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Quantity, timing, and type of childhood adversity and sleep quality in adulthood

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ABSTRACT

Objective: We investigated how quantity, timing, and type of childhood adversity were associated with subjectively reported and actigraphically measured sleep in adulthood.
Design: This is a cross-sectional design.
Setting: Data were collected from three clinical sites at the University of California, Los Angeles; the University of Wisconsin–Madison; and Georgetown, in the Washington, DC area.
Participants: The participants were a group of 863 U.S. adults aged 25–76 years who participated in the Biomarker Project in the Midlife in the United States Refresher study.
Measurement: Subjective sleep was measured by the Pittsburgh Sleep Quality Index and actigraphic sleep measures included sleep-onset latency, sleep efficiency, wake time after sleep onset, and total sleep time. Participants retrospectively reported whether they experienced 18 adverse events before age 18 years and the ages they experienced the events.
Results: Childhood adversity, operationalized as quantity (i.e., the total number of adverse events or experiencing 3 or more adverse events) and timing (i.e., experiencing adverse events during both childhood and adolescence) of adverse events, was related to worse subjective and actigraphic sleep (except for total sleep time) after adjusting for age, sex, and race. Models using the cumulative (i.e. dose-response) number of adverse events fit better than models using the timing and type specifications of childhood adversity in relation to subjective or actigraphic sleep measures (except for total sleep time).
Conclusions: These findings highlight the importance of considering the quantity of childhood adversity in relation to self-reported and actigraphically measured sleep in adulthood.

Introduction

Recent estimates suggest that as many as 70 million American adults suffer from chronic sleep problems,[1] and more than a third of American adults report insufficient sleep duration (i.e., less than seven hours).[2] Sleep problems are linked to negative physical and mental outcomes[3-5] and have serious economic implications.[6] Prior research has suggested that sleep problems are not only due to current circumstances but can be caused by a variety of factors that occur across the lifespan, including childhood adversity.[7-9] Early life experiences such as experiencing abuse, growing up in poverty, or the death of a parent in particular can influence sleep not only during childhood[10] and adolescence[11] but also in adulthood.[12,13] Given that about half of American adults have experienced at least one type of childhood adversity[14] and that childhood adversity is associated with a host of negative outcomes across the life span,[14,15] there is growing interest in studying the long-term influences of childhood adversity on sleep.[7]

Childhood adversity can produce long-term alternation in the hypothalamic-pituitary-adrenal (HPA) axis reactivity to stress (e.g., hyperactivity)[16] and interfere with normal neurodevelopment in childhood and adolescence.[17] These changes may directly influence sleep-wake cycle and lead to sleep problems[18] or indirectly impact adult sleep through increasing the risk of psychiatric conditions such as depression and post-traumatic stress disorder.[7,17] Features of childhood adversity, including quantity, timing, and type,[17] are important characteristics that may underlie the relationship between childhood adversity and sleep. Yet, few studies have simultaneously investigated how specific characteristics of childhood adversity are related to sleep and no research has analyzed which most optimally measures the relationship between childhood adversity and sleep in adulthood. This is important as it can help answer such questions as follows: is it the quantity of adverse events, their timing (e.g., during critical periods in development), or their type (e.g., parental death or

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academic issue) that is most important for sleep in adulthood? For sleep measures, it is also essential to identify whether the most relevant measure of adversity differs between "subjective" reports and "objective" measures of sleep. Thus, the goals of this study are to analyze and document the most optimal functional form of three major specifications of childhood adversity—quantity, timing, and type of adverse events[11,14]—in relation to subjective (measured by self-reports) and objective (measured by actigraphy) measures of sleep in adulthood.

Although previous research has analyzed the association between the quantity of adverse childhood events and sleep in adulthood, studies have operationalized event quantity inconsistently (e.g., dichotomously or as a count). Studies that coded adverse childhood events dichotomously (any or no childhood adversity) suggest that adults who experienced any childhood adversity were more likely to have worse sleep than those who did not experience any childhood adversity.[19,20] Other work has used a count specification to assess the dose-response relationship between childhood adversity and sleep and found that the likelihood of tiredness after sleeping, trouble falling sleep or staying asleep, and insomnia increased with the number of adverse childhood events.[5,21,22] There were similar findings for self-reports and actigraphy.[23] Despite the significant associations between the quantity of adverse childhood events and adult sleep, less is known about how to best measure the quantity of adverse events in relation to subjective *and* actigraphic sleep measures and how quantity measures compare to the timing or type of adverse events.

The *timing* of childhood adversity may be important as past work suggests that exposure to adverse events during critical or sensitive periods[24] may be especially harmful for well-being across the lifespan. Both childhood and adolescence are important periods with significant development in the HPA axis and brain.[7] Given that individuals in childhood and adolescence may experience different types of adversity or adverse events differently because of differences in social roles, social meanings of the events, and available resources,[24] exposure to adversity may have different effects on the HPA axis and brain in the two periods and thereby may have different influences on sleep in adulthood. Yet, only a handful of studies have examined how the *timing* of adverse events affects sleep, and these studies have mixed results. For instance, previous research has suggested that experiencing adversity in childhood, but not in adolescence, was related to higher levels of self-reported sleep disturbances in adulthood;[20] similar findings for actigraphic sleep measures were reported by Schäfer and Bader.[13] However, Schäfer and Bader[13] also found that adverse events in childhood or adolescence were not linked to subjectively reported sleep. Of course, some may experience adverse events only during a specific period, whereas others may experience recurring adverse events at multiple ages.[14] It is therefore important to distinguish these patterns and investigate how the timing of adverse events is related to sleep in adulthood.

The relationship between childhood adversity and sleep may also vary by *type* of adversity. Kuhlman et al.[15] suggested that emotional abuse, emotional neglect, and sexual assault, as compared with other adverse events, were more strongly linked to self-reported sleep problems in adulthood. Studies that compared various types of childhood maltreatment found that emotional neglect was the only predictor of adult insomnia.[25,26] Research linking childhood adversity to sleep has focused mainly on maltreatment, potentially at the expense of other types of adverse events such as stressful academic events or parental substance abuse. Our study, which includes several distinct types of adverse childhood events and examines their associations with subjective and actigraphic sleep measures, may help provide a more comprehensive understanding of the relationship between childhood adversity and sleep.

Based on previous research,[19,21,22] we hypothesize that experiencing any or a greater number of adverse childhood events is related to lower quality of subjectively reported and actigraphically measured sleep (Hypothesis #1). Similarly, exposure to adverse events in childhood, adolescence, or multiple periods is hypothesized to be associated with worse subjective and actigraphic sleep (Hypothesis #2).[20,24] Experiencing different types of adversity is also hypothesized to be related to lower quality of subjective and actigraphic sleep (Hypothesis #3).[15,26] Given the findings of previous research testing the functional form of childhood adversity and cardiometabolic outcomes[14] and of the dose-response relationship between adverse childhood events and sleep,[22] we anticipate that the dose-response specification will have the most optimal functional form (Hypothesis #4).

Participants and methods

Participants

Data for this investigation came from the Midlife in the United States (MIDUS) Refresher study.[27] In 2011–2014, the MIDUS Refresher study was conducted on a nationally representative sample of 3,577 adults. Later, these adults were invited to participate in a Biomarker Project, and 863 adults participated by visiting one of three clinical sites in 2012–2016.[28] Subjective sleep that was assessed by the Pittsburgh Sleep Quality Index (PSQI) was only collected in the Biomarker Project; actigraphic sleep was recorded only in the University of Wisconsin–Madison subsample (actigraphic subsample, $n = 278$). Thus, the analytic sample for this study is the 863 adults in the Biomarker Project who reported their subjective sleep quality. For analyses focused on objective sleep measures, we focus on the 278 adults for whom actigraphic sleep measures were collected. The MIDUS Refresher study was reviewed and approved by the institutional review board at the University of Wisconsin-Madison.[27]

Measures

Measures of sleep

The PSQI is a valid and reliable measure of self-reported sleep quality that has been widely used in community and clinic populations.[29,30] Participants responded to 19 questions about their usual sleep habits during the past month (e.g., "during the past month, when have you usually gone to bed at night?"). The 19 questions were combined into seven sleep components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. Each component was scored from 0 to 3, and the scores were summed to create a composite score of global sleep quality, ranging from 0 to 21, with higher scores indicating worse sleep quality.[29] We also fit models with the PSQI components and found the *linear* specification was the best fitting functional form of childhood adversity in the full sample and actigraphic subsample. For the three PSQI components captured with the actigraphy measures, quantitative and timing specifications were related to sleep latency and the type specification was related to sleep duration, whereas no specification was related to habitual sleep efficiency.

The 278 adults who visited the UW–Madison site recorded their actigraphy data using the Mini Mitter Actiwatch®-64 activity monitor, which started recording at 7:00 a.m. on the first Tuesday after they visited the site.[28] The monitors were worn on their nondominant wrist for seven continuous days. The vast majority of participants had valid data for seven days ($n = 258$, 92.8%), 15 (5.4%) had valid data for five to six days, and only 5 (1.8%) had valid data for three to four days. As suggested by prior research,[31] we included all participants in analyses. When we excluded five participants who

had less than 5 days' data, we found consistent results. Actigraphic measures of sleep quality included sleep-onset latency (SOL; the time, in minutes, required for sleep onset after initiating the intent to sleep), sleep efficiency (SE; the percentage of time spent in bed sleeping), wake time after sleep onset (WASO; the total time, in minutes, that scored as wake between sleep onset and sleep end), and total sleep time (TST; the total time, in minutes, that scored as sleep between sleep onset and sleep end). The mean levels of SOL, SE, WASO, and TST were computed by the Actiware program algorithms for each night and then averaged across seven nights or nights that had valid actigraphy data. Scores for SOL were log-transformed to correct for skewness and kurtosis. Each of the measures of sleep were standardized (i.e., Z-scores) in the regression models.

Childhood adversity

Childhood adversity was assessed using two sets of questions in the self-administration questionnaire from the MIDUS Refresher study.[27] In the first set of questions, participants were asked to report whether they had experienced any of seven adverse events (i.e., repeating school, sent away from home, parent out of job, parents drank, parents used drug, dropping out of school, and flunking out of school) at any point as a child or teenager. In the second set of questions, they were asked to report whether they had ever experienced any of 11 other adverse life events (i.e., expelled or suspended from school, fired, parental death, parental divorce, sibling death, lost home, physical assaulted, sexually assaulted, legal difficulties, in jail, and went on welfare). For all 18 adverse events, if participants experienced the events, they were also instructed to report the exact age when each event occurred. We coded only events that occurred before age 18 as childhood adversity.

To determine the *quantity*, *timing*, and *type* of adverse childhood events, we followed a procedure similar to that described by Friedman and colleagues,[14] with some changes to ensure adequate cell sizes. To identify the *quantity* of adverse childhood events, we used (1) a dichotomous variable indicating whether the respondents had experienced at least one adverse event (coded as 1) or none (coded as 0); (2) a continuous variable indicating the total number of adverse events experienced; and (3) a categorical variable indicating whether that number was 1, 2, 3+, or 0 (reference). To determine the *timing* of adverse events, we created the following categorical variables: (a) only experienced adverse events during childhood aged 0–12 years, (b) only experienced adverse events during adolescence aged 13–17 years, (c) experienced adverse events in both childhood and adolescence, or (d) experienced no adverse events between ages 0 and 17 (reference).

For the *type* of adverse childhood events, we collapsed the 18 adverse events into six categories: academic events (e.g., dropping out of school), justice/social welfare (e.g., serious legal difficulties/prison), financial stressors (e.g., parents out of a job), household challenges (e.g., parents used drugs), death/illness of a loved one (e.g., parental death), and physical/sexual abuse (e.g., sexually assaulted)[15] (see the Supplemental Material for the exact coding of the categories). For each category, responses were coded "1" if the respondent had experienced one or more adverse events and "0" otherwise. To gauge the sensitivity of this coding specification, we also analyzed other specifications of type (e.g., largely replicating[14] and having natural disasters as its own category), but the other specifications did little to change the most optimal functional form.

Covariates

We first controlled for participants' age, sex (male and female), and race (white and nonwhite) in our models. Next, we additionally controlled for other variables that may be affected by childhood adversity, including marital status (married/cohabiting and other), educational attainment (less than bachelor's degree and bachelor's degree or above), household income (the sum of wages, pension, social security, and other sources, and it was top-coded at $300,000 ($n = 17$)), alcohol problems (no or have alcohol problems), and depressive symptoms (measured by the Center for Epidemiologic Studies Depression Scale[32]).

Analytic strategy

We began by calculating descriptive statistics on our analytic samples. We then fit a series of ordinary least squares (OLS) regression models to examine how the quantity, timing, and type of adverse childhood events predicted the PSQI in the full sample and in the actigraphic subsample in M*plus* 8.2.[33] We then fit an identical series of linear regression models to predict the actigraphic measures of sleep. We first controlled for age, sex, and race, and then additionally controlled for marital status, educational attainment, household income, alcohol problems, and depressive symptoms in adulthood. To determine which form of childhood adversity model fit best for the subjective and actigraphic measures of sleep, we used the Bayesian Information Criterion (BIC), a technique commonly used for non-nested models, where the lowest BIC indicates the best model fit.[34] Missing data (household income had the highest rate of missingness at 3.1%) were handled via multiple imputation with 20 imputed data sets.[33]

Results

Descriptive statistics

Table 1 presents descriptive statistics of the full sample and the actigraphic subsample. The average score for subjective sleep was 5.91 in the full sample and 6.06 in the actigraphic subsample. The actigraphic measures indicate that for each night, on average, respondents took around 32.57 minutes to fall asleep, had a sleep efficiency of 79.2%, were awake for a total of about 45.22 minutes after sleep onset and before rising, and slept around 369.84 minutes. Over half the participants experienced at least one adverse event in childhood or adolescence. The highest proportions of participants had experienced one adverse event but reported adverse events at multiple ages. Household challenges and academic events were the two most common event types. We conducted additional analyses to compare the samples that suggested the full sample and the actigraphic subsample were generally similar in subjective sleep and childhood adversity but different in some of the covariates (see Supplemental Materials for details).

Quantity, timing, and type of childhood adversity and subjective measures of sleep

Table 2 shows the results of OLS regression models using the quantity, timing, and type of childhood adversity to predict subjective sleep in the full sample. When age, sex, and race were included as covariates, individuals who experienced any adverse events had worse subjective sleep ($b = 0.30$, $p < 0.001$). A greater number of events predicted higher scores—that is, worse subjective sleep ($b = 0.13$, $p < 0.001$) (see Fig. 1). Compared to participants who did not experience any events, those who experienced two ($b = 0.39$, $p < 0.001$) or three or more ($b = 0.49$, $p < 0.001$) events reported significantly worse sleep. Regarding the timing of adverse childhood events, experiencing events in childhood ($b = 0.25$, $p = 0.006$), adolescence ($b = 0.22$, $p = 0.038$), or multiple periods ($b = 0.38$, $p < 0.001$) predicted worse subjective sleep. For the type of adverse events, experiencing academic ($b = 0.27$, $p = 0.002$) or justice/social welfare ($b = 0.37$, $p = 0.023$) adverse events predicted worse subjective sleep. Of all the models, the model with a continuous total

Table 1
Descriptive statistics of the full sample and the actigraphic subsample for the Midlife in the United States Refresher Biomarker Project 2012–2016

Variables	Full sample ($N = 863$)	Actigraphic subsample ($N = 278$)
Subjective sleep scores (*M* (*SD*))	5.89 (3.28)	6.01 (3.31)
Actigraphic sleep measures (*M* (*SD*))		
Ln of sleep-onset latency in minutes		3.02 (0.98)
Sleep efficiency		79.17 (11.44)
Wake time after sleep onset in minutes		45.22 (26.32)
Total sleep time in minutes		369.84 (67.97)
Any adverse childhood events (*n* (%))	491 (56.9)	147 (52.9)
Total number of events (*M* (*SD*))	1.14 (1.39)	1.05 (1.36)
Number of events (*n* (%))		
One	223 (25.8)	71 (25.5)
Two	145 (16.8)	36 (12.9)
Three or more	123 (14.3)	40 (14.4)
Timing of events (*n* (%))		
Only events when aged 0 to 12 years	157 (18.2)	45 (16.2)
Only events when aged 13 to 17 years	120 (13.9)	37 (13.3)
Events at multiple age groups	214 (24.8)	65 (23.4)
Types of events (*n* (%))		
Academic events	192 (22.2)	59 (21.2)
Justice/social welfare	37 (4.3)	11 (4.0)
Financial stressors	143 (16.6)	34 (12.2)
Household challenges	261 (30.2)	77 (27.7)
Death/illness of a loved one	82 (9.5)	27 (9.7)
Physical/sexual abuse	100 (11.6)	30 (10.8)
Demographics		
Average age in years (*M* (*SD*))	52.72 (13.44)	51.44 (12.66)
Female (*n* (%))	450 (52.1)	158 (56.8)
White (*n* (%))	606 (70.2)	177 (63.7)
Bachelor's or higher (*n* (%))	450 (52.1)	124 (44.6)
Household income in thousand (*M* (*SD*))	83.81 (65.38)	73.13 (58.36)
Married/cohabitation (*n* (%))	513 (59.4)	158 (56.8)
Alcohol problems (*n* (%))	76 (8.8)	18 (6.5)
Depressive symptoms (*M* (*SD*))	9.26 (7.90)	9.87 (7.95)

number of adverse events as a predictor (Model 2) had the lowest BIC value, indicating the best overall fit. The pattern of adverse-event associations for models that additionally controlled for marital status, educational attainment, household income, alcohol problems, and depressive symptoms mirrored results in models controlling for only age, sex, and race, but only experiencing any adverse events ($b = 0.12$, $p = 0.049$) or two adverse events ($b = 0.21$, $p = 0.019$) was significantly associated with worse subjective sleep. Models 1 and 2 had the lowest BIC values (BIC = 4286.07 and 4286.35 for Models 1 and 2, respectively). Results for the actigraphic subsample largely echoed those for the full sample (see Supplemental Table S1), as did the model fit rankings. An exception being the statistically significant association between financial stressors and subjective sleep ($b = 0.45$, $p = 0.025$).

Quantity, timing, and type of childhood adversity and actigraphic measures of sleep

For the actigraphic subsample, we examined the associations between adverse childhood events and actigraphic measures of sleep, as depicted in Table 3. When age, sex, and race were included in models, a greater number of adverse events was associated with longer SOL ($b = 0.14$, $p = 0.001$), lower SE ($b = -0.17$, $p < 0.001$), and longer WASO ($b = 0.15$, $p = 0.004$). Participants who experienced three or more adverse events also reported longer SOL ($b = 0.54$, $p = 0.003$), lower SE ($b = -0.64$, $p = 0.001$), and longer WASO ($b = 0.54$, $p = 0.008$). Similarly, experiencing adverse events during both childhood and adolescence was related to longer SOL ($b = 0.34$, $p = 0.013$), lower SE ($b = -0.34$, $p = 0.022$), and longer WASO ($b = 0.35$, $p = 0.020$). Death/illness of a loved one was associated with lower SE ($b = -0.43$, $p = 0.042$). However, participants who reported two adverse events had longer TST ($b = 0.51$, $p = 0.001$) than those who reported no adverse events. Once again, the best fitting model was the one with a continuous total number of adverse events (Model 2). This is true for all actigraphic sleep outcomes examined other than the TST model, for which Model 3 had the best fit. The model fit rankings were similar when marital status, educational attainment, household income, alcohol problems, and depressive symptoms were included (see Table 4), but only total number of adverse events was related to lower SE ($b = -0.10$, $p = 0.042$), and experiencing two events was associated with higher TST ($b = 0.50$, $p = 0.001$).

Table 2
Coefficients and standard errors from models predicting subjective sleep from childhood adversity in the full sample of the Midlife in the United States Refresher Biomarker Project 2012–2016 (N = 863)

Models	Subjective sleep scores[a]				Subjective sleep scores[b]			
	b	*SE*	*p*	BIC	*b*	*SE*	*p*	BIC
Model 1: Any adverse event (none)	0.30	0.07	< 0.001	4476.17	0.12	0.06	0.049	4286.07
Model 2: Total number of adverse events	0.13	0.02	< 0.001	4466.81	0.04	0.02	0.070	4286.35
Model 3: Number of adverse events (none)				4477.77				4295.65
One	0.14	0.08	0.076		0.05	0.07	0.532	
Two	0.39	0.10	< 0.001		0.21	0.09	0.019	
Three or more	0.49	0.11	< 0.001		0.19	0.10	0.067	
Model 4: Timing of adverse events (none)				4486.99				4299.24
Only events when aged 0 to 12 years	0.25	0.09	0.006		0.09	0.08	0.262	
Only events when aged 13 to 17 years	0.22	0.10	0.038		0.13	0.10	0.183	
Events at multiple age groups	0.38	0.08	< 0.001		0.14	0.08	0.066	
Model 5: Types of adverse events (none)				4499.04				4315.83
Academic events	0.27	0.09	0.002		0.10	0.08	0.214	
Justice/social welfare	0.37	0.16	0.023		0.26	0.15	0.072	
Financial stressors	0.12	0.10	0.221		-0.003	0.08	0.973	
Household challenges	0.12	0.08	0.096		0.09	0.07	0.199	
Death/illness of a loved one	0.14	0.12	0.270		0.05	0.11	0.668	
Physical/sexual abuse	0.03	0.11	0.763		-0.04	0.10	0.691	

Note. Reference groups are in parentheses. Higher scores of subjective sleep indicate worse sleep quality. The y-standardized coefficients are reported.
BIC = Bayesian information criterion.
[a] Models control for age, sex, and race.
[b] Models control for age, sex, race, marital status, educational attainment, household income, alcohol problems, and depressive symptoms.

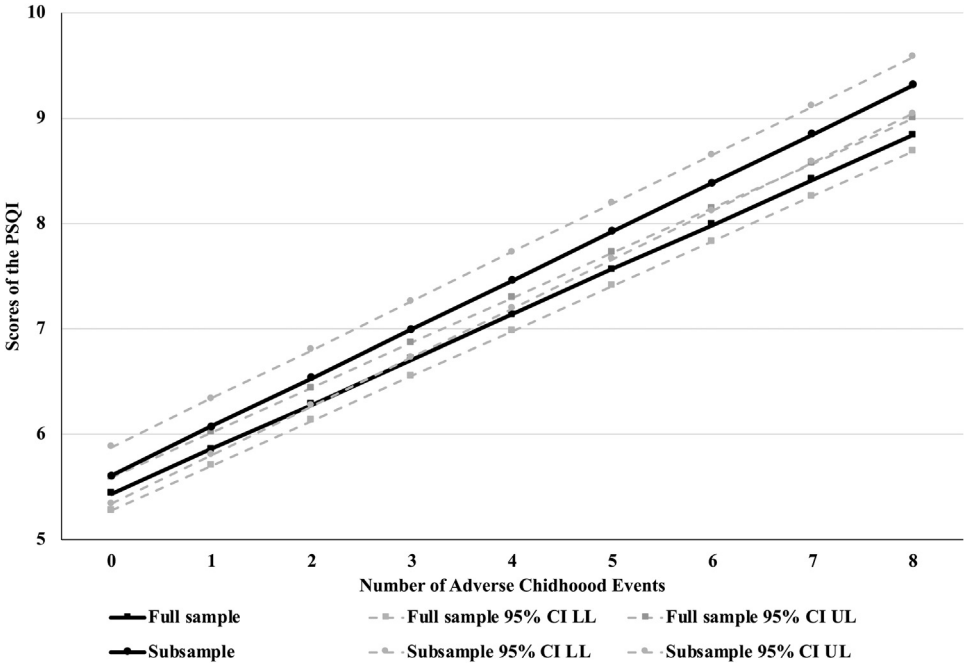

Fig. 1. The numbers of adverse childhood events and scores of the PSQI. *Note.* Covariates, including age, sex, and race, were mean-centered. Higher scores of the PSQI indicate worse sleep quality. PSQI = Pittsburgh Sleep Quality Index; CI = confidence interval; LL = lower limit; UL = upper limit.

Discussion

In this study, we operationalized childhood adversity in terms of quantity, timing, and type of adverse events to examine their association with subjective reports and actigraphic measures of sleep in adulthood. Our results indicated that adverse childhood events, operationalized as quantity, timing, or type, had negative influences on perception and physiological sleep in adults. These findings provide empirical evidence for the "long arm"[35] of childhood adversity on sleep in adulthood. Given the high prevalence of childhood adversity and the importance of sleep,[3-6,14] our findings imply that efforts to reduce exposure to adverse events in childhood and adolescence could have substantial population-level benefits.

Consistent with Hypotheses #1 and #2, we found that experiencing more adverse events, particularly three or more events, or adverse events in both childhood and adolescence was associated with worse self-reported sleep and actigraphic sleep, including SOL, SE, and WASO. These findings are consistent with previous studies[21-23] and highlight the importance of the quantity of childhood adversity on both perception *and* physiological process of sleep. Unlike prior studies suggesting adversity in childhood, but not in adolescence, contributed to worse self-reported sleep[20] and actigraphic

Table 3
Coefficients and standard errors from models predicting actigraphic sleep from childhood adversity in the actigraphic subsample of the Midlife in the United States Refresher Biomarker Project 2012–2016 (N = 278)

Models	SOL				SE				WASO				TST			
	b	*SE*	*p*	BIC	*B*	*SE*	*p*	BIC	*b*	*SE*	*p*	BIC	*b*	*SE*	*p*	BIC
Model 1: Any adverse event (none)	0.18	0.11	0.112	765.15	-0.13	0.11	0.233	2098.37	0.12	0.11	0.277	2601.56	0.03	0.11	0.821	3126.88
Model 2: Total number of adverse events	0.14	0.04	0.001	755.80	-0.17	0.05	< 0.001	2079.93	0.15	0.05	0.004	2590.61	-0.04	0.05	0.418	3126.13
Model 3: Number of adverse events (none)				768.32				2091.07				2601.89				3124.74
One	0.03	0.13	0.850		0.03	0.12	0.816		-0.06	0.13	0.631		-0.09	0.14	0.527	
Two	0.12	0.16	0.469		0.09	0.16	0.591		0.05	0.18	0.765		0.51	0.15	0.001	
Three or more	0.54	0.18	0.003		-0.64	0.19	0.001		0.54	0.20	0.008		-0.21	0.19	0.279	
Model 4: Timing of adverse events (none)				772.28				2101.95				2605.37				3134.53
Only events when aged 0 to 12 years	-0.02	0.18	0.919		0.11	0.15	0.437		-0.02	0.18	0.889		0.17	0.17	0.305	
Only events when aged 13 to 17 years	0.13	0.17	0.436		-0.05	0.16	0.758		-0.11	0.15	0.449		-0.21	0.18	0.239	
Events at multiple age groups	0.34	0.14	0.013		-0.34	0.15	0.022		0.35	0.15	0.020		0.06	0.14	0.658	
Model 5: Types of adverse events (none)				786.67				2110.94				2620.36				3149.08
Academic events	0.06	0.14	0.686		-0.17	0.15	0.276		0.30	0.16	0.066		0.07	0.15	0.664	
Justice/social welfare	0.32	0.37	0.395		-0.50	0.33	0.128		0.23	0.35	0.515		-0.31	0.35	0.385	
Financial stressors	0.14	0.16	0.381		-0.12	0.18	0.491		0.03	0.20	0.873		-0.08	0.19	0.680	
Household challenges	0.15	0.12	0.210		-0.03	0.12	0.841		0.02	0.15	0.894		0.17	0.14	0.198	
Death/illness of a loved one	0.14	0.23	0.539		-0.43	0.21	0.042		0.36	0.20	0.080		-0.15	0.20	0.465	
Physical/sexual abuse	0.27	0.19	0.155		-0.21	0.18	0.250		0.08	0.21	0.696		-0.29	0.22	0.193	

Note. Reference groups are in parentheses. The y-standardized coefficients are reported.
SOL = The natural log of sleep onset latency; SE = sleep efficiency; WASO = wake time after sleep onset; TST = total sleep time; BIC = Bayesian information criterion. Higher scores of SOL and WASO and lower scores of SE and TST indicate worse sleep quality. Covariates are age, sex, and race in all models.

Table 4
Coefficients and standard errors from models predicting actigraphic sleep from childhood adversity in the actigraphic subsample of the Midlife in the United States Refresher Biomarker Project 2012–2016 (N = 278)

Models	SOL				SE				WASO				TST			
	b	*SE*	*p*	BIC	*b*	*SE*	*p*	BIC	*b*	*SE*	*p*	BIC	*b*	*SE*	*p*	BIC
Model 1: Any adverse event (none)	0.02	0.12	0.868	760.36	0.04	0.10	0.676	2078.93	-0.06	0.11	0.616	2590.34	0.03	0.11	0.779	3145.36
Model 2: Total number of adverse events	0.07	0.05	0.123	757.66	-0.10	0.05	0.042	2072.90	0.07	0.05	0.173	2587.88	-0.03	0.04	0.475	3144.95
Model 3: Number of adverse events (none)				768.27				2079.15				2596.38				3143.99
One	-0.05	0.13	0.717		0.10	0.12	0.366		-0.15	0.12	0.228		-0.09	0.14	0.494	
Two	-0.05	0.16	0.750		0.25	0.15	0.105		-0.12	0.17	0.494		0.50	0.15	0.001	
Three or more	0.26	0.18	0.163		-0.33	0.18	0.062		0.24	0.20	0.234		-0.17	0.18	0.343	
Model 4: Timing of adverse events (none)				769.59				2085.69				2598.36				3151.80
Only events when aged 0 to 12 years	-0.14	0.18	0.453		0.25	0.14	0.076		-0.16	0.17	0.332		0.19	0.17	0.251	
Only events when aged 13 to 17 years	0.08	0.15	0.600		-0.01	0.15	0.962		-0.17	0.15	0.258		-0.24	0.18	0.180	
Events at multiple age groups	0.09	0.14	0.497		-0.08	0.14	0.574		0.10	0.15	0.501		0.09	0.14	0.506	
Model 5: Types of adverse events (none)				784.36				2099.20				2615.58				3168.11
Academic events	-0.15	0.14	0.279		0.04	0.15	0.786		0.09	0.17	0.601		0.05	0.15	0.738	
Justice/social welfare	0.14	0.36	0.685		-0.33	0.32	0.290		0.01	0.33	0.971		-0.34	0.36	0.343	
Financial stressors	0.13	0.14	0.337		-0.08	0.16	0.598		0.04	0.18	0.837		0.00	0.19	0.992	
Household challenges	0.10	0.12	0.403		0.02	0.12	0.834		-0.04	0.14	0.748		0.16	0.13	0.249	
Death/illness of a loved one	0.07	0.22	0.740		-0.36	0.20	0.072		0.28	0.20	0.145		-0.14	0.20	0.491	
Physical/sexual abuse	0.17	0.18	0.343		-0.11	0.17	0.505		0.01	0.20	0.978		-0.27	0.21	0.199	

Note. Reference groups are in parentheses. The y-standardized coefficients are reported.
SOL = The natural log of sleep onset latency; SE = sleep efficiency; WASO = wake time after sleep onset; TST = total sleep time; BIC = Bayesian information criterion. Higher scores of SOL and WASO and lower scores of SE and TST indicate worse sleep quality. Covariates are age, sex, race, marital status, educational attainment, household income, alcohol problems, and depressive symptoms in all models.

sleep,[13] our results suggest that experiencing adverse events in both periods was related to worse self-reported and actigraphic sleep. Cumulative exposure to adversity in both childhood and adolescence periods may produce long-term alternations in the HPA axis and brain,[16,17] thus explaining the association between adversity and perception *and* objective sleep in adulthood.[7]

For the type of adverse events, adverse academic events, justice/social welfare, financial stressors, or death/illness of a loved one were related to worse self-reported sleep or lower actigraphic SE, thus supporting Hypothesis #3. However, contrary to previous research,[20,36] childhood physical/sexual abuse was not linked to adult sleep. In ancillary analyses, we found that there were significant zero-order correlations between physical/sexual abuse and sleep measures (i.e., self-reported sleep in the full sample and SOL and SE in the actigraphic subsample), but these associations were statistically explained when we included controls for other adverse events and demographic variables. It is also important to note that the prevalence rate of self-reported physical/sexual abuse was lower in MIDUS than nationally representative estimates,[37] which may reduce statistical power in detecting the association between abuse and sleep and likely make these estimates conservative. The lower levels of physical/sexual assault in MIDUS may be because we analyzed only two broad questions about physical or sexual assault rather than a detailed list of acts of physical or sexual abuse. Moreover, participants' average age was 52.72, potentially leading to recall error. The null findings regarding physical/sexual abuse should be understood in the context of these issues.

Consistent with a prior study focusing on cardiometabolic conditions[14] and Hypothesis #4, we found that the best fitting functional form of childhood adversity was a cumulative dose-response term (i.e., count of total number of adverse events experienced) for the subjective and actigraphic sleep measures (except for the TST) compared with the timing and type specifications of adverse events. This supports previous studies that indicate a dose-response relationship between childhood adversity and adult sleep.[22,23] By comparing the dose-response relationship to other specifications, our findings imply that a dose-response relationship may be the most optimal way to describe the association between adverse childhood events and adult sleep, suggesting clinicians could use a count of adverse events rather than more detailed information to quickly surmise the influence of childhood adversity on sleep for adults.

There are important limitations of this study. First, as mentioned, our subsample of the MIDUS Refresher study is not nationally representative and is more advantaged than the U.S. population (e.g., 52.1% had a bachelor's degree or higher). Given the linkages between childhood adversity and educational attainment,[38] this relatively advantaged sample would likely lead to conservative results, especially as some of our adversity measures directly measured educational difficulties. Although the MIDUS sample is advantaged in some ways (e.g., lower levels of physical/sexual assault and higher levels of educational attainment), other representative surveys lack the detailed questions regarding childhood adversity (e.g., timing) and actigraphic measures of sleep available in the MIDUS. Second, because some adverse events may be more likely to occur in specific periods,[15] it is essential to distinguish the timing and type of childhood adversity. Analyzing the interaction between type and timing of adverse events may address this issue.[11] However, our sample sizes, particularly in the actigraphic subsample, were insufficient to conduct these analyses. Future studies with larger sample sizes could further disentangle this issue. Third, research has suggested that retrospective reports are more likely to underestimate childhood adverse events,[39] likely resulting in conservative results. Nonetheless, future studies would benefit from comparing multiple measures of childhood adversity such as prospective records *and* retrospective recalls, given that low to moderate agreement was found between prospective and retrospective measures.[40] Future research should also investigate how variables such as post-traumatic stress disorder and substance abuse may mediate the associations we document here.

Despite these limitations, our study adds to the literature on childhood adversity and sleep by systematically investigating how quantity, timing, and type of childhood adversity were associated with subjective reports and actigraphic measures of sleep. Our results echo the findings of previous studies,[13,14,21,22] suggesting cumulative adverse events in childhood predict worse sleep in adulthood. The linkages between childhood adversity and subjective as well as actigraphic sleep quality indicate that adverse events in early life affect not only the perception but also physiological processes of sleep and that efforts to minimize childhood adversity will profoundly benefit society.

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Appendix A. Supplementary Data

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