondary analyses examined sleep sufficiency and bedtime regularity as separate sleep dimensions. Cumulative sleep risk was evaluated using 0, 1, and 2 adverse sleep components, with 0 risks serving as the reference category; an ordinal specification was additionally used to assess a linear trend with increasing sleep risk. Fully adjusted models were also stratified by age (6–11 and 12–17 years) and sex to assess the consistency of associations across demographic subgroups.

A complete-case approach was used, excluding observations with missing values for the outcome, exposures, family resilience, or covariates. Model fit was evaluated using the quasi-Akaike information criterion and McFadden $R^2$ where applicable. All statistical tests were 2-sided, with statistical significance defined as $p<.05$. Analyses were performed using R, version 4.5.2 (R Foundation for Statistical Computing), with the survey package used to account for the complex survey design.

## Results

# Population characteristics

The survey-weighted study population represented 31.5 million US children aged 6 to 17 years (mean [SD] age, 11.5 [3.4] years), of whom 3.8 million (12%) had ADHD (Table 1). Nearly two-thirds of children (64%) had an AR sleep pattern, whereas 25% had IR sleep, 5.4% had AI sleep, and 6.1% had II sleep. Overall, 86% of children were classified as having high family resilience. Approximately 52% were male, 75% were White, 27% lived in households below 200% of the federal poverty level, and 38% had parents with less than a college degree. Most children lived in 2-parent households (92%), while 29% and 26% had mothers and fathers, respectively, with good, fair, or poor mental health. Additionally, 45% had parents who reported coping less well, 28% experienced food insecurity, 13% experienced housing instability, and 39% lived in less supportive neighborhoods. Characteristics varied across SRPs (Table 1). ADHD prevalence was highest among children with the II profile (20%), compared with 15% for AI, 12% for IR, and 11% for AR. Lower family resilience was also more common among children with II (31%) and AI (26%) profiles than among those with AR (11%). Children with the II profile had a greater prevalence of several socioeconomic, family, and neighborhood vulnerabilities, including household income below 200% of the federal poverty level (37%), less than college parental education (54%), poorer maternal mental health (44%), poorer paternal mental health (41%), lower parental coping (62%), food insecurity (46%), housing instability (22%), and lower neighborhood support (56%).

In unadjusted analyses, the II profile was associated with substantially higher odds of ADHD compared with the AR profile (OR 1·84, 95% CI 1·50 – 2·27; Table 2). The association remained after demographic adjustment (OR 1·72, 1·39 – 2·13) and was attenuated but persisted in the fully adjusted model. After adjustment for demographic, socioeconomic, family, household, and neighborhood characteristics, children with the II profile had 49% higher likelihood of ADHD than those with the AR profile (AOR 1·49, 95% CI 1·20 – 1·85). The IR profile was associated with modestly higher odds of ADHD (AOR 1·14, 1·00–1·30), whereas there was little evidence of an association for the AI profile (AOR 1·11, 0·86 – 1·44). In addition, lower family resilience was associated with higher odds of ADHD in the crude model (OR, 1.53; 95% CI, 1.22–1.92), but this association was attenuated after full covariate adjustment (AOR, 1.17; 95% CI, 0.94–1.47). There was no evidence that family resilience modified the association between SRPs and ADHD. The fully adjusted interaction estimates were AOR 1.25 (95% CI, 0.72–2.16) for AI sleep, AOR 0.79 (95% CI, 0.57–1.09) for IR sleep, and AOR 1.02 (95% CI, 0.66–1.57) for II sleep among children with lower family resilience relative to the corresponding reference interaction. Among other covariates, older age, male sex, White race, non-2-parent family structure, poorer maternal mental health, lower parental coping, food insecurity, and housing instability were associated with ADHD in the fully adjusted model. Overall model fit improved with progressive adjustment, with the fully adjusted model yielding a McFadden $R^2$ of 0.12 and QAIC of 31 566.

Adjusted probability analyses demonstrated the greatest ADHD burden among children with II profiles across family resilience (Table 3). Among children with high family resilience, the adjusted probability of ADHD increased from 10.4% (95% CI, 9.7%-11.1%) for the AR profiles to 14.8% (95% CI, 12.2–17.3%) for the II profiles, corresponding to an absolute difference of 4.3 percentage points (95% CI, 1.7-7.0). The IR profiles was associated with a smaller absolute difference of 1.3 percentage points (95% CI, 1.1–2.6), whereas the AI profiles showed little difference from the reference group. Among children with lower family resilience, the adjusted probability of ADHD was 12.0% (95% CI, 9.8%-14.2%) for the AR profiles and 17.2% (95% CI, 12.6%-21.8%) for the II profile, an absolute difference of 5.2 percentage points (95% CI, 0.1–10.2). In contrast, estimates for the AI and IR profiles were less precise and their confidence intervals for absolute differences included the null. Among children with the II profile, adjusted ADHD probability was 16·3% relatively higher in the lower-resilience than high-resilience group (17·2% vs 14·8%), with a 20·9% larger absolute probability difference relative to the AR profile (5·2 vs 4·3 percentage points), although these differences were descriptive because the formal SRPs-by-family resilience interaction was not statistically significant.

Family resilience-stratified analyses showed a consistent association between the II profile and higher odds of ADHD in both high-resilience (AOR 1·49, 95% CI 1·20 – 1·85) and lower-resilience (1·53, 1·04 – 2·25) groups (Fig. 1; **eTable 2**). Associations for the IR and AI profiles were less consistent across resilience strata; however, formal interaction tests provided no evidence that family resilience modified the association between SRPs and ADHD.

In subgroup analyses, the association between the II profile and ADHD was consistent across age and sex strata (**eTable 3**), with higher adjusted odds among children aged 6–11 years (AOR 1·49, 95% CI

1·04 – 2·14), those aged 12–17 years (1·68, 1·34 – 2·09), females (1·66, 1·26 – 2·18), and males (1·61, 1·25 – 2·07). Associations for the AI and IR profiles were less consistent across subgroups. Overall, these findings supported the consistency of the primary SPRs-ADHD association across age and sex groups.

Sensitivity analyses were consistent with the primary SRP findings. Compared with children with no adverse sleep components, those with one component had 12% higher adjusted odds of ADHD (AOR 1·12, 95% CI 1·01–1·25), and those with two components had 53% higher adjusted odds (1·53, 1·26 – 1·84), indicating a graded association with cumulative sleep risk (Fig. 2; **eTable 4**). When sleep components were modeled separately, sufficient sleep was associated with 11% lower adjusted odds of ADHD (AOR 0·89, 95% CI 0·80 – 0·99) and regular bedtime with 24% lower adjusted odds (0·76, 0·66 – 0·89; **eTable 5**). These findings supported the robustness of the primary SRPs association across alternative sleep specifications.

# Discussion

In this nationally representative study of US children aged 6 to 17 years, SRPs characterized by age-specific insufficient sleep and irregular bedtime were consistently associated with higher odds of ADHD. Compared with the AR profile, the II profile was associated with 49% higher adjusted odds of ADHD. Complementary analyses showed a graded association, with one adverse sleep component associated with 12% higher odds and two components with 53% higher odds of ADHD. The SRPs-ADHD association was consistent across age, sex, and family-resilience strata. Although adjusted ADHD probabilities were highest for the II profile, formal interaction analyses provided no evidence that family resilience modified the SRPs-ADHD association. Collectively, these findings suggest that the co-occurrence of age-specific insufficient sleep and irregular bedtime characterizes a particularly unfavorable sleep profile associated with ADHD among children.

Our findings extend previous evidence linking ADHD with insufficient sleep, bedtime difficulties, delayed sleep onset, and disturbances in sleep continuity [7, 8]. More recent population-based evidence has similarly shown associations between ADHD and parent-reported sleep difficulties, including after accounting for co-occurring disorders [35]. However, much of the existing literature has examined individual sleep characteristics or broadly defined sleep problems in isolation. By jointly considering age-specific sleep sufficiency and bedtime regularity, our findings suggest that the co-occurrence of these sleep characteristics might provide additional insight into sleep health among children with ADHD. This approach is consistent with multidimensional conceptualizations of sleep health, which recognize duration and regularity as distinct but complementary dimensions alongside timing, satisfaction or quality, efficiency, and daytime alertness [11, 21]. The graded association observed in our cumulative analysis further supports considering sleep characteristics jointly: ADHD odds were greatest when insufficient sleep and irregular bedtime co-occurred, whereas associations were weaker when only one adverse sleep characteristic was present [19, 23]. These findings suggest that characterizing pediatric

sleep solely by duration could overlook potentially relevant information about the regularity of sleep routines.

The consistent association observed for the II profile suggests that the co-occurrence of insufficient sleep and irregular bedtime might characterize children with greater ADHD burden than either sleep characteristic alone. This interpretation is supported by the complementary analyses: sufficient sleep and regular bedtime were each associated with lower odds of ADHD when modeled separately, whereas ADHD odds increased progressively with the accumulation of adverse sleep characteristics [12, 16, 17]. Insufficient and irregular sleep could plausibly relate to ADHD through overlapping neurobehavioral pathways involving attention, executive functioning, inhibitory control, and emotional regulation [9, 10, 13]. Sleep loss can impair prefrontal-dependent cognitive processes, whereas irregular sleep timing might contribute to circadian disruption and instability in sleep-wake regulation [21]. When insufficient duration and irregular timing co-occur, these processes could jointly contribute to difficulties in attention and behavioral regulation that overlap with core features of ADHD. However, the mechanisms underlying the observed associations cannot be determined from the present data.

The association between sleep and ADHD is also likely to be bidirectional. Hyperactivity, impulsivity, emotional arousal, and difficulty transitioning between activities could interfere with bedtime routines and sleep initiation, while insufficient or irregular sleep could exacerbate attentional, behavioral, and emotional difficulties [8, 12, 14]. Other factors, including medication timing, co-occurring mental health or behavioral conditions, screen use, and household routines, might further influence both sleep and ADHD-related behaviors [22, 36, 37]. Previous longitudinal evidence supports reciprocal relationships between sleep problems and ADHD symptoms, and sleep-focused interventions might improve selected behavioral and functional outcomes [14, 38, 39]. Therefore, our findings should not be interpreted as evidence that adverse SRPs cause ADHD; rather, they suggest that insufficient and irregular sleep frequently co-occur with ADHD and might reflect interconnected behavioral, developmental, and biological processes.

Family resilience provided additional context for the association between SRPs and ADHD. The II profile was associated with higher odds of ADHD in both resilience strata, but formal interaction analyses provided no evidence that family resilience modified this association. Although adjusted ADHD probabilities were higher among children with lower family resilience, differences between strata should therefore be interpreted descriptively. Previous research has linked family resilience with child sleep and caregiver well-being [25]; however, broad measures of resilience might not capture sleep-specific family processes, such as bedtime routines, parental limit setting, household schedules, and parent-child interactions surrounding sleep [17, 34]. Family resilience might function as a general psychosocial resource without necessarily modifying associations involving specific sleep behaviors. Even resilient families can face structural constraints, including work schedules, caregiving demands, economic strain, and housing instability, that interfere with sufficient and regular sleep [25, 34]. Sleep-specific family processes might therefore be more proximal to the SRPs-ADHD relationship than global family

resilience. Future longitudinal studies should examine whether these family-level processes influence the relationship between sleep patterns and ADHD-related outcomes.

This study extends previous research by considering age-specific sleep duration and bedtime regularity jointly rather than as isolated sleep characteristics. The graded association with cumulative sleep risk further suggests that clustering of adverse sleep characteristics might be relevant to ADHD, with the greatest odds observed when insufficient sleep and irregular bedtime co-occurred. The use of a nationally representative sample of children aged 6–17 years broadens these findings across developmental periods characterized by substantial changes in sleep timing, autonomy, and academic demands [22, 40, 41]. The study also incorporated family resilience as a potential contextual modifier, although formal interaction analyses did not support effect modification. Importantly, sleep duration and bedtime regularity are observable and potentially modifiable behaviors, supporting consideration of multiple dimensions of sleep health in pediatric and behavioral health assessment [34]. Future longitudinal and intervention studies should determine whether improving sleep sufficiency and regularity is associated with subsequent improvements in ADHD-related symptoms and functioning.

# Strengths and limitations

This study has several strengths, including the use of a large, nationally representative sample of US children, incorporation of the NSCH complex survey design, and simultaneous consideration of age-specific sleep sufficiency and bedtime regularity. The consistency of findings across sequentially adjusted models, family-resilience, age, and sex strata, and complementary cumulative-risk and individual-component analyses further strengthened the robustness of the observed associations. Several limitations should also be considered. First, the cross-sectional design precludes assessment of temporality or causal direction between SRPs and ADHD. Second, ADHD diagnosis, sleep duration, and bedtime regularity were caregiver reported and might be subject to recall or reporting error; the NSCH does not independently verify ADHD diagnoses through clinical assessment. Third, the available sleep measures did not capture other relevant dimensions, including sleep quality, sleep timing, daytime sleepiness, sleep disorders, or objective sleep measures. Fourth, although models adjusted for a broad range of demographic, socioeconomic, family, and neighborhood characteristics, residual and unmeasured confounding remains possible. Finally, SRPs were analytically derived from two sleep characteristics and should not be interpreted as a validated clinical classification or screening instrument.

## Conclusion

In this nationally representative study of US children, the co-occurrence of insufficient sleep and irregular bedtime was associated with the greatest odds of ADHD, with a graded association as adverse sleep characteristics accumulated. These findings extend previous sleep-ADHD research by highlighting the value of considering sleep sufficiency and regularity jointly rather than as isolated behaviors. The consistency of the association across age, sex, and family-resilience strata suggests that

multidimensional sleep health might be relevant across diverse child and family contexts. Longitudinal and intervention studies are needed to establish temporality and determine whether improving sleep sufficiency and regularity could influence ADHD-related symptoms and functioning.

## Declarations

# Author Contribution

Md Roungu Ahmmad: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.Md Shahinuzzaman: Conceptualization, Validation, Writing – review & editing.

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# Data Availability

This study used publicly available data from the 2022-23 National Survey of Children's Health (NSCH). The datasets and supporting documentation are publicly available from the US Census Bureau and the Maternal and Child Health Bureau. No new participant-level data were collected for this study. The analytic code used to derive the study variables and reproduce the analyses can be made available upon reasonable request to the author.

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# Tables

**Table 1**. Survey-Weighted Characteristics of US Children Aged 6 to 17 Years According to Synergistic Sleep Patterns (SSP) With ADHD Among US Children Aged 6 to 17 Years.

| Characteristic | Overall N = 31,509,954[1] | Sleep Rhythm Profiles (SRPs) | | | | p-value[2] |
|---|---|---|---|---|---|---|
| | | Adequate Regular (AR) N = 20,064,958[1] | Adequate Irregular (AI) N = 1,693,782[1] | Insufficient Regular (IR) N = 7,833,164[1] | Insufficient Irregular (II) N = 1,918,051[1] | |
| **ADHD** | 3,822,571 (12%) | 2,209,144 (11%) | 261,652 (15%) | 975,103 (12%) | 376,671 (20%) | <0.001 |
| **Family Resilience** | | | | | | <0.001 |
| High resilience | 26,998,337 (86%) | 17,832,726 (89%) | 1,250,548 (74%) | 6,588,788 (84%) | 1,326,276 (69%) | |
| Lower resilience | 4,511,617 (14%) | 2,232,232 (11%) | 443,234 (26%) | 1,244,376 (16%) | 591,775 (31%) | |
| **Age** | 11.5 (3.4) | 11.2 (3.5) | 13.1 (3.2) | 11.4 (3.3) | 12.8 (3.3) | <0.001 |
| **Sex** | | | | | | 0.009 |
| Female | 15,222,522 (48%) | 9,507,425 (47%) | 920,184 (54%) | 3,873,110 (49%) | 921,804 (48%) | |
| Male | 16,287,432 (52%) | 10,557,532 (53%) | 773,598 (46%) | 3,960,054 (51%) | 996,247 (52%) | |
| **Race** | | | | | | <0.001 |
| Non-White | 7,802,146 (25%) | 4,527,643 (23%) | 511,811 (30%) | 2,152,633 (27%) | 610,059 (32%) | |
| White | 23,707,808 (75%) | 15,537,314 (77%) | 1,181,971 (70%) | 5,680,531 (73%) | 1,307,991 (68%) | |
| **Poverty** | | | | | | <0.001 |
| ≥400% FPL | 13,129,795 (42%) | 9,239,267 (46%) | 526,476 (31%) | 2,814,353 (36%) | 549,700 (29%) | |
| 200–399% FPL | 9,783,074 (31%) | 6,079,011 (30%) | 479,997 (28%) | 2,566,309 (33%) | 657,757 (34%) | |
| <200% FPL | 8,597,086 (27%) | 4,746,680 (24%) | 687,310 (41%) | 2,452,502 (31%) | 710,594 (37%) | |
| **Parent Education** | | | | | | <0.001 |
| College degree or higher | 19,584,545 (62%) | 13,578,250 (68%) | 741,747 (44%) | 4,390,433 (56%) | 874,115 (46%) | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Less than college degree | 11,925,410 (38%) | 6,486,708 (32%) | 952,035 (56%) | 3,442,731 (44%) | 1,043,936 (54%) | |
| **Family Structure** | | | | | | <0.001 |
| Two-parent household | 28,902,786 (92%) | 18,752,696 (93%) | 1,507,527 (89%) | 6,959,803 (89%) | 1,682,760 (88%) | |
| Other family structure | 2,607,168 (8.3%) | 1,312,261 (6.5%) | 186,255 (11%) | 873,361 (11%) | 235,290 (12%) | |
| **Mother Mental Health** | | | | | | <0.001 |
| Excellent/very good | 22,391,688 (71%) | 15,007,663 (75%) | 962,383 (57%) | 5,341,439 (68%) | 1,080,202 (56%) | |
| Good/fair/poor | 9,118,267 (29%) | 5,057,294 (25%) | 731,399 (43%) | 2,491,725 (32%) | 837,849 (44%) | |
| **Father Mental Health** | | | | | | <0.001 |
| Excellent/very good | 23,472,568 (74%) | 15,634,185 (78%) | 1,093,139 (65%) | 5,604,661 (72%) | 1,140,583 (59%) | |
| Good/fair/poor | 8,037,386 (26%) | 4,430,773 (22%) | 600,643 (35%) | 2,228,503 (28%) | 777,468 (41%) | |
| **Parent Coping** | | | | | | <0.001 |
| Coping very well | 17,417,908 (55%) | 11,693,212 (58%) | 777,539 (46%) | 4,222,494 (54%) | 724,663 (38%) | |
| Coping less well | 14,092,046 (45%) | 8,371,745 (42%) | 916,244 (54%) | 3,610,670 (46%) | 1,193,388 (62%) | |
| **Emotional Support** | | | | | | <0.001 |
| Has emotional support | 24,574,984 (78%) | 16,269,551 (81%) | 1,120,090 (66%) | 5,888,109 (75%) | 1,297,235 (68%) | |
| No emotional support | 6,934,970 (22%) | 3,795,406 (19%) | 573,692 (34%) | 1,945,055 (25%) | 620,816 (32%) | |
| **Food Security** | | | | | | <0.001 |
| Food secure | 22,765,938 (72%) | 15,531,949 (77%) | 1,022,534 (60%) | 5,176,485 (66%) | 1,034,970 (54%) | |
| Food insecure | 8,744,016 (28%) | 4,533,008 (23%) | 671,248 (40%) | 2,656,679 (34%) | 883,081 (46%) | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Housing Instability** | | | | | | <0.001 |
| No housing instability | 27,381,893 (87%) | 18,008,454 (90%) | 1,368,251 (81%) | 6,513,209 (83%) | 1,491,978 (78%) | |
| Housing instability | 4,128,061 (13%) | 2,056,503 (10%) | 325,531 (19%) | 1,319,955 (17%) | 426,072 (22%) | |
| **Neighborhood Support** | | | | | | <0.001 |
| Supportive neighborhood | 19,071,899 (61%) | 12,973,907 (65%) | 834,827 (49%) | 4,422,914 (56%) | 840,250 (44%) | |
| Less supportive neighborhood | 12,438,056 (39%) | 7,091,050 (35%) | 858,955 (51%) | 3,410,250 (44%) | 1,077,801 (56%) | |

**Note:** Values are survey-weighted No. (%) for categorical variables and mean (SD) for continuous variables. Sleep Rhythm Profiles (SRPs) combined age-specific sleep sufficiency and weeknight bedtime regularity into 4 categories: Adequate-Regular (AR), Adequate-Irregular (AI), Insufficient-Regular (IR), and Insufficient-Irregular (II). P values were calculated using Rao-Scott–adjusted Pearson $\chi^2$ tests for categorical variables and design-based Kruskal-Wallis tests for continuous variables.

**Abbreviations:** AR, Adequate-Regular; AI, Adequate-Irregular; IR, Insufficient-Regular; II, Insufficient-Irregular; SRP, Sleep Rhythm Profile.

**Table 2.** Survey-Weighted Associations of Sleep Rhythm Profiles (SRPs) and Family Resilience With ADHD Among US Children Aged 6 to 17 Years.

| Characteristic | Crude | | | Crude + Demographic | | | Crude + Demo + Confounder | | |
|---|---|---|---|---|---|---|---|---|---|
| | OR | 95% CI | p-value | OR | 95% CI | p-value | OR | 95% CI | p-value |
| **Sleep Rhythm Profiles (SRPs)** | | | | | | | | | |
| Adequate-Regular | — | — | | — | — | | — | — | |
| Adequate-Irregular | 1.28 | 1.00, 1.65 | .052 | 1.24 | 0.97, 1.59 | .086 | 1.11 | 0.86, 1.44 | .31 |
| Insufficient-Regular | 1.17 | 1.04, 1.32 | .011 | 1.21 | 1.07, 1.37 | .003 | 1.14 | 1.00, 1.30 | .04 |
| Insufficient-Irregular | 1.84 | 1.50, 2.27 | <.001 | 1.72 | 1.39, 2.13 | <.001 | 1.49 | 1.20, 1.85 | <.001 |
| **Family Resilience** | | | | | | | | | |
| High resilience | — | — | | — | — | | — | — | |
| Low resilience | 1.53 | 1.22, 1.92 | <.001 | 1.53 | 1.24, 1.90 | <.001 | 1.17 | 0.94, 1.47 | .20 |
| **SRPs * Family Resilience** | | | | | | | | | |
| Adequate-Irregular * Lower resilience | 1.23 | 0.71, 2.16 | .5 | 1.22 | 0.72, 2.07 | .5 | 1.25 | 0.72, 2.16 | .41 |
| Insufficient-Regular * Lower resilience | 0.80 | 0.58, 1.11 | .2 | 0.79 | 0.57, 1.09 | .2 | 0.79 | 0.57, 1.09 | .21 |
| Insufficient-Irregular * Lower resilience | 0.94 | 0.61, 1.47 | .8 | 1.01 | 0.66, 1.54 | .9 | 1.02 | 0.66, 1.57 | .90 |
| **Age** | | | | 1.07 | 1.05, 1.08 | <.001 | 1.08 | 1.06, 1.09 | <.001 |
| **Sex** | | | | | | | | | |
| Female | | | | — | — | | — | — | |
| Male | | | | 2.11 | 1.90, 2.34 | <.001 | 2.14 | 1.92, 2.37 | <.001 |
| **Race** | | | | | | | | | |
| Non-White | | | | — | — | | — | — | |

| | | | | | | |
|---|---|---|---|---|---|---|
| White | 1.39 | 1.22, 1.59 | <.001 | 1.37 | 1.20, 1.57 | <.001 |
| **Poverty** | | | | | | |
| ≥400% FPL | | | | — | — | |
| 200–399% FPL | | | | 0.84 | 0.74, 0.95 | .01 |
| <200% FPL | | | | 0.89 | 0.77, 1.03 | .11 |
| **Parent Education** | | | | | | |
| College degree or higher | | | | — | — | |
| Less than college degree | | | | 0.85 | 0.75, 0.96 | .01 |
| **Family Structure** | | | | | | |
| Two-parent household | | | | — | — | |
| Other family structure | | | | 1.24 | 1.01, 1.52 | .04 |
| **Mother Mental Health** | | | | | | |
| Excellent/very good | | | | — | — | |
| Good/fair/poor | | | | 1.71 | 1.50, 1.95 | <.001 |
| **Father Mental Health** | | | | | | |
| Excellent/very good | | | | — | — | |
| Good/fair/poor | | | | 1.03 | 0.90, 1.18 | .70 |
| **Parent Coping** | | | | | | |
| Coping very well | | | | — | — | |
| Coping less well | | | | 1.36 | 1.22, 1.52 | <.001 |
| **Emotional Support** | | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Has emotional support | | | — | — | |
| No emotional support | | | 0.74 | 0.64, 0.85 | <.001 |
| **Food Security** | | | | | |
| Food secure | | | — | — | |
| Food insecure | | | 1.23 | 1.07, 1.41 | .003 |
| **Housing Instability** | | | | | |
| No housing instability | | | — | — | |
| Housing instability | | | 1.47 | 1.23, 1.75 | <.001 |
| **Neighborhood Support** | | | | | |
| Supportive neighborhood | | | — | — | |
| Less supportive neighborhood | | | 0.98 | 0.87, 1.09 | .70 |
| McFadden $R^2$ | 0.02 | 0.07 | 0.12 | | |
| QAIC | 33,281 | 32,366 | 31,566 | | |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | | | |

**Note:** Model 1 included Sleep Rhythm Profiles (SRPs), family resilience, and the SRPs × family resilience interaction. Model 2 additionally adjusted for age, sex, and race. Model 3 further adjusted for poverty, parental education, family structure, maternal mental health, paternal mental health, parental coping, emotional support, food security, housing instability, and neighborhood support. Adequate-Regular SRPs and high family resilience served as the reference categories. Estimates were obtained from survey-weighted logistic regression models accounting for the NSCH complex sampling design. ORs and 95% CIs are reported; ORs from adjusted models represent adjusted odds ratios. All P values were 2-sided.

**Abbreviations:** CI, confidence interval; NSCH, National Survey of Children's Health; OR, odds ratio; SRP, Sleep Rhythm Profile.

**Table 3.** Adjusted Probabilities and Absolute Differences in ADHD Across Synergistic Sleep Patterns (SSP) With ADHD Among US Children Aged 6 to 17 Years.

| Sleep Rhythm Profiles (SRPs) | Adjusted ADHD Probability, % (95% CI) | Absolute Difference, Percentage Points (95% CI) | P Value |
|---|---|---|---|
| **High family resilience** | | | |
| Adequate-Regular | 10.4 (9.7 to 11.1) | Reference | — |
| Adequate-Irregular | 11.5 (9.0 to 13.9) | 1.1 (−1.5 to 3.6) | .42 |
| Insufficient-Regular | 11.7 (10.6 to 12.8) | 1.3 (1.1 to 2.6) | .04 |
| Insufficient-Irregular | 14.8 (12.2 to 17.3) | 4.3 (1.7 to 7.0) | .001 |
| **Lower family resilience** | | | |
| Adequate-Regular | 12.0 (9.8 to 14.2) | Reference | — |
| Adequate-Irregular | 16.0 (10.0 to 22.0) | 3.9 (−2.5 to 10.3) | .23 |
| Insufficient-Regular | 11.0 (8.8 to 13.2) | −1.1 (−4.1 to 2.0) | .50 |
| Insufficient-Irregular | 17.2 (12.6 to 21.8) | 5.2 (0.1 to 10.2) | .04 |

**Note:** Adjusted ADHD probabilities were estimated from the fully adjusted survey-weighted logistic regression model. Absolute differences represent percentage-point differences relative to the Adequate-Regular SSP within each family-resilience stratum. Estimates are presented with 95% CIs. P values correspond to contrasts with the reference profile.

**Abbreviations:** ADHD, attention-deficit/hyperactivity disorder; CI, confidence interval; Synergistic Sleep Patterns (SSP).

# Figures

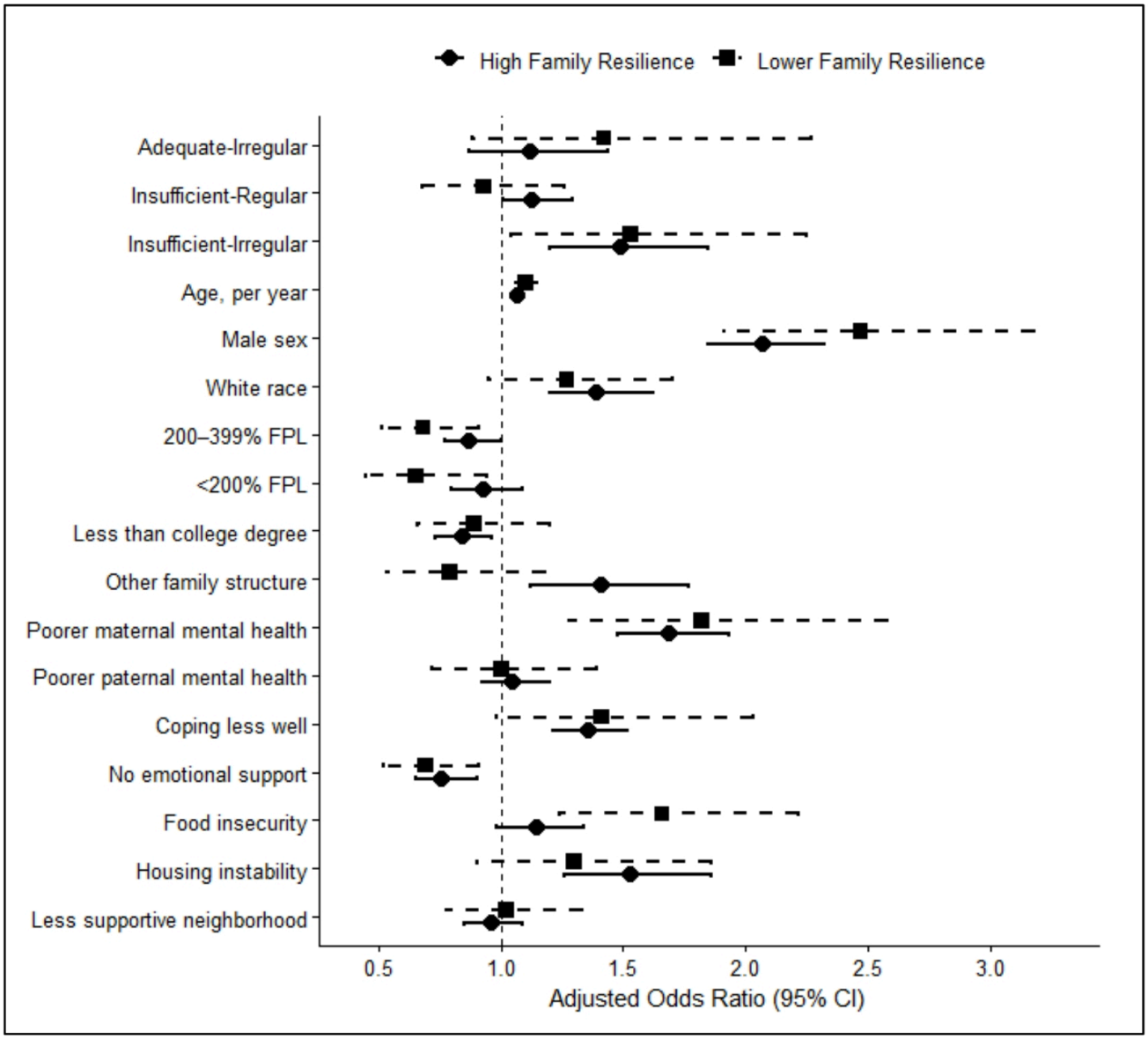



**Figure 1**

Adjusted Associations Between Sleep rhythm profiles (SRPs) and Attention-Deficit/Hyperactivity Disorder, Stratified by Family Resilience Among US Children Aged 6 to 17 Years. Points represent AORs, and horizontal bars represent 95% CIs from survey-weighted multivariable logistic regression models stratified by family resilience. Adequate-Regular sleep served as the reference category. Models were adjusted for age, sex, race, poverty, parental education, family structure, maternal and paternal mental health, parental coping, emotional support, food security, housing instability, and neighborhood support. Solid and dot-dash confidence interval lines represent high and lower family resilience, respectively. The vertical reference line indicates an AOR of 1.00. ADHD indicates attention-deficit/hyperactivity disorder; AOR, adjusted odds ratio; CI, confidence interval.

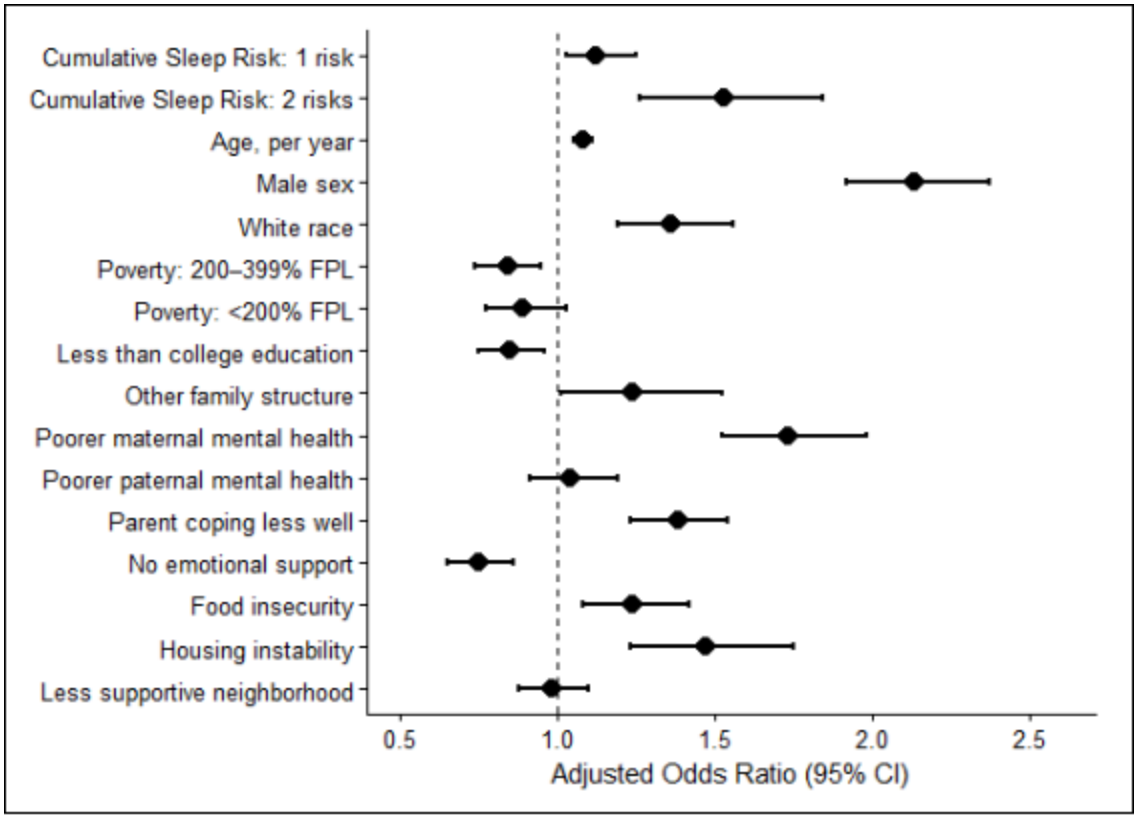



**Figure 2**

Adjusted Associations of Cumulative Sleep Risk and Sociodemographic, Family, and Neighborhood Characteristics With Attention-Deficit/Hyperactivity Disorder Among US Children Aged 6 to 17 Years. Points represent adjusted odds ratios (AORs), and horizontal bars represent 95% CIs estimated from a survey-weighted multivariable logistic regression model. Cumulative sleep risk was defined according to 2 adverse sleep components: insufficient age-specific sleep duration and irregular bedtime. Children with 0 sleep risks had adequate sleep duration and a regular bedtime; those with 1 sleep risk had either insufficient sleep duration or an irregular bedtime; and those with 2 sleep risks had both insufficient sleep duration and an irregular bedtime. The 0-risk group served as the reference category. The model was adjusted for age, sex, race, household poverty level, parental education, family structure, maternal and paternal mental health, parental coping, emotional support, food security, housing instability, and neighborhood support. The vertical dashed line represents the null value (AOR, 1.00).

## Supplementary Files

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